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IMPACT OF VARIOUS AGRO-INDUSTRIAL WASTES ON YIELD AND QUALITY OF *PLEUROTUS SAJOR-CAJU*

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A B S T R A C T

The study reports the effects of various agro-industrial wastes and their combinations on yield and quality characteristics of *Pleurotussajor-caju*. The results revealed substantial variances among different wastes for improving the yield and quality of *P. sajor-caju*. However, the fastest mycelial growth (22.45 days), the highest number of pin heads (35.0) and average number of fruiting bodies (19.75) were observed in *P. sajor-caju* cultivated on cotton waste with respect to other substrates. Likewise, the largest diameter (6.90 cm) of mushroom fruit body was obtained on cotton waste, whereas stalk diameter (2.50 cm) and stalk length (3.11 cm) were found maximum on combination of cotton waste and corn cobs (1:1). It was noted that *P. sajorcaju* grown on cotton waste exhibited 61%, 54%, 43%, 42% and 28% higher biological efficiency as compared to the ones cultivated on sugarcane bagasse, sugarcane bagasse + corn cobs (1:1), corn cobs, sugarcane bagasse + cotton waste (1:1), cotton waste + corn cobs (1:1), respectively. Similarly a maximum increase of 61% in total yield was recorded in *P. sajorcaju* grown on cotton waste with respect to other agro-industrial wastes.

Keywords: Agro-industrial wastes, biological efficiency, growth attributes, *Pleurotussajor-caju*.

INTRODUCTION

Oyster mushroom can grow on various types of lignocellulosic waste materials owing to its simple and low cost production technology, few environmental controls, shorter growth time less attacked by diseases and pest as compared to other edible mushrooms (Dehariya and Vyas, 2013). *Pleurotus* species are efficient lignin-degrading mushroom and can grow on a wide range of agro waste materials such as wheat straw, sunflower heads, chickpea straw, rice straw, and cotton waste (Iqbal *et al*., 2005; Naeem *et al*., 2014). *Pleurotus* species are rich source of proteins, amino acids, dietary fibers, minerals (K, Ca, P, Fe, Na and Mg), vitamins (C, B-complex, riboflavin, folic acid) and low in fat contents (Patil, 2012; Adebayo *et al*., 2014).

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Pleurotussajor-caju also known as grey oyster mushroom or phoenix tail mushroom is one of the most popular edible oyster mushroom cultivated in the tropical and subtropical areas of world belonging to the family Pleurotaceae, order Agaricales, and class Basidiomycetes (Miles and Chang, 2004). Production of *Pleurotussajor-caju* on commercial level is largely determined by the availability and utilization of cheap materials among them agricultural lignocellulosic wastes represent the ideal and most promising substrates for cultivation. Most edible fungi have strong enzymatic system and are capable of utilizing more complex texture of organic compound which occur in the form of agricultural wastes and industrial by-products which are very cheap in developing countries (Ali *et al*., 2012). In Pakistan cotton waste and sugarcane bagasse are produced annually 15 million and 18 million tons respectively in traditional cotton ginning industries and as a byproduct of sugarcane industries are burned and used as fuel (Haleem *et al.*, 2014; Arshad and Ahmad, 2016). Corn cobs are used in animal feed and also as burning fuel. These wastes can be converted into a useful biomass with protein contents up to 47.9% by growing edible mushroom which is a profitable business (Ingale and Ramteke, 2010). Furthermore, the use of these residues in bioprocesses may be one of the solutions to bioconversion of inedible biomass residues into nutritious protein rich food in the form of edible mushrooms.

Strengthening mushroom production industry in the rural areas as a diversifying business can increase the employment opportunities and providing income opportunities of small family farms. Moreover with the increasing population of the country, there is a high demand of nutritious food. Mushrooms with their nutritional value and high productivity are excellent food source to alleviate malnutrition in developing countries (Eswaran and Ramabadran, 2000).

In Pakistan mushroom cultivation has never been the priority of farmers despite of its delicious taste, highly nutritious and gives high production with little input. Mushroom growth may be coincided with type of substrates (waste material) used that leads to tremendous utilization of nutrients in the agro-industrial bio-wastes.

Therefore, the present study was planned to investigate the effect of various substrates like cotton waste, sugarcane bagasse, corn cobs and their combinations on the growth yield, biological efficiency and quality characteristics of *Pleurotussajor-caju*.

MATERIALS AND METHODS

Experimental design: The experiment was conducted in the Mushroom growth room of Medicinal and Mushroom Laboratory, Institute of Horticultural sciences, University of Agriculture Faisalabad. Treatments of substrates cotton waste and corncobs alone and in combination were made accordingly. Substrates filled bags were kept in dark for 3-4 weeks and mycelial running of mushroom were observed room temperature was maintained at 25°C. After the completion of mycelial running mouth of the bags were opened for fruit body formation. Temperature and humidity in the mushroom growth room for the fruit body formation was maintained at 20-22°C 85-95% respectively by spraying of water. The experiments were laid out in a completely randomized design with three replications in each treatment. Each experiment was repeated three times and the data presented are the mean of values obtained from these experiments. T1 = cotton waste, T2 = corn cobs, T3 = cotton waste + corn cobs (1:1), T4 = sugarcane bagasse, T5 = sugarcane bagasse + cotton waste (1:1), T6 = sugarcane bagasse + corn cobs (1:1).

Spawn preparation: Culture of the *Pleurotussajor-caju* was obtained from the Medicinal and Mushroom Laboratory, Institute of Horticultural Sciences, University of Agriculture Faisalabad and spawn was prepared using standard method as described by Ali *et al*., (2012) on sorghum grains. Sorghum grains were well washed in tap water and were later half boiled and spread over a tilted platform to drain out excess water followed by mixing of buffers in 3:1 ratio (30 g $CaCO_3$ and 10 g $CaSO_4$ per kg of half boiled sorghum grain). The sorghum grains were now half filled in bottles and were autoclaved at 121°C and 15 psi for 30 minutes and left overnight. The process was followed by inoculation of bottles by transferring inoculums of *Pleurotussajor-caju*from cultured plates. The bottles were placed in incubation chamber at a temperature of 25 ± 2°C. After 3-4 days of inoculation, white net web like fungal mycelium started spreading on the grains and completely covered them in 10-14 days. Spawn was then shaken in order to evenly distribute mycelia on the grain and later stored at 4°C until used.

Substrate preparation: Substrates (Corn cobs, sugar cane bagasse and cotton waste) were collected from the vicinity of Faisalabad and were sun dried. These materials were soaked separately in water for 24 h to ensure sufficient moisturization. Substrates were tested for the pH before the preparation and substrate pH was maintained at 6.5 with lime and $CaSO_4$. After the preparation of substrate with the moisture percentage of 65-70% these materials were filled in polythene bags (20 × 30cm) @ 800g in each bag accordingly in three different combinations as described. After filling the substrate these bags were sterilized at 121°C and 15psi. After the sterilization of substrate filled bags they were cooled to 30°C and spawn was added in the polythene bags @1% of bag weight.

Harvesting of Mushroom: Mushroom fruit body develop after two weeks of the mouth opened bags and harvest before the curling of the mushroom cap margins in three flushes and data of different parameters were recorded.

Data collection: The following data were collected for this study. Number of days for the completion of spawn running was observed on each treatment, number of pin heads, yield from first flush (g), yield of second flush (g), yield of third flush (g) yield of fourth flush (g), Pileus diameter (cm), Stem length (cm), Stem diameter (cm), number of fruit bodies, weight of individual fruit body (g), Total yield (g), Biological Efficiency (%), Biological efficiency was calculated as percentage conversion of dry substrate to fresh fruit bodies (Mandeel *et al*., 2005).

Statistical analysis: The data collected from three experiments for each study, were analyzed statistically using the MSTAT-C (Russel and Eisensmith, 1986). The Least Significant Difference (LSD) test ($P \leq 0.05$) was used to compare the differences among treatment means (Steel *et al*., 1997).

RESULTS

Days for the completion of spawn running: Number of days for the completion of spawn running was found significantly different on different substrates. Table 1 shows T1 took minimum number of days (22.45±0.46 days) for spawn running followed by T3 (24.80±0.48), T2 (24.96±0.48ab), T5 (25.01±0.36), T6 (25.98±0.37) while maximum number of days (26.22±0.37) was observed in T4 (cotton waste + corn cobs 1:1) as shown in Table 1.

Number of pin heads: *Pleurotussajor-caju* produced significantly different number of pin heads on different substrates as shown in Table 1. Maximum number of pin heads (35±0.61) was recorded on T1 (cotton waste), followed by T3 (29±0.51), T5 (27.0±0.47), T2 (26±0.45), T6 (25.0±0.44) while, minimum number of pin heads was observed on T4 (22.01±0.38).

Number of fruit bodies: The fruiting body is the edible part of mushroom. Data presented in Table 1 showed that there is a significant difference between substrates for number of fruit bodies' production. Highest number of fruit bodies (19.75±0.34) were produced by T1 (cotton waste) followed by T2 (16.57±0.29), T3 (16.41±0.28), T5 (15.87±0.28), T6 (15.00±0.26) while minimum number of fruit bodies (14.76±0.26) were observed on T4 (sugarcane bagasse) as shown in Table 1.

Pileus diameter (cm): The data regarding the pileus diameter is shown in Table 1. The comparison of treatments means showed that maximum diameter of pileus (6.90±0.12 cm) was obtained on T1 (cotton waste) substrate while, minimum diameter of pileus (4.10±0.07 cm) was noted on T4 (sugarcane bagasse). Non-significant difference regarding pileus diameter was observed among T2, T3, T5 and T6.

Stalk diameter (cm): Stalk diameter of *Pleurotussajor-caju* was observed on different substrates in this study and found significantly different on different substrates is shown in Table 1. Maximum diameter of stalk (2.50±0.04 cm) was obtained on T6 (sugarcane bagasse + corn cobs 1:1) followed by T3 (2.10±0.03 cm), T5 (1.80±0.03 cm), T1 (1.34±0.02 cm) while, minimum diameter of stalk (1.05±0.01 cm) was observed on T4 (sugarcane bagasse).

Stalk length (cm): The data regarding the stalk length was observed after harvesting of mushroom and found significantly different on different substrates as shown in Table 1. The maximum stalk length (3.11±0.05 cm) was noted on T6 (sugarcane bagasse + corn cobs 1:1) while, minimum stalk length (2.55±0.04 cm) was found on T2 (corn cobs).

Total Yield (g): The yield pattern of *Pleurotussajor-caju* was observed and showed in Figure1. Mushroom yield is calculated using fresh weight Dundar *et al*. (2009). A significant variation for mushroom yield was observed on different substrates. The maximum yield (259.23g) was obtained on T1 (cotton waste) followed by T3 (201.6 g), T5 (182.45 g), T2 (180.8 g), T6 (168.53 g) while, minimum yield (160.85g) was obtained on T4 (sugarcane bagasse) as shown in Figure 1.

Table 1 showed that in first flush maximum yield (93.20±1.64 g) was on obtained on T1 (cotton waste), while minimum (58.43±1.03 g) was obtained on T4, similarly in 2nd and third flush maxim yields (78±1.37 g, 54±0.95 g) were obtained on cotton waste, while minimum was obtained on T4, while in 4th flush minimum yield was obtained on T3 and maximum was observed in T1 as shown in Table1.

Biological Efficiency (%): Figure 2 represents the significant variation for biological efficiency of *Pleurotussajor-caju* on different substrates. The highest biological efficiency (81.0%) of *Pleurotussajor-caju*was found on of T1 which was followed by T3 (60.78 %), T5 (54.73 %), T2 (54.24 %). The lowest biological efficiency (48.25 %) was obtained on T4 (sugarcane bagasse) as shown in Figure 2.

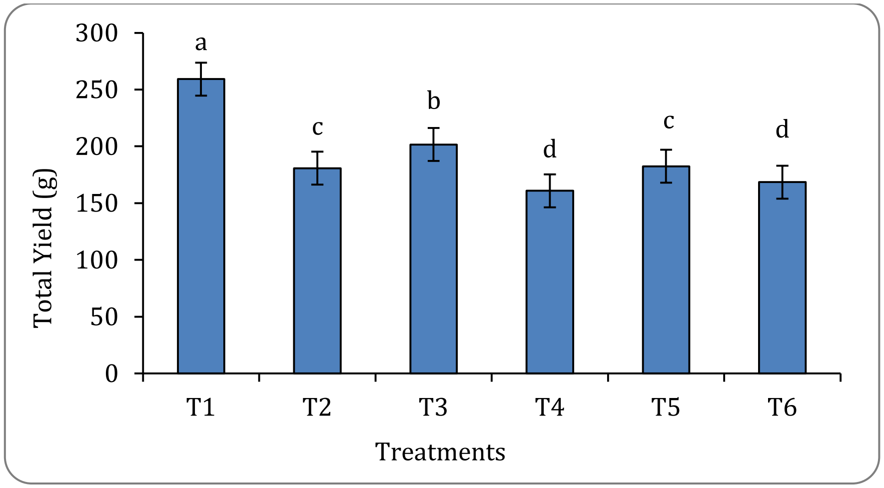

Figure 1. Effect of different substrates on the Total yield (g) of *Pleurotussajor-caju*. Values (%) are expressed as mean±standard error. Different letters indicate significant differences at P≤0.05.

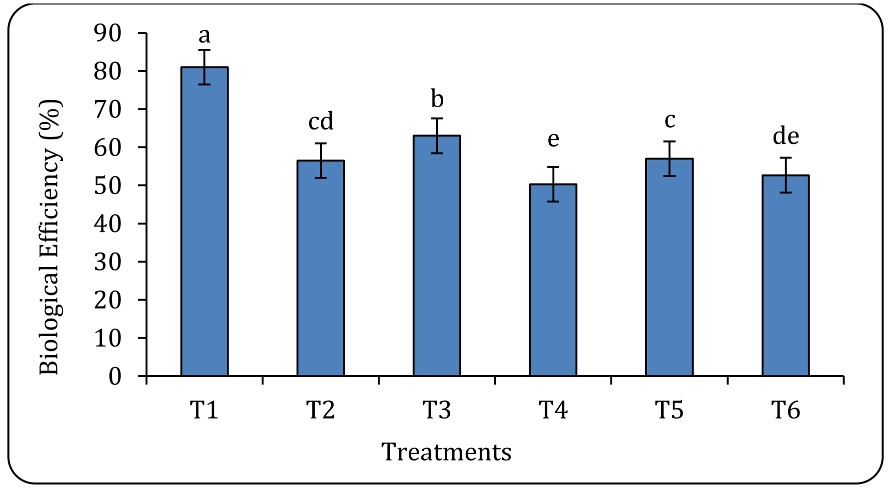

Figure 2.Effect of different substrates on the biological efficiency (%) of *Pleurotussajor-caju*. Values (%) are expressed as mean ±standard error. Different letters indicate significant differences at P≤0.05.

Table 1. Mushroom production quality characteristics for *Pleurotussajor-caju*on various substrates. Values are expressed as means ± standard error. Values with different small letters in the same column are significantly different at the level of 0.05.

Treatments	No. of days for completion of spawn running	Number of pin heads	Average No. of fruiting bodies	Pileus diameter (cm)	Stalk diameter (cm)	Stalk length (cm)	1st flush yield (g)	2nd Flush yield (g)	3rd flush yield (g)	4th flush yield (g)
T1	22.45±0.46c	35±0.61a	19.75±0.34a	6.90±0.12a	1.34±0.02d	2.64±0.04de	93.20±1.64a	78±1.37a	54±0.95a	34±0.6a
T2	24.96±0.48ab	26±0.45cd	16.57±0.29b	6.45±0.11b	1.14±0.02e	2.55±0.04e	74±1.30b	57±1.00bc	31.20±0.55e	18.60±0.32d
T3	24.80±0.48b	29±0.51b	16.41±0.28b	6.15±0.10b	2.10±0.03b	2.98±0.05ab	78.70±1.17c	59.5±1.05b	51.40±0.90b	12±0.21f
T4	26.22±0.37a	22.01±0.38e	14.76±0.26d	4.10±0.07 c	1.05±0.01f	2.87±0.05bc	58.43±1.03e	47.21±0.83e	35.00±0.61d	20.21±0.35c
T5	25.01±0.36ab	27.0±0.47c	15.87±0.28bc	6.21±0.10b	1.80±0.03c	2.77±0.04cd	63.12±1.11d	55.32±0.97c	40.87±0.72c	23.14±0.40b
T6	25.98±0.37ab	25.0±0.44d	15.00±0.26cd	6.14±0.10b	2.50±0.04a	3.11±0.05a	60.54±1.06de	51.56±0.90d	41.11±0.72c	15.32±0.27e

DISCUSSION

Our present study clearly indicates that cotton waste was the most effective to complete mycelial growth of *Pleurotussajor-caju*in minimum time. Similar findings were also reported by Samuel and Eugene (2012) and Ali *et al*., (2012). Mandeel*et al*., (2005) observed 2-4 weeks for the completion of spawn running of *Pleurotussajor-caju* on different substrates. While, Iqbal *et al.,* (2005) found 30.3 and 32.3 days for the completion of spawn running of *Pleurotussajor-caju* on cotton waste and corn cobs respectively. Mycelial growth is a primary step that creates appropriate internal environments for fruiting. Thus, outstanding growth of mycelium is a vibrant feature in mushroom cultivation (Sharma *et al.,* 2013). Fastest mycelial growth was noted on cotton waste substrate might be due to its higher nitrogen, C: N and cellulose contents as compared to other treatments as reported. Increase in number of days for spawn running on lignocellulosic waste materials might be due to slow hyphal growth of mushroom on substrates (Mandeel *et al*., 2005).

In the present study maximum pin heads was found on cotton waste Similarly, Khan *et al.,* (2013) observed 11.80-30.80 pinheads of *Pleurotus ostreatus* cultivated on cotton waste substrate. Narain *et al.,* (2008) reported that mushroom primordial development is dependent on the ligno-cellulosic materials especially the C: N ratio. While, Khan *et al.,* (2011) observed 27-30 number of fruit bodies of *Pleurotus ostreatus* on cotton waste substrate. Maximum number of fruit bodies increases the yield of the mushroom.

Among mushroom quality characteristics pileus diameter, stalk length, stalk diameter are very important attributes (Mondal *et al*., 2010). In this study maximum diameter of pileus was found on cotton waste Samuel and Eugene (2012) observed 2.89-5.69 cm pileus diameter of *Pleurotus ostreatus* on different substrates. Higher diameter of pileus on cotton waste might be due to the presence of adequate nutrient in the substrates. Since this is a yield attributing factor, the higher the diameter of the pileus the more the yield may increase. However, AMGA (2004) listed temperature, relative humidity, fresh air and compact material as the major ecological factors affecting stalk height, stalk diameter and cap size in mushrooms.

As far as stalk length of *Pleurotussajor-caju*is concerned our results are in consistence with the findings of Samuel and Eugene (2012) who observed 1.91- 3.90 cm stalk length of *Pleurotusostreatus* on different substrates. Similar findings were also observed by Mane *et al.,* (2007). Oyster mushroom quality depends on the length of stalk Mondal *et al*., (2010) found out that the higher the stalk length, the poorer the quality of the mushroom. Growers should use substrates that do not promote excessive growth of stalk length at the expense of marketable yield.

As far as total yield is concerned our results are in agreement with the studies of yield Mandeel *et al.,* (2005) recorded 158.9 to 264.1 g total yield of *Pleurotussajor-caju*on different substrates. The significant differences were observed in mushroom yields among different flushes produced by various substrates. The most of the total yields were produced during the first flush, while the fruit bodies obtained in the second, third and fourth flushes produced smaller amount of mushrooms.as the number of flushes increased the yield from each flush on all substrates decreased. Yield increases may be due to the increased level of nutrient available at higher rates would provide more energy for mycelial growth and primordial formation. Higher yield on cotton waste substrate is probably due to higher degradation, easier way of getting sugars from the cellulosic substances (Sharma *et al.,* 2013).

Higher the biological efficiency of substrate represents its higher suitability for the cultivation of mushroom. Mandeel *et al*., (2005) observed 47-78% B.E of *Pleurotussajor-caju*on different substrates. Substrates rich in usable nitrogen after spawn run may be a factor in enhancing bioconversion efficiency of mushrooms (Mandeel *et al*., 2005).

CONCLUSION

In view of the above, it can be concluded that yield contributing characteristics, and biological efficiency on cotton waste substrate was maximum, although combination of cotton waste with other waste materials like corn cobs and sugarcane bagasse can also be used for the production of the above findings suggest an opportunity for commercial cultivation of *P. sajor-caju*on various agro-industrial wastes and their combinations however; cotton waste is the most suitable substrate for such cultivation.

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REFERENCES

Adebayo, E.A., J.K. Oloke, M.A. Azeez, I.O. Omomowo and T.C. Bora, 2014.Assessment of the genetic diversity among ten genotypes of *Pleurotus* (oyster mushroom) using nutrient and mineral compositions.Scientia Hortic. 166: 59-64.

Ali, M.A., J. Ashraf, N.A. Khan and A. Rehman. 2012. Amendment of cotton waste with different waste materials of sugarcane industry for mycelial growth and fructification of oyster mushroom. Pak. J. Phytopathol. 24: 06-10.

Ali, M.A., M.I. Mehmood, R. Nawaz, M.A. Hanif and R. Wasim. 2007. Influence of substrate pasteurization methods on the yield of oyster mushroom (*Pleurotus species*). Pak. J. Agric. Sci. 44: 300-303.

AMGA. 2004. The Australian Mushroom Growers Association (AMGA), Locked Bag 3, 2 Forbes St, Windsor, NSW. Australia. p. 2756.

Arshad, M. and S. Ahmed. 2016. Cogeneration through bagasse: A renewable strategy to meet the future energy needs. Renew. Sustainable Energy Rev. 54: 732-737.

Dehariya, P. and D. Vyas. 2015. Evaluation of different spawns and substrates on growth and yield of *Pleurotussajor-caju*. Int. J. Recent Sci. Res. 6: 2908-2911.

Dundar, A. and A. Yildiz. 2009. A comparative study on *Pleurotusostreatus* (Jacq.) *P. kumm*.cultivated on different agricultural lignocellulosic wastes. Turk. J. Biol. 33: 171-179.

Eswaran, A., and R. Ramabadran. 2000. Studies on some physiological, cultural and postharvest aspects of oyster mushroom, *Pleurotuseous (Berk.) sacc*. Trop. Agric. Res. 12: 360-374.

Haleem, N., M. Arshad, M. Shahid and M. A. Tahir. 2014. Synthesis of carboxymethyl cellulose from waste of cotton ginning industry. CarbohydrPolym. 113: 249-255.

Ingale, A. and A. Ramteke. 2010. Studies on cultivation and biological efficiency of mushrooms grown on different agro-residues. Innovative Romanian Food Biotechnol. 6: 25.

Iqbal, S.H.M., CH. A. Rauf and M.I. Sheikh. 2005. Yield Performance of Oyster Mushroom on Different Substrates. Int. J. Agri. Biol. 7: 900-903.

Khan, M. W., M. A. Ali, N. A. Khan, M. A. Khan, A. Rehman and N. Javed. 2013. Effect of different levels of lime and pH on mycelial growth and production efficiency of oyster mushroom (*Pleurotus spp.*). Pak. J. Bot. 45: 297-302.

Khan, M.W., M. Ali and M. Farooq. 2011. Growth response of oyster mushroom (*PleurotusOstreatus*) by using different methods of spawning raised on cotton waste. Pak. J. Phytopathol. 23:156-158.

Mandeel Q.A., A.A. Al-Laith and S.A. Mohamed. 2005. Cultivation of oyster mushrooms (*Pleurotus* spp.) on various lignocellulosic wastes. World. J. Microbiol. Biotech. 21:601-607.

Mane, V.P., S.S. Patil, A.A. Syed and M.M.V. Baig. 2007. Bioconversion of low quality lignocellulosic agricultural waste into edible protein by *Pleurotussajor-caju* (Fr.) Singer. Journal of Zhejiang University Science B. 10: 745-751.

Miles, P.G. and S.T. Chang. 2004. Mushrooms: cultivation, nutritional value, medicinal effect, and environmental impact. CRC press. New York.

Mondal, S.R., M.J. Rehana, M.S. Noman and S.K. Adhikary 2010. Comparative study on growth and yield performance of oyster mushroom (*Pleurotusflorida*) on different substrates Agro technology Discipline, Khulna University, Khulna-9208, Bangladesh.

Naeem, M.S., M.A. Ali, S. Ali, H. Sardar, R. Liaqat and M. Shafiq. 2014. Growth and yield performance of oyster mushroom on different substrates. Mycopath. 12: 9-15

Narain, R., R.K. Sahu, S. Kumar, S.K. Garg, C.S. Singh and R.S. Kanaujia. 2008. Influence of different nitrogen rich supplements during cultivation of *Pleurotusflorida* on maize cobs substrate. Environmentalist. 29: 1-7.

Patil, S.S. 2012. Cultivation of *Pleurotussajor-caju* on different agro wastes. Sci. Res. Reporter. 2: 225-228.

Russell, D.F. 1986. MSTAT-C package programme.Crop and Soil Science Department, Michigan State University, USA.

Samuel, A.A., and T.L. Eugene, "Growth Performance and Yield of Oyster Mushroom (*PleurotusOstreatus*) on Different Substrates Composition in Buea South West Cameroon" Sci. J. Biochem. 6.

Sharma, S., R.K.P. Yadav, C.P. Pokhrel. 2013. Growth and Yield of Oyster mushroom (*Pleurotusostreatus*) on different substrates. J. New Biological Reports. 2: 03-08.

Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and Procedures of Statistics: A Biometrical Approach.3rd ed. McGraw Hill Book Co., New York.