https://doi.org/ 10.33472/AFJBS.6.5.2024. 6001-6016

African Journal of Biological Sciences

Performance of different supplements on growth and yield of Elm mushroom (*Hypsizygus ulmarius*)(Bull.:Fr.) redhead

Paratikshya Khadka[1]*, Chintamani Paudel[2], Keshab Kumar Jha[2], Gobinda Paudel[3], K.N. Shah*[4] and Santosh Singh*[4]

Performance of various supplements for growth and yield of elm mushroom.

[1] Dev Bhoomi Uttarakhand University, Dehradun, Uttarakhand, 248007
[2] Baba Farid Institute of Technology, Chakrata Road, Suddhowala, Dehradun, Uttarakhand, 248007
[3] Graphic Era Hill University, Bell Road, Clement Town Dehradun, Uttarakhand
[4]HNB Garhwal University (A Central University) Srinagar (Garhwal) 246174, Uttarakhand, India
*Corresponding Email:- naseer.ahmed56@gmail.com & singhrawat.santosh@gmail.com

Article History
Volume 6, Issue 5, 2024
Received: 09 May 2024
Accepted: 17 May 2024
doi: *10.33472/AFJBS.6.5.2024. 6001-6016*

Abstract

Mushroom cultivation is a sustainable way to make use of agricultural waste and satisfy the rising demand for nutritious nourishment. The goal of this study was to evaluate the effects of different supplements (agricultural organic wastes) on yield and growth of elm mushrooms (*Hypsizygus ulmarius*). A Completely Randomized Design (CRD) with three replications per treatment was followed as statistic design to evaluate the treatments which comprised of different agriculture organic waste *i.e.*,wheat straw, mustard oilcake, chickpea bran and wheat bran. There were a total of 10 treatments of various combination of wheat straw withmustard oilcake, chickpea bran and wheat bran at different concentration. The quickest times for spawn run (19.67 days), primordia formation (29.33 days) and harvest (36.57 days) were observed when 10% chickpea bran was added to wheat straw. It also showed the maximum biological efficiency (116.2 %) and total fresh weight (535g). The addition of mustardoilcake, on the other hand, decreased production and caused contamination. The results highlight how important supplement type and concentration are for increasing biological efficiency and mushroom yield. Chickpea bran emerged as a promising alternative to conventional supplements like wheat bran, offering both economic and sustainableadvantages.

Keywords: Agricultural, Biological, Efficiency, Elm, Mushroom and Waste.

Introduction

Mushroom are interesting fungus that come in a range of sizes, forms and flavors. Till now, thousands of fungihave been discovered in biodiversity which are of various natures. Out of those, only some fungal species develop to grow in the form of fruiting body. The fungus which consistsof fruiting body is known as mushroom. In nature there is wide range of availability of mushrooms which are different to each other according to their mode of nutrition, growing conditions, economic importance, nutritive value etc. In today's global environment where food consumption patterns are changing quickly, consumers are requesting foods that readily meet their daily nutritional needs. Mushrooms can play a significant part in meeting the everyday demand for easily accessible and nutritious meals. The way people view mushrooms and their products is already changing for the better. One benefit of technical innovation for rural farmers is their increased ability to reach a worldwide audience and learn about the various options available in the field of mushroom production. They have special qualities and are utilized in cuisine and also for medicinal purpose. Mushroom cultivation is one of the many applications of agriculture waste technology for the large-scale recycling of agriculture waste into a valuable nutritional food. Its cultivation is easy and its cost of production is also low. Like all fleshy fruits and vegetables, mushrooms are highly perishable of their high moisture content and delicate in nature. In addition, mushroom isconsidered to be the world largest untapped sources of nutrition for future generations **(Aditya et al., 2023).**

Among allthe edible mushrooms, oyster mushroom cultivation is quite popular in Asian countries due to its easy cultivation method. The most remarkable aspect of modern mushroom cultivation is its landless agriculture based on lignocellulosic agriculture wastes (wheat straw, rice straw, sugarcane leaves, banana leaves and many more) that are otherwise unusable **(Khade et al., 2019)**. There are several technological elements involved in mushroom growth dynamics that are similar to those found in our typical agricultural crop plants. These include vegetative growth (when the mycelium grows vigorously) and

reproductive growth (when the entire umbrella-like structure that we call a mushroom develops). The finest growing condition, high quality substrate and high-quality spawn are necessary for mushroom cultivation to be effective, furthermore environmental like temperature and humidity support the growth of mushrooms **(Uddin et al., 2010)**. The right time, dosage and methods of supplements are important for mushroom cultivation, as well as several important aspects of cultivation, such as the composting process, temperature under control of mycelial growth before and after coating, hygiene measures, selection and application of a supplements time and especially the uniform distribution of the product used in the substrate, all affect the subsequent harvest. The purpose of the additions supplements is to speed up the production process and boost mushroom yields by providing additional nitrogen and/or quickly broken-down carbs **(Royse, 2002)**. Supplements refer to protein and nitrogen-rich substances employed to enhance the growth and production capabilities of substrates. Typically organic in nature, these additives include materials such as wheat bran,chickpea bran rice bran, various flours like maize, chickpea rice, cowpea, horse gram, mustard oilseed cake, molasses, among others **(Sanjel et al., 2021)**. In case of oyster mushroom, mostly species of *Pleurotus*genus is used which is resembled by elm mushroom known as *Hypsizygus ulmarius* with a better yield and biological efficiency. Keeping in mind the above mention facts, the present research aimed to assess the effects of different supplements on yield and growth of elm mushrooms (*Hypsizygus ulmarius*) by using different agriculture organic waste to enhance the production.

Materials and methods

Experimental sites and design

The experiment was conducted to analyse theeffect of different supplement on growth and yield of elm mushroom whichwas carried out at Mushroom Research Centre, Krishivan Research Centre, Dehradun during 2021-2022. The experiment was conducted by using Completely Randomised Design (CRD) with 10 treatmentswhich was replicate thrice. Wheat bran, chickpea bran and mustard oilcake were used as supplement in different ratio at 10, 20

and 30%. Wheat straw was used as primary substrate which was supplemented with 10, 20 and 30% of the supplements (wheat bran, chickpea bran and mustard oilcake). The 10 treatments were, T_1(Wheat straw @100%), T_2(Wheat Straw @ 90%+Wheat Bran 10%), T_3(Wheat Straw80% +Wheat Bran 20%), T_4(Wheat Straw 70% + Wheat Bran 30%), T_5(Wheat Straw 90%+Chickpea Bran 10%), T_6 (Wheat Straw80% +Chickpea Bran 20%), T_7 (Wheat Straw 70%+Chickpea Bran 30%), T_8(Wheat Straw 90%+Mustard oil cake 10%), T_9(Wheat Straw 80% +Mustard oil cake20%) and T_{10}(Wheat Straw 70% + Mustard oil cake30%). Wheat straw was procured from nearby farm while the supplements were purchased from nearby cattle feed store. The spawn used for the experiment was 2% of the substrate weight and was obtained from Prakriti Mushroom Lab, Dehradun.

Substrate preparation and sterilization

Wheat straw was dried in full sunlight for 7 days and was chopped using a chaff cutter into small bits of 2-3 cm. The substrate was sterilized by using chemical sterilization technique by soaking the substrate in 75 ppmcarbendazim and 500 ppm Formaldehyde for 18 hours **(Shukla & Jaitly 2011 and Rajak, 2011)**. After sterilization in chemicals, the wheat straw was dried in shade until the moisture of the straw was obtained upto 60%. The supplements were added in the required concentration and mixed with the substrates. Later, the substrates were then filled in polypropylene bags of 10x16-inch size bags with 500g of dry weight of substrates. Before filling the bag with substrate, spawn was added @2% and bags was sealed properly with the help of non-absorbent cotton followed by 5-6 holes in the bags sealed with the help of sterilized needle for proper aeration. The holes were covered with cotton to prevent contamination. The bags were kept inside an incubation room with favourable conditions for spawn run.

Incubation and cropping maintenance

The mushroom bags were placed inside an incubation room with temperature of 20-25^{o}C and relative humidity of 80-90% with the help of humidifier was maintained throughout the growing period. The room was kept in dark condition and with no exchange of air to increase the carbon dioxide concentration required for spawn run. After spawn run was detected in almost 95% bags and pinning was observed, cuts in shape of Xwere made in the bags to facilitate the growth and development of pinheads into mushrooms. Fluorescent light was used in growing room to help mushroom growth. Ventilation was introduced after primordia formation to maintain Co_2 level in the growing chamber. Light irrigation was given in the form of spray to maintain the moisture in the bags throughout the growing season.

Harvesting and data collection

Harvesting was done at full maturity when the pileus of the fruiting body starts to became ways. The fruiting bodies was harvested by twisting the fruiting bodies in clock-wise or anti-close-wise movement. After first harvest, the mycelium dries out instantly. So, to initiate the second fruiting, the mycelia should be scraped off followed by light spray of water. The data was collected for period of spawn run, primordia formation, fresh mushroom weight, length and diameter of the pileus. The biological efficiency was also calculated by using the formula **(Chang and Miles, 1981)** given below:

Biological Efficiency (BE) = $\frac{Fresh\,Weight\,of\,Mushroom}{Dry\,Weight\,of\,Substrate\,Used} \times 100$

Statistical analysis

The data from observations were analysed using ANOVA of 5% significance level (**Gomez and Gomez, 1984**). The average value of each treatment in each parameter was tested differently using (DMRT) Duncan multiple range analysis on R-studio.

Results

1. Duration for spawn run, primordia formation and harvest

The data for duration for spawn run, primordia formation and harvestis presented in Table 1. The duration required for the full spawn run, defined as the total period from spawning to the complete colonization of the substrate with whitish mycelial growth. From the findings, it was observed that wheat straw supplemented with @10 % chickpea bran (T_5) took minimum period for spawn run of 19.67 days which was at statistically similar withwheat straw supplemented with @20% chickpea bran (T_6) at 20 days and wheat bran @50% (T_2) at 21 days. The maximum duration was recorded in control (T_1) and wheat bran @ 30 % (T_4) at 31.33 days respectively. The duration required for primordia formation is the period required for the emergence of pinheads as shown in Table 1. However, the highest days for primordia formation was recorded at 41.67 days with the treatment Control (T_1) and supplementation of Wheat straw+Mustard cake @20% (T_9) which are statistically similar.The minimum duration for pinheads' development was observed at 29.33 days in treatment T_5(chickpea bran @10%) followed by 32.33 days and 33.67 days with the addition of wheat bran @10 % (T_2) and wheat bran @20 % (T_3) respectively. On the other hand, the maximum duration for pinhead formation was recorded at 35 days supplemented with chickpea bran @30% (T_7).

The shortest day for harvesting the *Hysizygus ulmarius* was observed at 36.67 days in the treatment T_5 i.e., supplemented with wheat straw+chickpea bran @10% which is statistically at par with (T_2) wheat bran @ 10% at 38.67 days, while the maximum duration was recorded in treatment T_9 (wheat straw+mustard oil cake @20%) which was at 53.00 days. The duration recorded for first harvest was at 52.00 days, 49.33 days, 52.00 days and 53.00 days in Control (T_1),chickpea bran @20%(T_6),chickpea bran @30% (T_7) andmustard

oilcake @20% (T_9) respectively and all are statistically similar. However, the treatment T_3(wheat bran @20%) recorded the first harvest at 40.33 days followed by T_4(wheat bran @30%) at44.33 days and T_8(mustard oil cake @10%)at 48.67 days.

2. Average fresh weight and biological efficiency

The data for average fresh weight and biological efficiency is presented in table 2 and graphically depicted in fig. 2. The total fresh weight was found significantly highest(535.0 g)in treatment T_5(chickpea bran @10%)which is statistically at par with T_2(wheat bran @10 %)467.89 g, T_3(wheat bran @20%) 464.56 g, T_4(wheat bran @30%) 451.78 g, T_6(chickpeabran @20%) 438.44 g and T_7(chickpea bran @30%). On the other hand, the lowest(354.22 g) fresh weight was found in treatment T_1(Control). However, the maximum (116.2 %) biological efficiency was recorded in treatment supplemented with chickpea bran @10%(T_5),followed by 103.33% supplemented with wheat bran @10 % (T_2), whereas the lowest(66%) was recorded in supplemented with mustard oilcake @20% (T_9).

3. Pileus Diameter and Length

As presented in table 3 and graphically depicted in fig. 3, it was revealed that the media supplemented with chickpea bran @10% (T_5) recorded significantly highest(10.42 cm)length and (10.67 cm) diameter of *Hypsizygusulmarius*. However, the smallest (7.03 cm) length and (5.5 cm) diameter was recorded in treatment T_9(mustard oil cake @20%).

Discussion

In the present study, it was observed that wheat straw supplemented with chickpea bran @10% showed the minimum time required for spawn run, pinheads'formation, duration for harvest, total fresh weight, biological efficiency, length of the fruit and diameter of pileus which is due to increase in the production of various enzymes such as cellulases, hemicelluloses, and laccase is directly linked to the addition of chickpea bran. These enzymes are responsible for breaking down cellulose, hemicelluloses and lignin (**Kumar et al., 2019)**. These enzymes help in the mycelial colonization as reported by **(Ferdinandi et al., 2014)**. Supplements are typically added either towards the conclusion of substrate preparation, before spawning or to stimulate vegetative growth across the substrate **(Naraian et al., 2009)** to encourage mushroom colonization.The outcomes can be credited to improvethe total fresh weight and biological effectiveness, particularly with nitrogen supplementation when utilizing organic materials such as chickpea bran and wheat bran **(Salama et al., 2019)**. In

mushroom cultivation, supplement plays an important role in enhancing production but the ratio should be low as higher supplement may lead to lower yield, contamination and mycelium inhibition as reported by **Yildiz et al., 2002; Fanadzo et al., 2010 and Upadhyay et al., 2018**. In case of wheat straw supplemented with mustard oilcake @30% was contaminated after 31 days of spawning. The average duration for spawn run recorded in this research is 19-31 days which is aligned with the findings of **Shah and Ashraf, 2004**. **Aditya et al., 2023** also reported maximum yield by the supplement of cotton seed cake followed by gram flour with biological efficiency of 162% which align with our result of maximum yield and biological efficiency with the supplementation of chickpea bran. The biological efficiency and yield both are statistically similar in wheat bran and chickpea bran both @10% is aligned with the findings of **Khade et al., 2019** and **Musakhail et al., 2011** who also recorded the maximum biological efficiency by using gram flour as a supplement. The supplement was mainly used to increase C:N ratio, biological efficiency and higher yield **(Aditya et al., 2023)**.The pileus diameter and mushroom length was observed highest with the application of chickpea bran which align with the findings of **Khade et al., 2019; Sher et al., 2011 and Raymond et al., 2013**. Hence, mushrooms can readily utilize organic nitrogen sources from chickpea bran and wheat bran because absorbing these molecules is more dynamic than integrating them. This enables mushrooms to acquire more energy for mycelial growth and fruiting **(Salama et al., 2019)**. However, supplement like mustard oil cakes results in contamination and reduced yield when used in higher concentration. **Krupodorova et al., 2015** as well as **Sanjel *et al.*,2021** similarly observed diminished yields and inhibition when supplementing with mustard oil seed cake, corroborating the outcomes of the current study.

Conclusion

Oyster mushroom cultivation is nowadays taking over the market due to its nutritional values and higher biological efficiency but the commonly used species are *Pleurotusostreatus*, *Pleurotus florida, Pleurotus sajor-caju* and other species of *Pleurotus*. This study successfully demonstrated the higher biological efficiency in*Hypsizygus ulmarius* with the use of supplements like rice bran and chickpea bran. The use of Chickpea powder/gram powder is common as a mushroom supplement but using chickpea bran would be economically as well as sustainable alternative to wheat bran and gram powder to increase mushroom yield and biological efficiency. The application of chickpea bran and wheat bran showed a significant increase in total fresh weight, biological efficiency, duration for spawn run, primordia formation and harvest. However, the use of mustard oil cake resulted in contamination as well as lower yield even in lesser concentration which can be result of anti-fungal properties which requires more research to be conducted.

Acknowledgement

The authors would like to thank each and every one of the scientists and staff of Krishivan Research Centre for Agripreneurship and Environmental Protection Samiti, Jhajra, Dehradun, India for their help and support. We also thank the academic editor for their intelligent reading of our work and their useful remarks and the anonymous reviewers who both made substantial contributions to the quality of the text.

References

Aditya and Jarial, R. S. (2023a). Utilization of agro-industrial wastes and organic supplements for cultivation of blue oyster mushroom. *Bangladesh Journal of Botany*, **52(**1), 179–185. https://doi.org/10.3329/bjb.v52i1.65249

Adityaand Jarial, R. S. (2023b). Utilization of agro-industrial wastes and organic supplements for cultivation of blue oyster mushroom.*Bangladesh Journal of Botany*, **52**(1), 179–185. https://doi.org/10.3329/bjb.v52i1.65249

Chang, S.T. and Miles, P.G. (1981). Edible Mushrooms and Their Cultivation. *CRC Press Inc.Boca* Raton Florida, Pp-480.

Fanadzo, M., Zireva, D. T., Dube, E.and Mashingaidze, A. B. (2010). Evaluation of various substrates and supplements for biological efficiency of *Pleurotus sajor-caju* and *Pleurotus ostreatus*. *African Journal of Biotechnology*, *9*(19), 2756–2761. http://www.academicjournals.org/AJB

Ferdinandi, P., Godliving Y, Sungusia, M., Mshandete, Manoni, A. and Kajumulo A. (2014). Ligninolytic enzymes activities of *pleurotus sapidus* during vegetative growth and fruit development on sugarcane residues-based substrates, 3(4), 58–71.

Gomez, K.A. and Gomez, A.A. (1984) Statistical Procedure for Agricultural Research. 2nd Edition, Willey, Hoboken, 28-192.

Khade, R. S., Jadhav, A. C., Dhavale, M. C. and Gaikwad, A. P. (2019). Evaluation of different supplementations on growth and yield of elm oyster (*Hypsizygus ulmarius*) Mushroom. *International Journal of Current Microbiology and Applied Sciences*, *8*(11), 1084–1095. https://doi.org/10.20546/ijcmas.2019.811.128

Krupodorova, T.and Barshteyn, V. Y. (2015). Alternative substrates for higher mushrooms mycelia cultivation.*Journal of BioScience and Biotechnology*,4(3), 339-347. http://www.jbb.uni-plovdiv.bg

Naraian, R., Sahu, R., Kumar, K., Garg, S. K., Singh, C. S. and Kanaujia, R. S. (2009). Influence of different nitrogen rich supplements during cultivation of Pleurotus florida on corn cob substrate. *Environment Systems and Decisions, Springer, 29(1)*, 1–7.

Rajakumar, S. R., Christdhas H. D., Sutharajakumar, C. R. and Kannan, L. C. (2019). Effect of different substrate alone and in combination on the sporophore production of elm oyster mushroom (*Hypsizygus ulmarius*). *Journal of Pharmacognosy and Phytochemistry*, 8(3): 3167-3171.

Rajak, S., Mahapatra, S. C., & Basu, M. (2011). Yield, fruit body diameter and cropping duration of oyster mushroom (*Pleurotus sajor-caju*) grown on different grasses and paddy straw as substrates. European Journal of Medicinal Plants, 1(1), 10–17.DOI: 10.9734/EJMP/2011/108

P. Raymond, A. Mshandete,& A. Kivaisi (2013). Cultivation of oyster mushroom (*Pleurotus* HK-37) on solid sisal waste fractions supplemented with cow dung

manure. *Journal of Biology and Life Science*, *4*(1). https://doi.org/10.5296/jbls.v4i1.2975

Royse, D. (2002). Influence of spawn rate and commercial delayed release nutrient levels on *Pleurotus cornucopiae* (oyster mushroom) yield, size, and time to production. *Appl Microbiol Biotechnol , 58,* 527–531.

Salama, A. N. A., Abdou, K., Helaly, A. A.and Salem, E. A. (2019). Effect of different nutritional supplements on the productivity and quality of oyster mushroom (*Pleurotus ostreatus*). *InternationalJournal of Agricultural Research,* 44 (2), 12-24

Sanjel, P., Shrestha, R. K.and Shrestha, J. (2021). Performance of oyster mushroom (*Pleurotus ostreatus*) grown on different fingermillet husk substrates. *Journal of Agriculture and Natural Resources*, *4*(1), 291–300. https://doi.org/10.3126/janr.v4i1.33370

Shah, Z.A. and Ashraf, M.I.C.M. (2004). Comparative study on cultivation and yield performance of oyster mushroom (*Pleurotus ostreatus*) on different substrates (wheat straw, leaves, saw dust). *Pakistan Journal of Nutrition*, *3(3),* 158–160.

Sher, H., Al-Yemeni, M. and Khan, K. (2011). Cultivation of the oyster mushroom (*Pleurotus ostreatus*) in two different agro-ecological zones of Pakistan. *African Journal of Biotechnology*, *10*(2), 183–188. https://doi.org/10.5897/AJB10.877

Shukla, S. and Jaitly, A.K. (2011). Morphological and biochemical characterization of different oyster mushroom (*Pleurotus spp*.). *Journal of Phytology*, *3*(8), 18-20

Musakhail, S.W. andJiskam, M.M. (2011). Growth and yield of oyster mushroom (*Pleurotus ostreatus*) as affected by gram powder amendment in substrate. *Pakistan Journal of Phytopathoogyl*, *23,* 35–41.

Uddin, M. N., Yesmin, S., Khan, M. A., Tania, M., Moonmoon, M. and Ahmed, S. (2010). Production of oyster mushrooms in different seasonal conditions of bangladesh. *Journal of Scientific Research*, *3*(1), 161. https://doi.org/10.3329/jsr.v3i1.6130

Upadhyay, R. C., Singh, S. K., Yadav, M. C.and Royse, D. J. (2018). Effect of organic nitrogen supplementation in Pleurotus species.*Mushroom Biology and Mushroom Products*. 225-232https://www.researchgate.net/publication/288934259

Yildiz, S., Mit, U., Yildiz, C., Derya G.E. and Temiz, A. (2002). Some lignocellulosic wastes used as raw material in cultivation of the *Pleurotus ostreatus*

culturemushroom. *Process Biochemistry*. 38(3): 301-306. DOI:10.1016/S0032-9592(02)00040-7

Tables 1: Effect of supplementation on the duration required for spawn run, primordiaformation and harvest

Treatment	**Days to Spawn run (***)**	**Days to Primordia Formation (***)**	**Days to Harvest (***)**
T_1[(Control) Wheat straw]	31.33[a]	41.67[a]	52.00[a]
T_2 (Wheat straw + Wheat bran @10%)	21.00[d]	32.33[cd]	38.67[d]
T_3 (Wheat straw + Wheat bran @20%)	25.67[bc]	33.67[c]	40.33cd
T_4 (Wheat straw + Wheat bran @30%)	31.33[a]	40.00[ab]	48.67[ab]
T_5 (Wheat straw + Chickpea bran @10%)	19.67[d]	29.33[d]	36.67d
T_6(Wheat straw + Chickpea bran @20%)	20.00[d]	39.33[ab]	49.33a
T_7 (Wheat straw + Chickpea bran @30%)	28.67[ab]	35.00[c]	52.00[a]
T_8 (Wheat straw + Mustard oilcake @10%)	22.33[cd]	38.33[b]	44.33[bc]
T_9 (Wheat straw + Mustard oilcake @20%)	23.00[cd]	41.67[a]	53.00[a]
T_{10} (Wheat straw + Mustard oilcake @30%)	31.00[a]	C	C
CV	7.99	4.95	5.62
LSD	3.48	3.15	4.49
SEM (±)	0.64	0.608	0.86
Grand Mean	25.4	36.81	46.11

Note: *Different letters in the same column represents significant difference using Duncan's Multiple Range test (P≤ 0.05) and average was calculated from three replicates

'*', '**', '***' – significant at the 10 %, 5 %, and 1 % level, respectively.

SEM (±): Standard Error of Mean, CV: Coefficient of Variation

Table 2: Effect of Supplementation on the total fresh weight and biological efficiency

Treatment	**Total Fresh Weight (**)**	**Biological Efficiency (%)**
T_1 [(Control) Wheat straw]	354.22[b]	76.53
T_2 (Wheat straw + Wheat bran @10%)	467.89[ab]	103.33
T_3 (Wheat straw + Wheat bran @20%)	464.56[ab]	102.12
T_4 (Wheat straw + Wheat bran @30%)	451.78[ab]	95.33
T_5 (Wheat straw + Chickpea bran @10%)	535.00[ab]	116.20
T_6 (Wheat straw + Chickpea bran @20%)	438.44[ab]	95.33
T_7 (Wheat straw + Chickpea bran @30%)	463.44[ab]	98.86
T_8 (Wheat straw + Mustard oilcake @10%)	373.00[b]	91.26
T_9 (Wheat straw + Mustard oilcake @20%)	348.33[b]	66.00
T_{10} (Wheat straw + Mustard oilcake @30%)	C	C
CV	16.7	
LSD	125.15	
SEM (±)	22.86	
Grand Mean	0.432	

Note: *Different letters in the same column represents significant difference using Duncan's Multiple Range test (P≤ 0.05) and average was calculated from three replicates

'*', '**', '***' – significant at the 10 %, 5 %, and 1 % level, respectively.

SEM (±): Standard Error of Mean, CV: Coefficient of Variation

Table 3: Effect of supplementation on the length and diameter of the mushroom

Treatment	Length (cm) (*)	Diameter (cm) (*)
T_1 [(Control) Wheat straw]	8.97^{abc}	7.36^{bc}
T_2 (Wheat straw + Wheat bran @10%)	9.66^{abc}	9.32^{ab}
T_3 (Wheat straw + Wheat bran @20%)	8.4^{bc}	8.18^{abc}
T_4 (Wheat straw + Wheat bran @30%)	8.11^{bc}	7.61^{bc}
T_5 (Wheat straw + Chickpea bran @10%)	10.42^{a}	10.67^{a}
T_6 (Wheat straw + Chickpea bran @20%)	8.98^{abc}	7.16^{bc}
T_7 (Wheat straw + Chickpea bran @30%)	7.49^{c}	6.6^{c}
T_8 (Wheat straw + Mustard oilcake @10%)	7.7^{bc}	7^{bc}
T_9 (Wheat straw + Mustard oilcake @20%)	7.03^{c}	5.5^{c}
T_{10} (Wheat straw + Mustard oilcake @30%)	C	C
CV	12.009	18.01
LSD	1.77	2.4
SEM (±)	0.34	0.46
Grand Mean	8.53	7.71

Note: *Different letters in the same column represents significant difference using Duncan's Multiple Range test ($P \leq 0.05$) and average was calculated from three replicates

'*', '**', '***' – significant at the 10 %, 5 %, and 1 % level, respectively.

SEM (±): Standard Error of Mean, CV: Coefficient of Variation

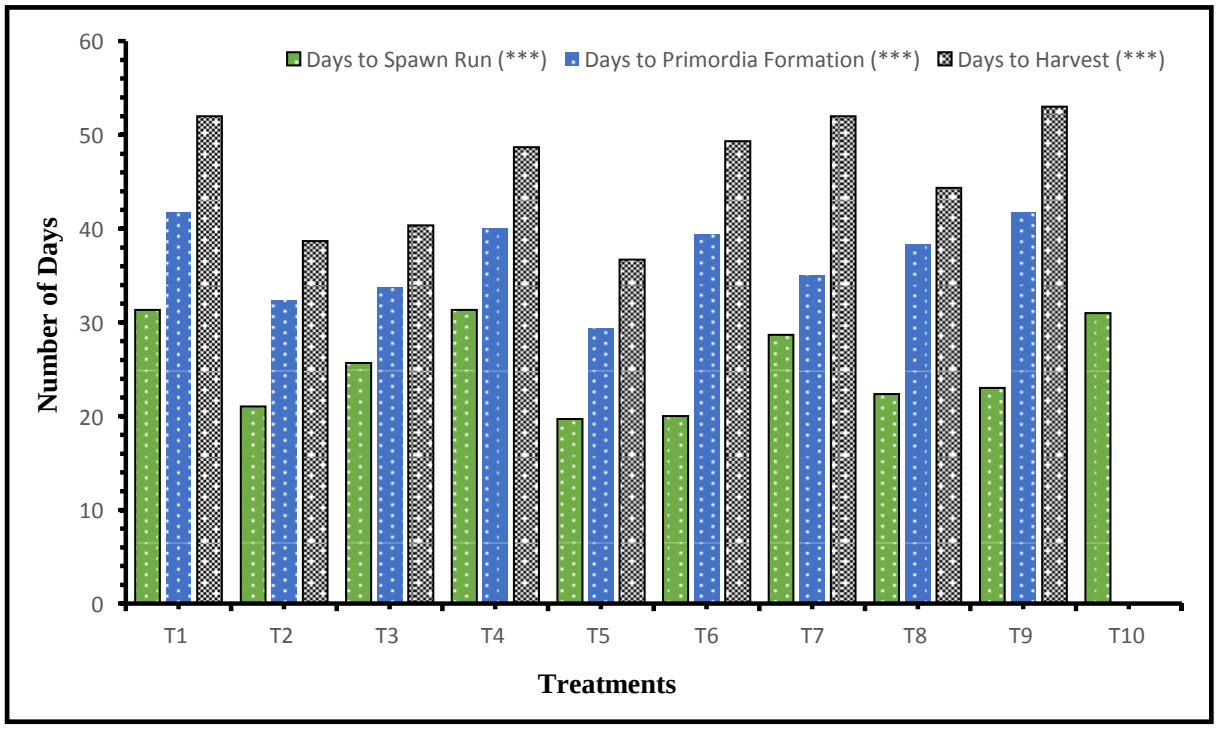

Fig. 1: Mean of duration required for spawn run, primordia formation and harvest

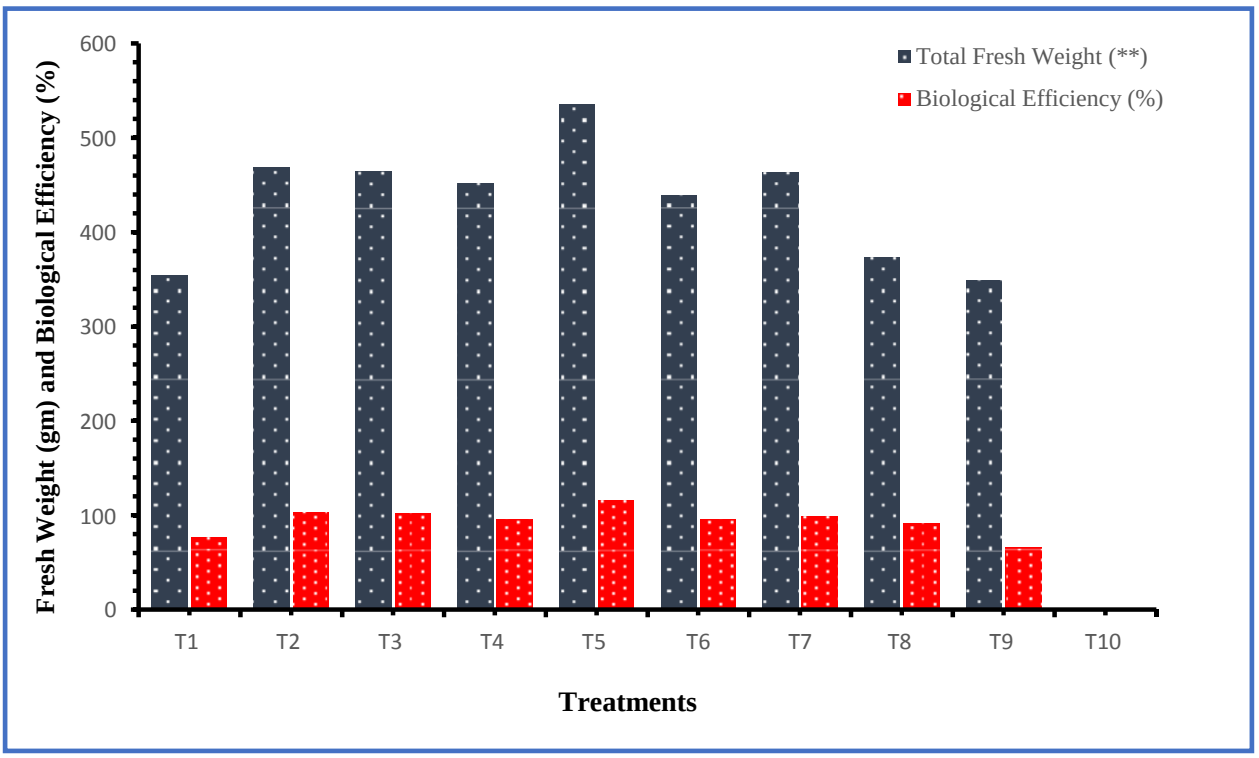

Fig. 2: **Mean of total fresh weight and biological efficiency**

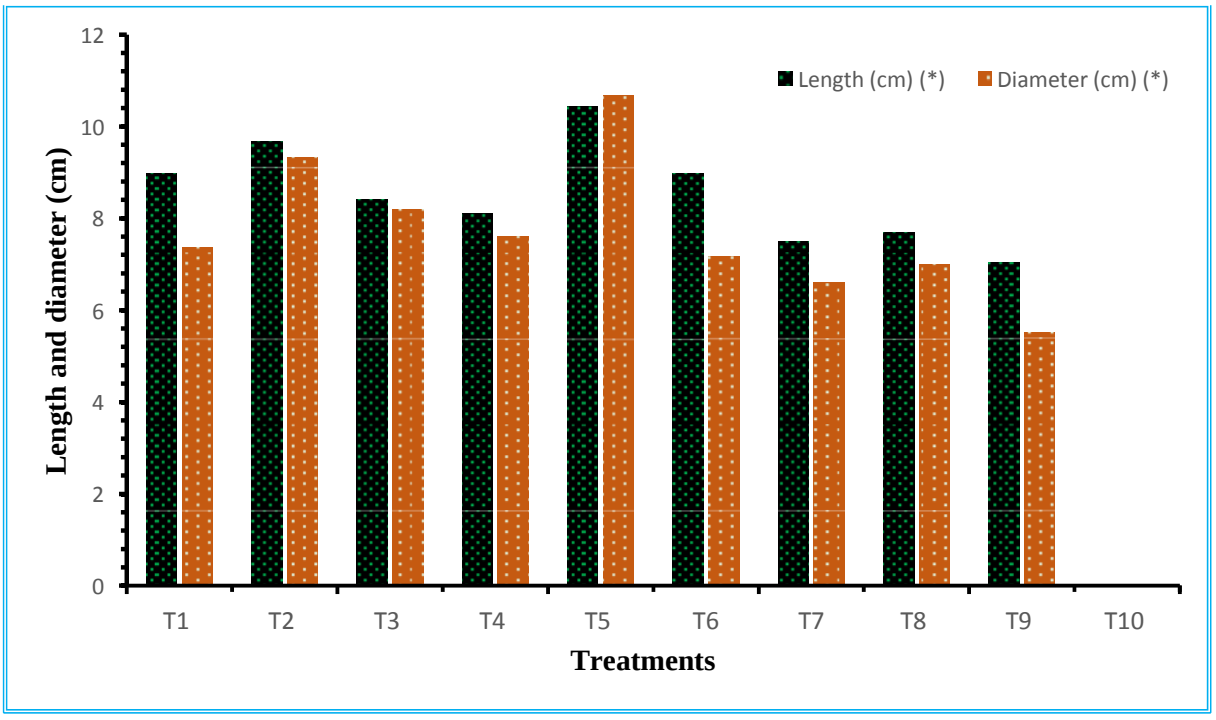

Fig. 3: Mean of length and diameter of the mushroom

Plate 1: Length and breath of elm mushroom

Plate 2: Fresh weight of Mushroom