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COMPARATIVE STUDY ON THE GROWTH RATE OF EXOTIC AND LOCAL STRAINS OF *VOLVARIELLA VOLVACEA* ON DIFFERENT SUBSTRATES

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ABSTRACT

High cost of animal protein and shortage in availability is deteriorating the quality of health and increasing environmental pollution. The continuous accumulation of organic waste materials is becoming a potential source of environmental pollution. Edible fungi are nature's recycler, which can convert lignocellulosic wastes into protein rich food. This mushroom can be successfully cultivated on several crop residues, certain agricultural and industrial wastes. Five different wild and exotic strains including Vvpk a local strain and Vv436, Vv428, Vv430, Vv422; exotic strains were evaluated for their productivity on the six different crop residues including cotton waste, paddy straw, banana leaves, sugarcane baggase, corn stovers and pulses straw as substrates under different humidity and temperatures. Cotton waste was proved to be the best substrate by producing highest yield followed by paddy straw and banana leaves. The mushroom obtained from cotton waste was of high quality. We may imply that these agricultural waste materials may successfully be used for the production of high quality protein in arid and semi-arid environment, and the hazardous effects of these materials on human health and environmental quality may also be reduced.

Keywords: Agricultural wastes; environmental pollution; mushroom; protein; yield

INTRODUCTION

The advancement in the agricultural technology has to pace with the food production for increasing population of the world and to recycle the agricultural wastes without creating environmental pollution. This is a big challenge for the agricultural scientific community to grow more food by utilizing the waste materials. The cheapest and effective way to convert these wastes in to edible protein is mushroom cultivation (Chang, 1991). Edible fungi are nature's recycler, which can convert lignocellulosic wastes in to protein rich food. Edible mushroom cultivation is one of the most economically viable processes for the bioconversion of many types of lignocellulosic wastes (Buswell *et al.*, 1996). Mushroom

cultivation is a direct utilization of their ecological role in the recycling of industrial and agricultural solid wastes into edible protein, which could be a functional food or a source of drugs and pharmaceuticals. Spent mushroom compost, generated from the mushroom industry, could be exploited as a soil fertilizer and as a bioremediating agent (Chiu *et al.*, 2000).

Currently, millions of tons of agricultural wastes are discarded, burned, neglected and has become a burden because of the destruction and by creating environmental pollution. Waste materials from farms, plantations or factories are used as substrates for the cultivation of the mushrooms. Agro-wastes, produced in abundance in the tropics are cotton waste, sugarcane bagasse, sisal bagasse wheat and rice straw, rice bran, corncobs, bracts of pineapple crown, oil palm waste, grass, sawdust, coffee pulp, coffee bran, coconut fiber water hyacinth plants, Banana leaves coconut husks, orange peel and wood logs mostly are the examples of organic waste used as substrates. Otherwise all these materials are useless by-products. (Salmones *et al.*, 1996; Bhawna and Thomas,

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2003). Mushrooms have been widely utilized as food and have many health giving properties. Mushrooms are rich source of protein, vitamins including water soluble vitamins, riboflavin, biotin and thiamine, fats, carbohydrates, amino acids including all essential amino acids and essential minerals (Chang and Buswell, 1996; Jiskani, 2001; Buigut, 2002). These are low in fat, carbohydrates and salts (Genders, 1990). Dietary fibers are present in sufficient amount and play an important role for the regulation of digestive tract (Manzi *et al.*, 2001). The edible mushrooms possess unique characteristics in terms of color, taste, aroma and texture, which make them attractive for human consumption (Chang and Miles, 1991). In Pakistan the awareness of mushroom has increased to great extent for the last few years. Among the various mushrooms cultivated in the country, *Volvariella volvacea* (Chinese mushroom) holds a good promise because most areas of the country are tropical and sub tropical and therefore more suitable for the cultivation of Chinese mushroom. This mushroom can be successfully cultivated on several crop residues like paddy straw cotton waste wheat straw and sugarcane industrial waste (Khan *et al.*, 1982).

Considering the importance of mushroom as a good source of protein and its role in degrading the wastes, especially the agricultural residues, this study was conducted to evaluate different wild and exotic strains for their productivity on different crop residues.

MATERIAL AND METHODS

Collection and identification of *Volvariella volvacea*: Fruiting bodies of *V. volvacea* strain *Vvpk* (Pakistan) were collected from the botanical garden of University of Agriculture, Faisalabad, Pakistan. The exotic cultures of four exotic strains *Vv436* (Malaysia), *Vv422* (Philippines), *Vv428* (Hong Kong) and *Vv430* (Taiwan) were imported from mushroom spawn laboratory of Pennsylvania State University, America. Identification of mushroom *V. volvacea* was done by using the methods of Zoberi (1972) and Oso (1975). The mycelium of the five strains including local and exotic of *V. volvacea* was obtained and cultures were maintained on PDA by regular sub culturing during the period of investigation.

Production of spawn: The spawn of five different strains of *V. volvacea* was produced separately by using cotton waste, calcium carbonate and water in the ratio of 32:2:66, respectively, as described by Chang and Miles (2004).

Substrates preparation: Cotton waste, a byproduct of textile mills was collected from industrial area. Paddy straw, lentil straw, corn stovers, Banana leaves and

sugarcane baggase were collected from research area of university of Agriculture, Faisalabad, Pakistan. All these agro-wastes except cotton waste were chopped into small pieces with the help of fodder cutter. These chopped agro-wastes and cotton waste were soaked in to water for 24 hours and then placed on cemented floor, to remove the excessive water from the wastes to keep the moisture up to 70%. Banana leaves were also chopped with help of fodder cutter. These chopped leaves were soaked in water for 4 hours and then drained later. Lime was mixed @ 5% to each substrate on dry weight basis. Later on these substrates were covered with polythene for four days for fermentation. Then five beds were made of each substrate and each bed was of 3 kg weight on dry weight basis of the substrate.

Spawning: The seven days old, prepared spawn of each strain was inoculated on all the substrates. Five replications were made of each substrate and each replication was of 3 kg, of agro-waste on dry weight basis. Gram flour was dusted on each layer of the beds to provide the instant energy to fungus for growth. Each bed was again covered with polythene sheath from all sides till the completion of spawn running.

Regulation of temperature, humidity and light: The temperature and humidity are two critical factors for the spawn running and fructification of the mushroom and were maintained by wetting the flour, thrice in a day. Slight watering was done before the appearance of first fruiting bodies. After this beds were just kept moist by watering

Comparison of the mushroom growth on different substrates: Growth of five different strains of Chinese mushroom (*V. volvacea*) was compared on six substrates i.e., cotton wastes, paddy straw sugarcane baggase, banana leaves, corn stovers and lentil straw. The comparison among the substrates was made by calculating the average yield obtained from each substrate.

Statistical Analysis: Analysis of variance techniques (ANOVA) were applied to analyze the data (Steel *et al.*, 1997) using completely randomized design and means were compared by Duncan's Multiple Range Test (Duncan, 1955).

RESULTS

The data for the effect of the substrates on 100% spawn running (Table 1) showed that maximum time was taken by the strains for 100% spawn running (5.50 days), both on pulses straw and corn stovers, and slowest spawn running was on these substrates, while minimum time was taken for 100% spawn running on cotton waste by all the strains

followed by the paddy straw (5 days), sugarcane baggase (5.18 days) and banana leaves (5.30 days). This difference of time was non-significant between the corn stovers and pulses straw but the difference was significant among the other substrates.

Table 1. Effect of substrates on 100% spawn running of the strains

Treatment	Strains					Mean (Crop x Treat)
	Days					
	Vv(PK)	Vv436	Vv428	Vv430	Vv422	
Cotton waste	4.20±0.133	4.40±0.163	4.80±0.133	5.30±0.153	5.70±0.153	4.88±0.102 D
Paddy straw	4.40±0.163	4.50±0.167	4.70±0.153	5.70±0.153	5.90±0.100	5.04±0.111 CD
Banana Leaves	4.80±0.249	4.80±0.291	4.70±0.213	5.70±0.213	6.50±0.167	5.30±0.141 AB
Corn stovers	5.00±0.211	4.80±0.200	5.40±0.163	5.60±0.163	6.20±0.133	5.40±0.103 A
Sugarcane baggase	4.70±0.153	4.60±0.163	4.80±0.133	5.50±0.167	6.30±0.153	5.18±0.113 BC
Pulses straw	4.80±0.133	5.20±0.133	5.60±0.163	5.60±0.163	6.30±0.153	5.50±0.096 A
LSD						0.20

Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05).

The (Table 2) showed that minimum time taken for pinhead formation was taken on cotton waste (3.02 days) and corn stovers (3.16 days) as compared to the other substrates used for the cultivation. Among the substrates the cotton waste and corn stovers promoted the pinhead formation of the mushroom as compared to the other substrates. The difference of time for pinhead formation by the strains on banana leaves, pulses straw, sugarcane baggase and paddy straw was found to be non significant and this time difference was also non significant between the cotton waste and corn stovers.

Table 2. Effect of substrates on the pinhead formation of strains of *V.volvacea*

Treatment	Strains					Mean (Crop x Treat)
	Days					
	Vv(PK)	Vv436	Vv428	Vv430	Vv422	
Cotton waste	2.50±0.167 g	2.70±0.153 fg	2.80±0.133 fg	3.30±0.153 be	3.80±0.133 ab	3.02±0.093 B*
Paddy straw	2.70±0.153 fg	3.30±0.153 be	3.30±0.153 b-e	3.50±0.167 ad	4.00±0.000 a	3.36±0.085 A
Banana Leaves	2.80±0.133 eg	3.70±0.153 abc	3.70±0.153 abc	3.70±0.153 abc	3.50±0.167 ad	3.48±0.082 A
Corn stovers	2.90±0.100 efg	2.80±0.133 fg	2.70±0.213 fg	3.50±0.167 a-d	3.90±0.100 aa	3.16±0.092 B
Sugarcane baggase	3.20±0.200 cf	3.50±0.167 ad	3.50±0.167 a-d	3.70±0.153 abc	3.60±0.163 ae	3.50±0.077 A
Pulses straw	3.10±0.100 def	2.80±0.200 fg	3.70±0.153 abc	3.70±0.153 abc	3.80±0.133 ab	3.42±0.086 A
LSD						0.19

*Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean.

The data for the effect of substrates on the fructification time (Table 3) showed that minimum average time was taken by strains for the fructification on cotton waste (2.44) days, paddy straw and the pulses straw also took almost same time (2.48 days) and (2.50 days) respectively after cotton waste. The difference for the fructification time between the cotton waste, paddy straw and pulses straw was not significant. The sugarcane baggase showed minimum efficiency and took maximum average time (2.72 days) for fructification by the strains. Banana leaves and corn stovers took same time (2.60 days) and (2.58 days) respectively for the fruiting bodies formation of mushroom.

Table 3. Effect of substrates on fructification

Treatment	Strains					Mean (Crop x Treat)
	Days					
	Vv(PK)	Vv436	Vv428	Vv430	Vv422	
Cotton waste	2.20±0.133	2.20±0.133	2.50±0.167	2.70±0.153	2.60±0.163	2.44±0.071 B*
Paddy straw	2.10±0.100	2.30±0.153	2.40±0.163	2.70±0.153	2.90±0.100	2.48±0.071 B
Banana Leaves	2.50±0.167	2.40±0.163	2.60±0.163	2.70±0.153	2.80±0.133	2.60±0.070 AB
Corn stovers	2.50±0.167	2.30±0.153	2.70±0.153	2.60±0.163	2.80±0.133	2.58±0.071 AB
Sugarcane baggasse	2.30±0.153	2.70±0.153	3.00±0.000	2.80±0.133	2.80±0.133	2.72±0.064 A
Pulses straw	2.30±0.153	2.50±0.167	2.20±0.133	2.80±0.133	2.70±0.153	2.50±0.071 B
LSD						0.18

*Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean

The effect of the substrates on the yield of the strains (Table 4) showed that highest average yield of the mushroom was obtained from the cotton waste (734.3g), followed by the paddy straw (590.8g), banana leaves (483.2g), pulses straw (385.4g), sugarcane baggase, (297.2g) and corn stover, (251.0 g), respectively.

Table 4. Effect of substrates on the yield of the strains

Treatment	Strains					Mean (Crop x Treat)
	Fresh weight (g)					
	Vv(PK)	Vv436	Vv428	Vv430	Vv422	
Cotton waste	821.0±5.09 a	769.4±3.91 b	734.1±4.08 c	696.1±2.64 d	650.7±2.75 e	734.3±8.54 A
Paddy straw	651.4±2.93 e	623.9±3.16 f	591.7±2.20 g	567.1±3.21 h	520.1±1.99 j	590.8±6.60 B
Banana Leaves	547.3±3.07 i	523.5±2.23 j	496.2±3.12 k	443.7±3.53 l	405.1±2.34 n	483.2±7.54 C
Corn stovers	291.4±2.43 s	287.2±3.77 s	257.0±1.89 u	226.5±2.82 v	192.9±3.83 w	251.0±5.49 F
Sugarcane baggase	318.3±2.81 r	343.1±4.37 q	319.4±3.61 r	273.6±2.69 t	231.7±2.72 v	297.2±5.85 E
Pulses straw	439.1±2.23 l	417.3±2.84m	386.3±3.90 o	361.0±2.75 p	323.4±3.38 r	385.4±5.98 D
LSD						3.65

Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean

DISCUSSION

The production of agricultural waste, sewage and municipal solid waste in a large quantity is big problem, which the people of both rural and urban areas are facing. Safe disposal of these wastes without polluting the environment is big challenge.

In the present study six different agricultural wastes, cotton waste, rice straw, banana leaves, corn stovers, sugarcane baggase and pulses straw were selected to evaluate these substrates for mushroom production and their recycling in edible biomass. These above mentioned agro-wastes were selected, because all these were abundantly and cheaply available in the fields of Pakistan, round the year. According to Chang and Miles (1991) the Chinese mushroom (*V. volvacea*) is appropriate for cultivation in tropical regions, the most common edible mushroom in south-east Asia and produced almost all over the world. Each agro- waste was used as a single substrate, no combination of the agro-wastes was used in order to make the mushroom cultivation more easy and to calculate the potential of each agro-waste for mushroom production. These wastes were also selected, by keeping in view the previous experimentation of the different scientists which used variety of agro-wastes for cultivation of *V. volvacea* in the past. Garo (1964) used paddy straw, dried banana stalks and leaves, water hyacinth, wheat straw and sugarcane baggasse. Gupta *et al.*, (1970) tried wheat, maize, barley, oat, pearl millet, and sorghum straw. Chang (1974) cultivated *V. volvacea* on cotton waste compost in plastic green houses. Khan *et al.*, (1994) tried dried water hyacinth for the cultivation of *V. volvacea*. Salmones (1996) used 13 agro industrial

wastes, banana leaves, bracts of pineapple crown, coconut fiber, coffee bran, coffee pulp, corn cob, corn stover, orange peel, rice bran, rice straw, sisal bagasse, sugarcane bagasse and wheat straw as substrate. Tonial *et al.*, (2000) used industrial residues from cassava and potato starch processing as substrates to produce the edible mushroom *Volvariella volvacea*. Philippoussis *et al.*, (2001) used three agricultural wastes, i.e. wheat straw, cotton waste and peanut shells. Zervakis *et al.*, (2001) evaluated wheat straw, cotton gin-trash, peanut shells, poplar sawdust, oak sawdust, corn cobs and olive press-cake. Obodai *et al.*, (2003) tried banana leaves, cocoyam peelings and oil-palm pericarp. Belewu and Belewu (2005) evaluated the banana leaves for *V. volvacea* cultivation.

The growth of the mushroom on the substrates was measured in terms of spawn running, pinhead formation fructification and ultimate yield of three flushes from each substrate. In Pakistan the performance of the exotic strains of *V. volvacea* was evaluated for the first time. The results for the spawn running showed that all the strains less time for spawn running, both on the cotton waste and paddy straw as compared to the other substrates. The slow rate of spawn running was observed on the sugarcane baggase and pulses straw. The time taken by the strains for pinhead formation was less on the cotton waste and corn stovers but on the other substrates all the strains took almost same time for pinhead formation and did not showed the significant difference. The highest yield was obtained from cotton waste (734.3g), followed by the paddy straw (590.8g), banana leaves (483.2g). The other data regarding the yield performance of *V. volvacea* in general

also confirmed the results obtained by the other scientists. Most of the scientists obtained the appreciable yield on cotton waste, paddy straw and banana leaves. Garo (1964) obtained highest yield from the beds of banana leaves as compared, dried banana stalks and leaves, water hyacinth, wheat straw and sugarcane baggase. Gupta *et al.*, (1970) observed low yield on wheat, oat, sorghum, maize, pearl millet and barley straw as compared to the yield obtained from paddy straw. Khan *et al.*, (1994) obtained highest yield from water hyacinth + cotton waste at the rate 1:1. Salmones *et al.*, (1996) recorded highest biological efficiency on rice straw. Philippoussis *et al.*, (2001) observed higher growth rate of *V. volvacea* on composted cotton waste substrate. Akinyele and Akinyosoye (2005) reported high fungal growth rate on cotton waste (98.23 ± 0.1 mm) and a mixture of rice husk and cotton waste. Zervakis *et al.*, (2001) found on cotton gin-trash the highest linear growth and colonization rates. Obodai *et al.*, (2003) highest production on banana leaves, cocoyam peelings and oil-palm pericarp as substrates. Belewu and Belewu (2005) recorded the total weight of the fruits 2.5 kg, with biological efficiency 15.21% on banana leaves. It is concluded from this study that with little effort and proper management, we can produce more food by recycling the waste materials to feed the people and also get rid of these wastes without polluting the environment. Mushroom cultivation is fantastic approach to utilize crop residues and to make it more attractive and profitable business.

REFERENCES

- Akinyle, B. and F. Akinyosoye. 2005. Effect of *Volvariella volvacea* cultivation on the chemical composition of agrowastes. African Journal of Biotechnology, 4.
- Belewu, M. and K. Belewu. 2005. Cultivation of mushroom (*Volvariella volvacea*) on banana leaves. African journal of Biotechnology, 4.
- Bhawna, A. and G. V. Thomas. 2003. Biological efficiency of different *Pleurotus* species on the leaf stalk biomass from coconut palm. Mushroom Research, 12.
- Buigut, S. 2001. Mushroom production in sustainable small-scale farming system-opportunities and constraints: a survey of Uasin Gishu district. Proceedings of the Horticulture seminar on Sustainable Horticultural Production in the Tropics at Jomo Kenyatta University of Agriculture & Technology, Juja, Kenya 3rd-6th October. pp. 1-5.
- Buswell, J. A., Y. J. Cai, S. T. Chang, J. F. Peberdy, S. Y. Fu and H. S. Yu. 1996. Lignocellulolytic enzyme profiles of edible mushroom fungi. World Journal of Microbiology & Biotechnology, 12: 537-542.
- Chang, S. 1974. Production of the straw-mushroom (*Volvariella volvacea*) from cotton wastes. Mushroom Journal.
- Chang, S. and P. Miles. 1991. Recent trends in world production of cultivated edible mushrooms. Mushroom Journal.
- Chang, S. and P. Miles. 2004. *Volvariella*-A high temperature cultivated mushroom. Mushroom-Cultivation, Nutritional Value, Medical Effect and Environmental Impact (Chang, ST and Miles PG, Eds.) pp: 277-304.
- Chang, S. T. 1991. Mushroom biology and Mushroom production. Mushroom J 11: 45-52.
- Chang, S. T. and J. A. Buswell. 1996. Mushroom nutraceuticals. World Journal of Microbiology & Biotechnology, 12: 473-476.
- Chang, S. T. and P. G. Miles. 1991. Recent trends in world production of cultivated mushrooms. Mushroom Journal, 504: 15-18.
- Chiu, S.-W., S.-C. Law, M.-L. Ching, K.-W. Cheung and M.-J. Chen. 2000. Themes for mushroom exploitation in the 21st century: Sustainability, waste management, and conservation. The Journal of General and Applied Microbiology, 46: 269-282.
- Duncan, D. B. 1955. Multiple Range and Multiple F Tests. Biometrics, 11: 1.
- Garo, V. M. 1964. A comparative study on the suitability of rice straw, dried banana stalks, banana leaves, wheat straw, water hyacinth and sugarcane bagasse (*Volvariella volvacea* Bres. Production. Science J, 1: 130.
- Gupta, G., B. Bajaj and D. Suryanarayana. 1970. Studies on the cultivation of paddy straw mushroom (*Volvariella volvacea* and *V. diplasia*) in India. Indian phytopathology.
- Haq, I. U., S. A. Khan, M. Shoib and M. Iqbal. 2014. First record of *Polyalthia Longifolia* Leaf Blight caused by *Nigrospora sphaerica* in Pakistan and its chemical management. 8th international conference on "agriculture, food security and climate change. University of Poonh Rawalakot.
- Jiskani, M. 2001. Energy potential of mushrooms. The Dawn economic and business review: 15-21.

- Khan, S. M., S. M and M. I. Haq. 1994. Studies on the cultivation of Chinese mushroom *Volvariella volvacea* on water hyacinth. Pakistan Journal of Phytopathology, 6: 130-134.
- Khan, S. M., A. Qadir and M. Ramzan. 1982. Fungal mycelium as a source of protein for animal feed. 21st National Science Conference, pp.28.
- Manzi, P., A. Aguzzi and L. Pizzoferrato. 2001. Nutritional value of mushrooms widely consumed in Italy. Food Chemistry, 73: 321-325.
- Obodai, M., J. Cleland-Okine and P. N. Johnson. 2003. Use of agricultural wastes as substrate for the mushroom *Volvariella volvacea*. Tropical Science, 43: 121-124.
- Oso, B. A. 1977. Mushrooms in yoruba mythology and medicinal practices. Economic Botany, 31: 367-371.
- Philippoussis, A., G. Zervakis and P. Diamantopoulou. 2001. Bioconversion of agricultural lignocellulosic wastes through the cultivation of the edible mushrooms *Agrocybe aegerita*, *Volvariella volvacea* and *Pleurotus* spp. World Journal of Microbiology and Biotechnology, 17: 191-200.
- Salmones, D., K. N. Waliszewski and G. Guzmán. 1996. Use of some agro-industrial lignocellulose by-products for edible mushroom *Volvariella volvacea* cultivation. Revista Internacional de Contaminación Ambiental, 12: 69-74.
- Steel, R., J. Torrie and D. Dickey. 1997. Principles and procedures of statistics: a biometrical approach, 3rd edn (McGraw-Hill: New York).
- Tonial, T. M., P. Ashok, M. Chiarello and C. Soccol. 2000. Cultivation of *Volvariella volvacea* to produce biomass from potato and cassava processing residues by submerged fermentation. Indian Journal of Microbiology, 40: 35-40.
- Zervakis, G., A. Philippoussis, S. Ioannidou and P. Diamantopoulou. 2001. Mycelium growth kinetics and optimal temperature conditions for the cultivation of edible mushroom species on lignocellulosic substrates. Folia Microbiologica, 46: 231-234.
- Zoberi, M. H. 1972. Bolbitiaceae. Tropical Macrofungi. Palgrave Macmillan UK, pp. 114-116.