Development of New Cultivation Technology for Straw Mushroom (*Volvariella volvacea)* Using Locally Available Raw Materials

A. S. NISSANKA[1], P. RAJAPAKSHE[2] and R.H.M.K.RATNAYAKE[1]

[1]*Department of Horticulture and Landscape Gardening, Faculty of Agriculture and Plantation Management Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), Sri Lanka*
[2]*Regional Agricultural Research and Development Centre, Makandura, Gonawila (NWP), Sri Lanka*

ABSTRACT

Paddy straw mushroom (*Volvariella volvacea*) is an edible mushroom variety which can be cultivated under tropical and sub tropical conditions. In Sri Lanka, though the majority of farmers grow oyster mushroom, they are willing to undertake other mushroom types, including straw mushroom and milky mushroom. Straw mushroom cultivation is highly rewarding because of the favorable climatic condition in Sri Lanka and the abundant availability of raw materials. The existing outdoor method for straw mushroom cultivation introduced by the Department of Agriculture (DOA) gives low or/and irregular yield. As the optimum environmental conditions are important in straw mushroom production, an indoor cultivation method was tested with the existing outdoor method. Cotton waste and paddy straw were used as growing media in both outdoor and indoor conditions under four treatments *viz.* paddy straw compost in polythene house (T1), cotton waste compost in polythene house (T2), paddy straw in outdoor environment (T3) and cotton waste in outdoor environment (T4) and tested in a Completely randomized Design with three replicates. The results revealed that, the indoor cultivation method with cotton waste compost substrate (T2) gives significantly higher values for the average yield (7033.69 kg / ha), average marketable yield (6607.75 kg / ha) and the number of mushrooms (2.41×10^6 / ha) compared to other treatments. Outdoor culture in straw substrate (T3) gave the lowest values for the same yield parameters (577.48 kg / ha, 525.73 kg / ha and 1.85×10^5 / ha, respectively). Indoor cultivation method with paddy straw compost and cotton waste compost both resulted higher yields when compared to the yields in outdoor cultivation. Because paddy straw is freely available, combining of paddy straw compost and cotton waste compost as the substrate for straw mushroom culture under indoor conditions would be more profitable.

KEYWORDS: Cotton waste, Indoor, Outdoor, Straw, Straw Mushroom

INTRODUCTION

The mushroom is a fleshy, spore bearing macro organ of fungi belonging to class bacidiomycetes (Chang and Miles, 1987). There are about 5000 different species of mushrooms of which at least 1250 are reported to be edible (Alam and Raza, 2001). However, only 20 species are used for commercial cultivation (Pathak *et al.*, 1998). Nowadays, mushroom is becoming popular throughout the world since it has wonderful food and medicinal values (Alam and Raza, 2001). The edible mushrooms contain a high percentage of protein, all indispensable amino acids, vitamin C and B-complex and other biochemical compounds. It is also considered as a high valued natural medicine (Pathak *et al.*, 1998).

The mushroom, after harvesting can be marketed as fresh, canned, dried or made into powder, soup, pickle, jam, jelly and chutney(Alam and Raza, 2001; Dey, 2000). Drying and canning of mushroom is specially needed for the export market and sometimes even for local market. The most common edible mushroom species in the world are Button mushroom (*Agaricus bisporus*), Straw mushroom *(Volvariella volvacea),* Winter mushroom *(Flammulina velutipes),* Shitake mushroom *(Lentinus edodes) and* Oyster mushroom (*Pleurotus spp)* (Chang and Miles, 1987).

The local demand for mushroom is steadily increasing especially because of the hotel industry and super markets. However, production is not sufficient to meet the local demand. Around 2,000 families are engaged in mushroom growing at small scale in Sri Lanka (Emmanuel, 2004). Most of the mushroom growers in Sri Lanka cultivate Oyster mushroom. However, different mushroom varieties have different tastes, nutritional and medicinal values, costs and benefits. Moreover, the preferences of people vary depending on the above characters. Therefore, diversification of local and introduced mushroom varieties is beneficial for the farmers as well as for the consumers.

Straw mushroom (*Volvariella volvacea*) is a popular mushroom variety among people because of its distinct flavour, pleasant taste, higher protein content and shorter cropping duration compared to other cultivated mushroom species. Straw mushroom is also known as paddy straw mushroom, Chinese mushroom, worm mushroom, Tributary mushroom or Nanhua mushroom (Chang and Miles, 1987; Bhal, 2000). It belongs to family Pluteaceae and has been cultivating for many years in the countries of tropical and sub tropical regions (Chang and Miles, 1987). It needs a high temperature (35°C) for better and early hyphal growth. For the formation of fruiting bodies, a temperature of 30 ± 2 ° C and, a relative humidity of 80 - 90 percent are required (Chang and Hayes, 1978). When considering the climatic conditions prevailing in Sri Lanka, a good potential exists for the successful cultivation of straw mushrooms.

The yield of straw mushroom depends on the cultural methods and quality of substrate. Prior to

1970, rice straw was practically the only material used for preparing the medium for *Volvariella volvacea*. Straw alone is not effective as a culture medium as it contains a little food and slow rate of decomposing (Anon, 1983). Therefore, straw mushroom is presently grown in combination with rice straw and cotton waste; cotton waste compost, guinea grass, sugar-cane bagasse, dried banana leaves, oil palm bunch waste, oil palm pericarp waste, water hyacinth and sisal tow (Chang and Hayes, 1978). Cultivation of this mushroom is ideal in rural areas where rice straw is abundant after each rice harvest and it can provide additional income and food to rice farmers in between planting seasons.

An outdoor cultivation method was introduced for straw mushroom by the Department of Agriculture, Sri Lanka. However, farmers are reluctant to use this method because of the uncertainty of production, irregular or low yield, difficulty in controlling pests and diseases and environmental factors (Anon, 1983). Unlike Oyster mushrooms straw mushroom is highly sensitive to climatic conditions and their fluctuations. To overcome these problems some South East Asian countries have developed indoor cultivation methods, utilizing mushroom houses under controlled environment. Such techniques have to be developed considering the existing climatic conditions and other socio-economic factors in that region. The success of straw mushroom commercialization would depend on improving the existing method in to simple. Therefore, an experiment was conducted to identify the suitability of an indoor cultivation method for straw mushrooms under Sri Lankan conditions, using locally available low cost raw materials.

MATERIALS AND METHODS

1. Farmer Survey

A Survey was conducted in collaboration with the Regional Agricultural Research and Development Centre, Makandura to study the present situation of mushroom growers in three selected districts in Sri Lanka. The random samples of farmers were selected from Puttlum, Kurunegala and Gampaha districts and the sample sizes were 26, 26 and 15 respectively. Information on personal details of farmers, mushroom species presently grown, farmers' attitudes on going for new types and the problems in mushroom cultivation were gathered using a pre-tested questionnaire.

2. Field Experiment

2.1. Experimental Site

The experiment was conducted at the Regional Agricultural Research and Development Centre, Makandura from January to July 2006. The site belongs to Low Country Intermediate Zone of Sri Lanka where the average day and night temperatures are 31.9° C and 22.4° C, respectively with an annual rainfall of more than 1400 mm. Four types of media were prepared as the growing substrates for mushroom, using dried straw and cotton waste as the raw materials. The compost preparation, spawning and incubation were done as follows.

2.2. Indoor Cultivation

Composts were prepared using paddy straw and cotton waste. Paddy straw composting was done by soaking dried paddy straw (30 kg) in a two percent lime solution for four hours and the excess water was allowed to drain. Paddy straw was spread on a clean platform as a thin layer. One percent of urea and five percent cow dung (measured on dry weight basis of the raw material) were evenly spread on the wetted paddy straw and mixed well. A heap was built using straw and the dimensions of length, width and height were 2 m. It was covered by black polythene and the turning of heap was done twise in two days intervals. Paddy straw compost was ready to use after six days. The method of composting cotton waste (by-products of textile industry) was similar to that of straw composting and the excess water in the cotton waste was removed manually by squeezing.

A barrel roof type polythene house (length – 5 m, width – 3 m, middle height - 1.5 m) was constructed using transparent polythene (gauge 300). The roof was covered with black polythene when the inside temperature exceeded 35° C and a black polythene was also used inside the polythene house to avoid contact of direct sunlight with the beds. Pre-prepared compost layer was tightly packed (five inches thick) in to the wooden frame (90 cm × 22.5cm × 30cm) which was laid on the floor and beds of cotton waste compost and straw compost were prepared in that manner. A small amount of cotton waste compost was spread on the top of straw compost beds. The media were inoculated with the spawn and on top of it, another five inches thick compost layer and a layer of spawn was packed. Finally, a compost layer was placed on it and after tight packing, the frame was removed. The beds were covered with black polythene (gauge 300) for five days and afterwards, removed for fruiting.

2.3. Outdoor cultivation

Dried paddy straw (30 kg) was soaked in water for four hours and was allowed to drain excess water. Cotton waste (30 kg) was wetted by spraying water and kept for four hours. Paddy straw beds and cotton waste beds were prepared and inoculated as similar to indoor method. Beds were covered with two transparent polythenes. Two inches thick dried straw layer was placed on the top of polythene. In five days time, polythene was removed sprayed with water and the beds were again covered with two polythenes while four inches were opened in the middle of the beds during the harvesting period.

The experiment was arranged in a Completely Randomized Design with three replicates and the treatments were as follows;

Treatment 1 - Paddy straw compost in polythene house
Treatment 2 - Cotton waste compost in polythene house
Treatment 3 - Paddy straw in outdoor (control)
Treatment 4 - Cotton waste in outdoor

The temperature and relative humidity in the indoor and outdoor environments during the experimental period are given in Table 1.

Table 1 - Average (minimum and maximum) temperatures and relative humidity observed during cultivation period:

Parameter	Indoor	Outdoor
Minimum temperature	29 ° C	27.5 ° C
Maximum temperature	33.5 ° C	30 ° C
Relative humidity	83 %	76.2.%

Table 2 - Average bed temperatures of each treatment during cultivation period:

Treatment	Bed temperature °C
T1	31.2
T2	31.16
T3	30.9
T4	30.79

Mushrooms were harvested at the egg stage before opening, in the morning and afternoon. Beds were sprayed with water twice a day. Minimum and maximum temperatures (at 8 am, 12 noon, 3 pm) inside the poly house and in open area were recorded using minimum and maximum thermometer and the bed temperatures were recorded daily using soil thermometer. Starting from seven days after inoculation, fresh weight (kg) of the harvest (total yield) and marketable yield (kg) were measured daily, using Trade Sprang Balance (Model 2265). The total number of mushrooms harvested and the number of marketable mushrooms were recorded daily. Occurrence of diseases and intensity of contamination, number and species of insects and other pests were recorded at three days interval. Dates of pin head formation and mycelium growth at opening (as a percentage of the total area) were recorded.

RESULTS AND DISCUSSION

1. Farmer Survey

1. 1. Farmers' preference for mushroom types

The survey revealed that the highest number of farmers (82.17 percent) cultivated Oyster mushroom, while only 2.9 percent grow Button mushroom and 14.93 percent cultivate both types (figure 1).

According to the results, 96.97 percent of farmers expressed their willingness to grow other mushroom varieties except Oyster and Button mushrooms (figure 2) while only 3.03 percent of farmers were not willing to go for other varieties.

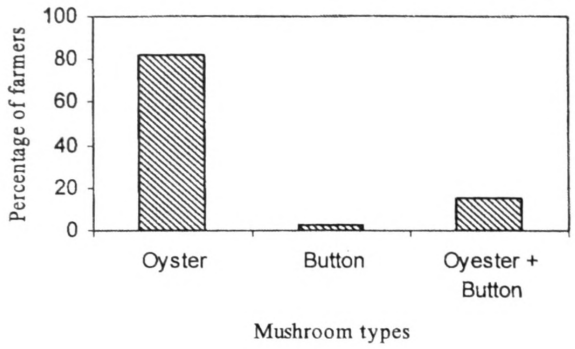

Figure 1 - Mushroom Types Cultivated by Farmers:

Among the farmers who like to grow other varieties, a higher percentage (49.15 percent) preferred growing both Milky and Straw mushrooms (Figure 3).

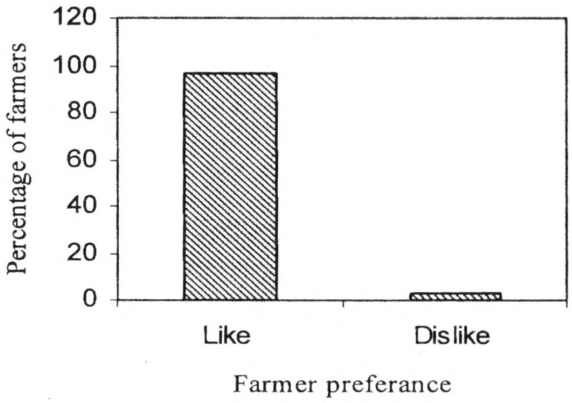

Figure 2 - Farmers' Willingness to Grow Other Mushroom Types:

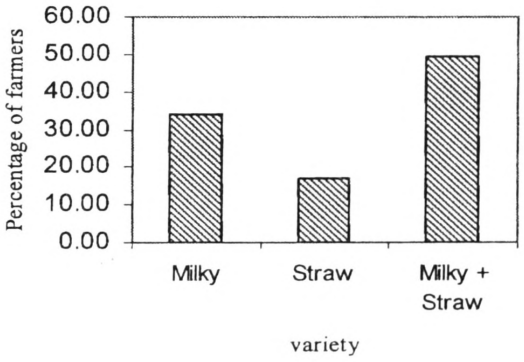

Figure 3 - Farmer Preference to Grow Mushroom Types:

1.2. Problems in mushroom cultivation

The survey data revealed that the major constrains encountered by the mushroom growers are pest and disease problems and lack of knowledge on proper control measures, technical problems such as construction of mushroom houses, marketing problems and difficulties in obtaining good quality seeds.

2. Field Experiment

2.1. Yield Parameters

2.1.1. *Avarage yield (fresh weight) of mushrooms*

There was a significant effect of growing condition on fresh weight of mushroom. Cotton waste compost in poly house (T2) recorded the highest yield (7033.68 kg / ha) which was significantly different from other treatments. Paddy straw in outdoor (T3) resulted the lowest yield (577.48 kg / ha). However, it did not significantly differ from the yield obtained under cotton waste in outdoor (T4). The yield from paddy straw medium in indoor conditions (T1) was significantly higher (2703.59 kg / ha) than that of outdoor condition (T3) (Table 3). However, T1 resulted a significantly lower yield when compared to T2. The yields under indoor condition were higher than that of outdoor condition because indoor conditions permit easy regulation of temperature, humidity, light and ventilation (Chang and Hayes, 1978).

The higher yield resulted in cotton waste compost medium indoors (T2) could be explained with the outcome of previous studies which have shown that straw along is not effective as culture material as it contains a little food value and slow decomposing (Anon, 1983). Straw mushroom is unable to utilize lignin, however, can depend on hemi-cellulose and cellulose as a major food source (Chang and Miles, 1989), because it lacks the capability of producing phenoloxidizing and lignin–transformation enzymes (Chang, 2004). Therefore, it can utilize the highly cellulosic cotton waste better than lingo-cellulosic paddy straw and thus produces a higher yield (Quimio, 2003).

Table 3 - Avarage (fresh) weight and Average marketable(fresh) weight of mushroom under different treatments:

Treatment	Average (fresh) weight (kg/ha.)	Average marketable (fresh) weight
T1	2703.59^{b}	2674.51^{b}
T2	7033.68^{a}	6607.75^{a}
T3	577.48^{c}	525.73^{c}
T4	1168.64^{bc}	982.35^{c}

Treatment means having common letters in a column are not significantly different by LSD 5%

2.1.2. *Marketable yield*

A significantly higher marketable yield (6607.75 kg / ha) was observed in cotton waste medium in indoor (T2) while the lowest value (525.73 kg /ha) was given by paddy straw compost in outdoor (T3) (table 2). However, there were no significant differences between T3 and T4 while Paddy straw compost in indoor (T1) also resulted a notably higher yield than T3 and T4. The difference between total fresh weight and marketable fresh weight was due to pest attacks and physical damages (Table 3).

2.1.3. *Total number of mushrooms*

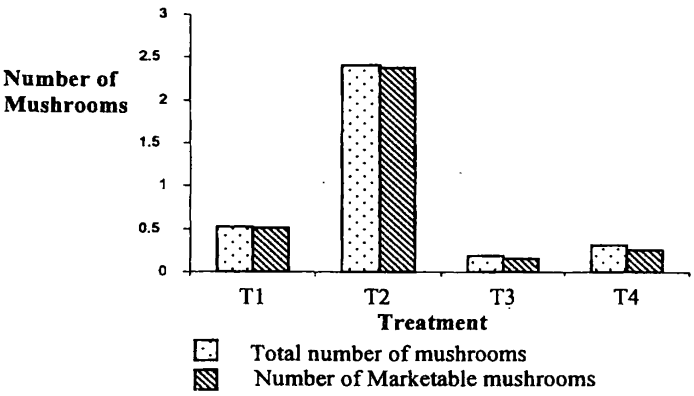

Figure 4 - Total number of mushrooms and marketable number of mushrooms harvested under different treatments:

Significant differences were observed in number of mushrooms among the four treatments ($p<0.05$). The highest number of total mushrooms which was significant, (2.41×10^{6} / ha) was recorded in cotton waste medium in indoor (T2) while, the lowest (1.85×10^{5} / ha) was recorded in paddy straw in outdoor (T3). There were no significant differences between T1, T3 and T4 (Figure 4).

2.1.4. *Total number of marketable mushrooms*

Significant differences in the number of marketable mushrooms were observed among four treatments ($p<0.05$). The highest number of marketable mushrooms (2.37×10^{6} / ha) was recorded in cotton waste medium in indoor (T2) while the lowest (1.6×10^{5} / ha) was recorded in paddy straw under outdoor condition (T3). However, there were no significant differences between T1, T3 and T4 (Figure 4).

2.1.5. *Mushroom yield in relation to time*

According to figure 5 and 6 all treatments exhibited the highest yield and number of mushrooms in the first week. Yield decreased over the second and third weeks in all treatments. However, the decline was more prominent in cotton waste medium in indoor (T2).

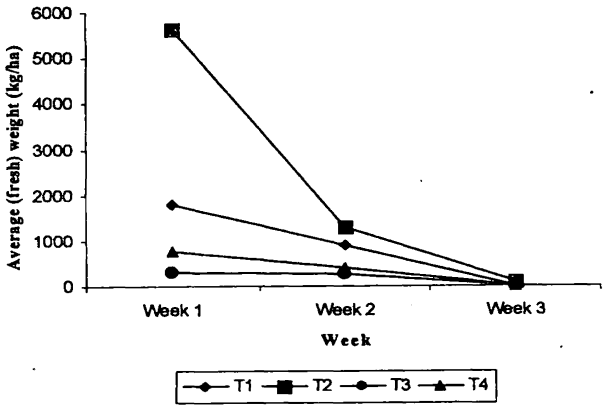

Figure 5 - Total Mushroom Yield in Relation to Time:

According to literature, straw mushroom produces two flushes and cropping period depends on weather and nutrient content of the media (Chang and Hayes, 1978). First flush produces 85- 90 percent of the expected yield and second flush produces only 10 – 15 percent of the expected yield (Pathak *et al.*, 1998).

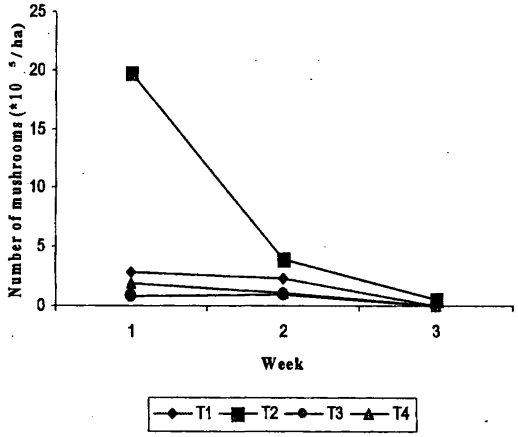

Figure 6 - Total Number of Mushrooms in Relation to Time:

2.2. Pest and disease incidences

Wet rot of mushrooms was observed which can be caused by *Sclerotium* spp. and some bacteria (Bhal, 2000). Beds were contaminated with a wild mushroom variety named *Coprinus aratus* and with paddy seedlings. Slugs (*Pulmonata spp.*) and snails (*Helix aspersa*), *Millipedes*, larval stages of some *Drosaphila s*pecies were found as pests.

CONCLUSIONS

The study reveals that the indoor cultivation method with cotton waste compost substrate gives the highest yield in straw mushroom cultivation. Indoor cultivation method with paddy straw compost and cotton waste compost both resulted higher yields when compared to the existing DOA recommended outdoor cultivation method. During this experimental period it was able to maintain the temperature in the range of 29 to 32 °C, humidity at 83 percent and a shade level of 64 percent inside the polythene house giving ideal conditions for straw mushroom cultivation. Outdoor cultivation does not provide controlled temperature, relative humidity and shade levels. Requirement of the high initial cost for constructing polythene house is the main drawback of indoor cultivation method. Cotton waste would be a better substrate than paddy straw for straw mushrooms. In Sri Lanka, paddy straw is freely available than the cotton waste. As cotton waste is also not an expensive raw material, combining of paddy straw compost and cotton waste compost as the substrate for straw mushroom cultivation under indoor conditions would be more profitable. Further studies are needed to confirm the appropriate proportion of these two raw materials in the substrate, and to find out low cost structures instead of polythene house and thereby, to develop a new cultivation package for straw mushroom.

ACKNOWLEDGEMENTS

Authors wish to acknowledge Professor S.J.B.A. Jayasekara, Dean, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka , Dr. B. Ranaweera, Head, Department of Horticulture and Landscape Gardening and Dr. W.J.S.K. Weerakkody and the stuff of the computer unit, for their guidance during this study. Authors also express their gratitude to the staff and the labourers of the Regional Agricultural Research and Development Center (RARDC), Makandura, for the assistance provided throughout the study.

REFERENCES

Alam, S.M. and Raza, S. (2001). "Importance of mushroom". NIA, Pakistan. pp.1-3.

Anon (1983). *Growing mushrooms – Oyster mushrooms, ear mushrooms, straw mushrooms.* Regional office for Asia and Pacific, Bangkok. pp. 142-159.

Bhal, N. (2000). *Handbook on mushrooms*, 4th Ed. Oxford and IBH publishing Co. Pvt. Ltd, New Delhi, India. pp. 99.

Chang, S.T. (1978). *Volvariella volvacea.* In: *The biology and cultivation of edible mushrooms*, Eds. S.T. Chang and W. H. Hayes. A subsidiary of hercourt braces Jovanovich publishers, London. pp. 573 - 600.

Chang, S.T. and P.G. Miles (1987). *Edible mushrooms and their cultivation.* CBS publishers and distributors, Delhi, India. pp. 3, 8, 12, 225-251.

Chang, S.T.(2004). Biology and cultivation technology of *Volvariella volvacea.* Department of biology, The Chinese University of Hong Kong, Hong Kong. Available from: http:// www.mushworld .com/tech (Accesses on 20 April 2006)

Dey, S.C. (2000). *Mushroom growing.* Agrobios, India. pp. 72.

Emmanuel, L. (2004). Mushroom industry in Sri Lanka. Available from: http://www.mushworld.com/tech (Accesses on 15 March 2006)

Pathak, V.N., N. Yadav and M. Gaur (1998). *Mushroom production and processing technology.* Agrobios, India. pp. 1, 76-82.

Quimio, T.H. (2003). Updates on spawn production of *Volvariella volvacea,* the tropical straw mushroom. Department of plant pathology, University of the Philippines Los Banos collage, Laguna, Philippines. Available from: http:// www.mushworld .com/tech (Accesses on 15 March 2006)