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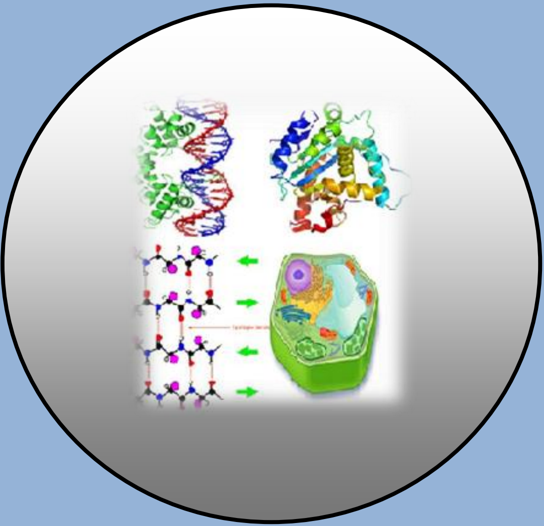

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Efficiency of Different Concentrations of Water Hyacinth (*Eichhornia crassipes* (Mart.) Solms.) and Sawdust as Substrate for the Cultivation of *Pleurotus ostreatus* (Jacq. Ex. Fr.) Kummer (Oyster Mushroom)

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ABSTRACT

The suitability of slender and bulbous water hyacinth (Eichhornia crassipes (Mart.) Solms) a noxious weed and saw dust as either main substrate or in combination of different concentrations for production of Pleurotus ostreatus (Jacq. Ex. Fr.) Kummer were evaluated. The substrates affected P ostreatus production differently but the effect of slender and bulbous water hyacinth on production were not significantly different from each other. The substrates with 50:50 mixture of slender water hyacinth +saw dust and 50:50 mixture of bulbous water hyacinth + saw dust had highest number of fruiting bodies 39.99 and 38. 84 and total yield 117.0g and 114.3g respectively. Compact saw dust produced the least number of fruiting bodies (23.01) and yield (65.01g). The physical nature of 50:50 mixture of slender water hyacinth + saw dust and 50:50 mixture of bulbous water hyacinth + saw dust and their available nutrients resulted in high biological efficiency and production efficiency and also good quality P. ostreatus mushroom with wide pileus 7.47cm and 7.63cm and short stipe length 4.60cm and 4.31cm respectively. The utilization of this noxious weed for mushroom cultivation and production is a value added process that seeks its advantageous use.
Keywords: Pleurotus ostreatus, Water Hyacinth, Biological Efficiency, Yield and Good Quality Mushroom.

INTRODUCTION

Water hyacinth (*Eichhorniae crassipes* (Mart.) Solms) is one of the fastest growing plants on earth. Originating in the upper Amazon, it has now spread to at least 50 countries around the world in the tropical and sub-tropical regions including Nigeria (**Ong Khong Seng et al.**

1982). Water hyacinth first appeared on the waters of the south-western part of Nigeria in 1984 through the Republic of Benin (**Akinyemiju 1987**). Since then, the weed has invaded over 60% of Nigeria's fresh and brackish coastal waters including the Benin and Escravos River networks that are major operational areas for petroleum companies (**Farri and Boroffice 1999**). The weed threatens fishing and causes 50% loss of fish catch in Nigeria (**Farri and Boroffice 1999**). Slender water hyacinth and the bulbous water hyacinth are found in every infested water body in Nigeria. The Federal government of Nigeria through the National Agency for Science and Engineering Infrastructure (NASENI) attempted to control this weed through physical removal and herbicides application, but recognized that these methods were not sustainable due to high cost and negative effects of herbicides on human, fish and water. In 1994, 3.5M naira (US$23,333) were spent on the physical clearing of the River Niger upstream of the Kainji lake, and on the average US$5000 was spent on the manual removal from just one hectare of infested area (**Farri and Boroffice 1999**).
Mushroom is a non-traditional horticultural crop having high quality protein, high fibre value, vitamins and minerals (**Narayanasamy *et al*. 2009**). Cultivation of edible mushroom is a biotechnology process, which aids in reducing and equally protecting the environment from excess solid waste (**Mshandete and Cuff 2008; Sánchez 2010; Idowu and Kadiri, 2013**). Water hyacinth is being used as supplementary substrate for mushroom production in some African countries such as Zimbabwe and Tanzania. **Tagwira *et al*.** (**1998**) reported that an addition of 10% water hyacinth supplement to a substrate of saw dust and groundnut shells increased oyster mushroom production by 250% and 221% respectively. This prolific aquatic weed has been shown to be a more viable substrate for mushroom cultivation than rice straw (**Murugesan et al. 1995**). **Kivaisi *et al***. (**2004**) used this weed to cultivate a domesticated strain (*Pleurotus flabellatus*) in Tanzania at two places with different temperature and relative humidity regimes. The use of water hyacinth for mushroom cultivation could be a cost effective way of controlling it while at the same time producing protein rich food. This study was however undertaken to determine the suitability of a combination of slender water hyacinth, bulbous water hyacinth and sawdust for the cultivation of *Pleurotus ostreatus* in Nigeria.

MATERIAL AND METHODS

These experiments were conducted during 2012 in the Mushroom Unit of the National Horticultural Research Institute, Ibadan, Nigeria. Two types of water hyacinth (*Eichhornia crassipes*) (slender and bulbous) were harvested at Epe lagoon (N06^{0}34′ 13.753″, E003^{0}59′ 21.273″) in Lagos State while sawdust was collected at the Forestry Research Institute, Ibadan, Nigeria (FRIN). The experiment was laid out in a completely randomized design with 3 replicates. The 9 treatments (substrates) consisted of bulbous water hyacinth alone, slender water hyacinth alone, sawdust alone, 75% bulbous water hyacinth + 25% sawdust, 50% bulbous water hyacinth + 50% sawdust, 25% bulbous water hyacinth + 75% sawdust, 75% slender water hyacinth + 25% sawdust, 50% slender water hyacinth + 50% sawdust, 25% slender water hyacinth + 75% sawdust.

Substrate Preparation

The roots of the harvested water hyacinth were removed and the water hyacinth shoots (WHS) were dried in the sun for 7days. The dry WHS were chopped into pieces of 3-5 cm long.

The chopped WHS and sawdust were separately moistened with water and left overnight to allow for moisture absorption. Water hyacinth was mixed at 25%, 50% and 75% with sawdust as listed treatments. 300g of each of the treatments were weighed and packed into heat resistant polyethylene bags. The open end was made into neck prepared by using heat resistant PVC (Poly Vinyl Chloride) tube (2.5cm diameter) and covered with a cotton plug. The packed bags were sterilized in an autoclave at 121^{o}C for 30 minutes and allowed to cool to room temperature.

Spawning and Spawn run

Two-week-old actively growing mushroom mycelium (spawn) was introduced through the neck into the sterilized bags according to the method of **Quimio *et al.*** (**1990**). Inoculated bags were placed in the incubation room for four weeks to allow for the mushroom mycelium to permeate the substrate bags. The spawn running period ended when the substrate was sufficiently colonized by the mushroom mycelium.

Cropping and Harvesting

The bags were later transferred to the cropping room (temperature 28-30^{o}C, relative humidity of 79–92%) and sprinkled with water, when necessary, to maintain the cropping condition. The induction of fruiting condition caused the formation of primordial (mushroom initials) which grew into mushroom fruiting bodies. The mushrooms were harvested when the caps were fully opened by grasping the basidiocarp by the stalk followed by gentle twisting and pulling them off the substrate (**Quimio *et al.* 1990**). The harvested fruiting bodies were weighed

Data collection and statistical analyses

Data collected were days to substrate colonization and primodial initiation, , number of fruits, width of pileus, length of stipe, total fruiting body weight, mean fruit weight, biological and production efficiencies.

The mean fruit weight, production and biological efficiency were calculated as follows:

i. Mean fruit weight: total weight of fresh mushrooms harvested/ total number of mushrooms harvested.
ii. Biological efficiency (B.E. %) was determined at the end of the harvesting period as: fresh weight of mushrooms harvested divided by the dry weight of the original substrate, expressed as a percentage (**Miles and Chang 1997**).

$$\text{B.E.} = \frac{\text{Fresh weight of mushroom x 100\%}}{\text{Dry weight of substrate}}$$

iii. Production efficiency (P.E.): fresh weight of mushrooms harvested divided by weight of substrate before cropping expressed as a percentage.

$$\text{P.E.} = \frac{\text{Fresh weight of mushroom x 100\%}}{\text{Weight of substrate before cropping}}$$

Other data collected were number of fruits, fruit weight, width of pileus, length of stipe, days to full mycelia colonization, day to primodial initiation and extension per day. Data were subjected to analysis of variance. Significantly different treatment means were separated using Student Newman Keuls (SNK) (SAS, 2009) (*p=0.05*) and the least significant difference (LSD) with GENSTAT software (**GENSTAT, 2006**) (*p=0.05*).

RESULTS

The results of the day to full mycelia colonization on single substrate of slender or bulbous water hyacinth (*Eichhornia crassipes*) or saw dust or mixture of different concentration of water hyacinth and saw dust are not significantly different from each other. Also the days taken for primordial initiation after completion of mycelia growth was not significantly different from each of the treatments (Table 1).

The high number of fruitbodies of *Pleurotus ostreatus* produced by single substrates of slender water hyacinth (39.99) and bulbous water hyacinth (38.97) were not significantly different from each other however single substrate of saw dust produced the least number of fruiting bodies (23.01) (Table 2).

Across all the substrates, the maximum yield was obtained from 50:50 concentrations substrate of slender water hyacinth + saw dust (117.0g) and bulbous water hyacinth + saw dust (114.3g) whereas the minimum yield was obtained from single substrates of saw dust (65.01g). Although the single substrates of saw dust had the least numbers of fruiting bodies (23.01) and fruit weight (65.01g), however it recorded one of the highest mean fruit weight (2.84g) which is not significantly different from the fruit weight obtained on all the substrates of different concentrations (Table 2).

The widest pileus were recorded on substrates with different concentrations of slender water hyacinth + saw dust (50:50) (7.47 cm), slender water hyacinth + saw dust (25:75) (7.17 cm), bulbous water hyacinth + saw dust (50:50) (7.63 cm) and bulbous water hyacinth + saw dust (25:75) (7.11 cm) whereas the smallest pileus were recorded on single substrates of water hyacinth either slender (3.47 cm) or bulbous (3.21 cm) which were not significantly different from each other (Table 2).

The single substrate of saw dust recorded the longest stipe (5.17 cm) while substrates with slender water hyacinth + saw dust (75:25) and bulbous water hyacinth + saw dust (75:25) had the shortest stipe of 3.47 cm and 3.49 cm respectively (Table 2).

The BE and PE were affected by the different substrates on *P. ostreatus*. Substrates with slender water hyacinth + saw dust (50:50) and bulbous water hyacinth + saw dust (50:50) were observed to have the highest BE of 111.43% and 108.86% respectively (Fig. 1) and PE of 43.49% and 42.49% respectively (Table 2). Single substrate of saw dust yielded the lowest among all the substrates with BE of 61.91% (Fig. 1) and PE of 25.49% (Table 2).

DISCUSSION

The cultivation of edible mushroom *Pleurotus ostreatus* (Jacq. Ex. Fr.) Kummer, on water hyacinth and saw dust either as main substrate or in combination of different concentration is a value added process which converts an otherwise notorious aquatic weed and wood waste to economic benefit. The insignificant differences in the days to primordial initiation and days to full mycelia colonization of *P. ostreatus* on the single and mixed substrates could be that the lignin in all the substrates was sufficient for its mycelium development. **Xiujin *et al*.** (**2001**) observed that *Pleurotus* spp had greater capability to digest lignin and the degradation played an important role in the development of mycelium.

Mushroom substrate structure has been reported to be an important factor for the growth of the mycelium as it allows penetration of the mycelium, which ultimately influences fruiting of mushroom (**Tripathy *et al.* 2011**), also yield of mushroom is directly related to the spread of mycelium into the substrate (**Thomas *et al*. 1998**).

Consequently the lowest number of fruiting bodies and mushroom yield obtained on substrate of only saw dust could be due to its compactness which might have limited the mycelia penetration and effective utilization of the substrate for formation of fruiting bodies. This is in agreement with the report that the compactness of cotton waste and oil palm waste in the test tubes probably stimulated fermentation which eventually inhibited mycelial growth (**Ali and Khan 1981**). The highest yield of *P. ostreatus* obtained from 50:50 mixture of slender water hyacinth +saw dust and 50:50 mixture of bulbous water hyacinth + saw dust could be that their nitrogen composition was more adequate for the formation of fruit bodies. Also the water holding capacity and the rate of aeration were more appropriate which consequently resulted in widest pileus formation. Interactions between environmental factors and nutrients in mushroom growth substrate have been reported to play important role in inducing formation of the fruiting bodies which results in mushroom size variations (**Reyes *et al*. 2009; Kurtzman 2010**). The short stipe length and wide pileus *P. ostreatus* mushroom recorded on 50:50 mixture of slender water hyacinth +saw dust and 50:50 mixture of bulbous water hyacinth + saw dust qualified the harvested mushroom as good quality according to the report of **Zadrazil** (**1978**) which stated that the shorter the mushroom stipe, the higher the quality and vice versa.

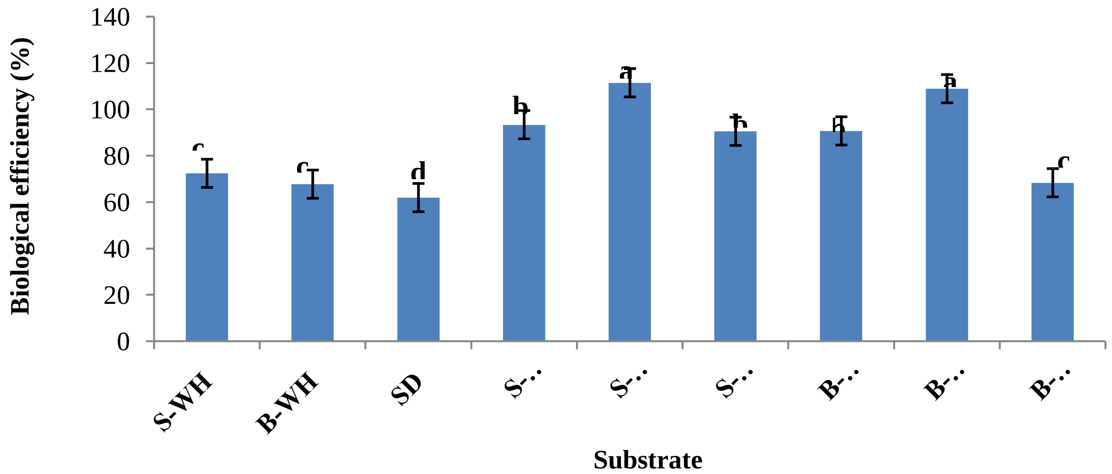

Fig 1. Biological efficiency of *Pleurotus ostreatus* on different ratios of water hyacinth h and sawdust substrates.

S-WH = Slender water hyacinth only, B-WH = Bulbous water hyacinth only, SD = Saw dust, S-3WH+1SD = Slender water hyacinth + sawdust (3:1), S-2WH+2SD = Slender water hyacinth + saw dust (2:2), S-1WH+3SD = Slender water hyacinth + saw dust (1:3), B-3WH+1SD = Bulbous water hyacinth + sawdust (3:1), B-2WH+2SD = Bulbous water hyacinth + saw dust (2:2) and B-1WH+3SD=Bulbous water hyacinth + saw dust (1:3).

The large sized fruit bodies are considered to be of good quality and rated highly in mushroom production, **Onyango *et al*.** (**2011**). The BE determines how mushroom utilizes nutrients present in the substrate efficiently. The composition of substrate used greatly influences the BE values obtained (**Chang Ho and Yee 1977; Chang and Miles 1982**).

The high BE and PE recorded on 50:50 mixture of slender water hyacinth + saw dust and 50:50 mixture of bulbous water hyacinth + saw dust could be related to the physical nature of the substrates and available nutrients which were suitable for formation of more number of heavy fruiting bodies with wide pileus and short stipe.

CONCLUSION

The use of water hyacinth and saw dust either as main substrate or in combination of different concentrations as substrates had varied effect on *P. ostreatus* production although the effects of the 2 types of water hyacinth were not significantly different from each other. The 50:50 mixture of slender water hyacinth +saw dust and 50:50 mixture of bulbous water hyacinth + saw dust had greatest influence on number of fruiting bodies and total yield. The physical nature of these substrates and their available nutrients were suitable for high BE and production of good quality *P. ostreatus* mushroom with short stipe length and wide pileus. The utilization of this noxious weed is a value added process that seeks to reduce its negative effects on water ways.

Table 1. Mushroom growth on different ratios of water hyacinth and sawdust substrates.

Substrates	Days to full mycelia colonization	Days to primordial initiation	Mean extension/ day (cm)
Slender WH only	28.67	26.00	1.20
Bulbous WH only	28.44	26 00	1.20
Sawdust only	28.00	25.00	1.20
Slender 3WH+1SD	28.00	24.67	1.20
Slender 2WH+2SD	28.00	25.00	1.20
Slender 1WH+3SD	28.33	26.00	1.20
Bulbous 3WH+1SD	28.00	25.71	1.20
Bulbous 2WH+2SD	28.00	24.80	1.20
Bulbous 1WH+3SD	28.39	25.93	1.20
$LSD_{0.05}$	2.49	2.21	0.00

Means with the same letters along column are not significantly different from one another (SNK at p ≤0.05)
WH = Water hyacinth, SD = Sawdust

Table 2. Mushroom yield on different ratios of water hyacinth and sawdust substrates

Substrates	NF	FW (g)	Mean FW (g)	Width of pileus (cm)	Length of stipe (cm)	Production Efficiency (%)
Slender WH only	39.99 a	75.99 c	1.90 b	3.47 d	4.27 b	30.15 c
Bulbous WH only	38.97 a	74.88 c	1.92 b	3.21 d	4.29 b	29.71 c
Sawdust only	23.01 c	65.01 d	2.84 a	4.80 c	5.17 a	25.44 d
Slender 3WH+1SD	32.76 b	98.01 b	2.99 a	5.40 b	3.47 c	35.77 b
Slender 2WH+2SD	39.99 a	117.0 a	2.93 a	7.47 a	4.60 b	43.49 a
Slender 1WH+3SD	38.01 a	95.01 b	2.50 a	7.17 a	4.47 b	35.45 b
Bulbous 3WH+1SD	33.75 b	95.19 b	2.82 a	5.28 b	3.49 c	34.74 b
Bulbous 2WH+2SD	39.84 a	114.30 a	2.87 a	7.63 a	4.31 b	42.49 a
Bulbous 1WH+3SD	33.87 b	71.73 c	2.56 a	7.11 a	4.37 b	26.78 d

Means with the same letters along column are not significantly different from one another (SNK at p ≤0.05)
NF = Number of fruits, FW = Fruits Weight, WH = Water hyacinth, SD = Sawdust

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REFERENCES

Akinyemiju, O.A. 1987. Invasion of Nigeria water by water hyacinth. *J. Aquat. Plant Manage*. 25:24-26.

Ali, M.A., Khan, S.M. 1981. Progress and prospects of paddy straw mushroom cultivation in Pakistan. Mushroom Sci 11:83-88

Chang-Ho, Y., Yee, N.T. 1977. Comparative study of the physiology of *Volvariella volvacea* and *Coprinus cinereus*. *T Brit Mycol Soc.* 68:167-72

Chang, S.T., Miles, P.G. 1982. Introduction to mushroom science. In: Chang ST, Quimio TH (eds). Tropical mushrooms: biological nature and cultivation methods. Hong Kong: Chinese University Press, pp. 3-10

Farri, T.A., Boroffice, R.A. 1999. An overview on the status and control of water hyacinth in Nigeria. In: Hill MP, Julien MH, Center TD (eds) Proceedings of the 1st IOBC Water Hyacinth Working Group, Harare, November 1998, pp 18-24

Genstat. 2006. Genstat. 5 release 3:2 Lawes Agricultural Trust, Rothamsted Experimental Station, Oxford, United Kingdom

Idowu O.O**.** Kadiri, M. 2013. Growth, yield and nutritional quality of *Pleurotus tuberregium* (Fries) singh grown on sawdust of different wood types from South-Western Nigeria. J. Biol. Chem. Res. Vol. 30(2) 764-775.Kivaisi, A.K., Magingo, F.S.S., Mamiro, B. 2004. Performance of *Pleurotus flabellatus* on water hyacinth (*Eichhornia crassipes)* shoots at two different temperature and relative humidity regimes. *Tanzania J Sci*. 29(2):11-17.

Kurtzman, R.H. 2010. Ventilation for mushroom cultivation: the importance of the needs of mushrooms and of the gas laws. *Micol Apl Int.* 22(2):63-78

Miles, P.G., Chang, S.T. 1997. Mushroom biology. World Scientific Press, Hong Kong, pp 1-96

Murugesan, A.G., Vijayalakshmi, G.S., Sukumaran, N., Marianppan, C. 1995. Short communication. Utilization of water hyacinth for oyster mushroom cultivation. Bioresource Technol 51:97-98

Mshandete, A.M., Cuff, J. 2008. Cultivation of three types of indigenous wild edible mushrooms: *Coprinus cinereus, Pleurotus flabellatus* and *Volvariella volvocea* on composted sisal decortications residue in Tanzania. Afr. J. Biotechnol 7(24):4551-4562.

Narayanasamy, P., Suganthavel, P., Sabari, P., Divya, J., Vanchinathan, M. 2008. Cultivation of mushroom (*Pleurotus florida*) by using two different agricultural wastes in laboratory condition. *The Internet J Microbiol* 7 number 2. doi 10.5580/ 2324.

Ong Khong Seng, Yeoh Bee, Qhin Abbas Bin Mohd Salleh (1982). Management and control of water hyacinth in Malaysia. Report of the Regional Workshop on Biological control of water hyacinth. Bangalore, India. pp 45-48.

Onyango, B.O., Palapala, V.A., Arama, P.F., Wagai, S.O., Gichimu, B.M. 2011. Suitability of selected supplemented substrates for cultivation of Kenyan native wood ear mushrooms (*Auricularia auricula*). *Am J Food Technol* 6:395–403

Quimio, T.H., Chang, S.T., Royse, D.J. 1990. Technical guidelines for mushroom growing in the tropics. FAO Plant Production and Protection Paper 106, pp 160-170

Reyes, R.G., Lopez, L.L.M.A., Kumakura, K., Kalaw, S.P., Kikukawa, T.E.F. 2009. *Coprinus comatus*, a newly domesticated wild nutriceutical mushroom in the Philippines. *J. Agric. Technol*. 5(2):99-316

Sánchez, C. 2010. Cultivation of *Pleurotus ostreatus* and other edible mushrooms. *Appl. Microbiol*. Biotechnol. 85(5):1321-1337

SAS Institute. 2009. SAS User's Guide: Statistics. SAS Institute, Inc., Cary, NC

Tagwira, A., Mphuru, A., Chang, S.T., Mswaka, A., Pauli, G., Mshigeni, K. 1998. Effect of supplementing substrates with water hyacinth for mushroom production. http://www.zeri.org/news/1998/november/nov98. htm, ZeriNews letter, November 1998

Thomas, G.V., Prabhu, S.R., Reeny, M.Z. Bopaiah, B.M. 1998. Evaluation of lignocellulosic biomass from coconut palm as substrate for cultivation of Pleurotus sajor-caju (Fr.) Singer. *World J for Microbiol and Biotechnol* 14:879-882

Tripathy, A., Sahoo, T.K., Begera, S.R. 2011. Yield evaluation of paddy straw mushrooms (*Volvoriella spp*.) on various lignocellulosic wastes. Bot Res Inter 4(2) 19-24

Xiujin, L., Yunzhi, P., Ruihong, Z. 2001. Compositional changes in microstructural changes of cotton seed hull substrate during *Pleurotus ostreatus* growth and the effects on feed value of the spent substrate. *Tran CSAE* 17:96-100.

Zadrazil, F. 1978. Cultivation of *Pleurotus*. The biology and cultivation of edible mushrooms by S.T. Chang and W.A. Hayes (eds). Academic press INC. Orlando, Florida, pp1-62.

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