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EVALUATION OF GROWING PADDY STRAW MUSHROOM UNDER MAIZE CANOPY

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ABSTRACT
Field experiments were conducted to study the yield potential of paddy straw mushroom (*Volvariella volvacea*) which are grown under maize crop canopy using different crop wastes (Paddy straw, wheat straw, banana pseudostem, sugarcane trash, maize and sorghum stalks) in three regions of Tamil Nadu (Coimbatore-Ln1; Erode-Ln2; and Erode-Ln3). The study revealed that average yield of mushrooms that are grown in paddy straw substrates was significantly higher at Erode-Ln3 (4.34 Kg Bed^{-1}) irrespective of wastes. The yield of mushrooms grown with banana psedostem was significantly lower that ranged from 0.78 to 0.99 Kg Bed^{-1}. The biological efficiency of mushroom was also higher in paddy straw substrates in all locations that ranged from 15.2 to 17.4 per cent. The paddy straw mushroom grown in sorghum stalks recorded significantly lower weed population in all locations at 30 days after the induction of mushroom beds and the reduction was ranged from 7.28 to 12.1 $No.m^{-2}$. The average reduction in weed population at 30 days after the introducing mushroom beds ranged between 42.1 to 65.5 per cent lower as compared to control plots. It can be concluded that yield of paddy straw mushroom with paddy straw substrate was significantly recorded higher yield in all the locations.

INTRODUCTION

The Chinese straw mushroom or paddy straw mushroom, *Volvariella volvacea* (Bull ex fr.) Singer, an important edible mushroom is being grown in a specialized growth chambers (Reyes, 2000). The *Volvariella volvacea* is also called as 'warm mushroom' because it grows as the relatively high temperature range of 30 -35°C for mycelia development (Reyes, 2000). This is considered to be a important edible mushroom (Chung and Chand, 1972 and Bahukhandi, 1989) in tropics and subtropics region and especially it is being cultivated in China, Thailand, Indonesia, Vietnam and other Southeast Asian countries. In particular, in countries like Hong Kong and Philippines, paddy straw mushrooms are generally grown under open field conditions and ensure that mushroom beds were protected from direct sunlight and rain (Alicbusan, 1982 and Chang, 1982). In general, paddy straw mushrooms are grown in a growth chambers under protected weather conditions. In which, temperature and relative humidity are considered to be important weather elements to grow paddy straw mushrooms (Reyes, 2000; Reyes, *et al*. 1998; and Krishnamoorthy *et al*., 2002). Similar microclimate also prevailed under crop canopy during specific growth stages. In India, growing paddy straw mushroom under crop canopy was reported in humid weather (Krishnamoorthy *et al*., 2005; Manoharan *et al*., 2004). In which, paddy straw and maize stalks were adopted under this earlier system and mushrooms were harvested within 10-12 days period. The optimum temperature ranged between 30-35ºC with prevailing more than 85 per cent humidity is considered to be optimum values for the growth of paddy straw mushroom that allow harvesting of mushrooms with in 9 to 11 days after the release of inoculum in the beds.

In general, microclimate of a crop is internally controlled by crop geometry and however, strongly influenced by weather prevailed over a region externally on microclimate prevailed in a crop canopy. Thus, microclimate of a same crop is not exhibiting similar microclimate in other locations of a region. Therefore, microclimate prevailed under maize crop canopy in different region is not always uniform. Certainly by keeping mushroom beds in between the crop rows are act as mulching and suppress growth of weeds, which needs further investigations. The main objective is to study the yield potential of paddy straw mushroom grown in different agro climate regions with various crop wastes and their weed controlling ability in maize crop. Hence, study has been undertaken to determine the yield performance of paddy straw mushroom under maize crop canopy in different locations of Tamil Nadu, India.

MATERIALS AND METHODS

Field experiments were conducted using maize (var. CoMH4; spacing 60x30 cm) crop as raised in farmers field in three different locations of Tamil Nadu *viz*., Coimbatore (Ln1-Coimbatore district); TN Palayam (Ln2-Erode district) and Kondaya mpalayam (Ln3-Erode district). *Spawn preparation:* Cultures of *Volvariella volvacea* identified by the Tamil Nadu Agriculture University were used for the study (Radhajeyalakshmi *et al*., 2014). The straw spawns were prepared according to the method suggested by Ahlawat and Tewari (2007). The paddy straw are chopped to a length of 5 cm approximately and soaked with water for one hour. Drain the excess water and shade dried until it reaches moisture

content approximately 65 per cent. Then chopped paddy straw was mixed with coarsely powdered autoclaved horse gram at the rate of 20g per kg of substrates on dry weight basis. These mixtures were filled in polypropylene bags (45x30cm) and the mouth will be closed with lid made with PVC ring (1 inch diameter). The mouth is carefully plugged with non-absorbent cotton and covered with a piece of paper and autoclaved with a temperature of 126°C at 1.42 kg/cm2 pressure for 90 minutes. The bags were inoculated with the cultures of *Volvariella volvaceae* maintained on PDA medium under aseptic conditions. These bags were incubated at 32-36°C over racks in a dust free room. Spawn growth will appear quickly and the fungus mycelium covers the entire bag with in 7-10 days. Later, pink to brown colour chlamydospores will appear in groups inside the layers of bag with in 10 to 12 days, which is an indication of maturity of spawn that are used for the study. *Mushroom bed preparation:* The crop waste such as paddy straw, wheat straw, dried banana pseudostem, sugarcane trash, maize and sorghum stalks were used for the preparation of paddy straw mushroom beds as suggested by Krishnamoorthy *et al*. (2005). The mushroom beds consists of compact beds of 60 cm height weighing 25 kg of substrate on dry weight basis were prepared and kept in between maize crop rows at 40 days after sowing. The mushroom beds were prepared in such a way that each bundles weighed to one kg on dry weight basis and one meter in length. These bundles were soaked in water for 48 hours and allowed for partial fermentation. Later, five such bundles were placed as a first layer in parallel to crop rows and paddy straw spawn (each weighing 25g) was spread uniformly over the beds leaving equal distance. Over spawn layer, 25g of sterilized horse gram powder were distributed uniformly. Repeat the procedure for other four layers and cover the beds at the end. These beds were placed in maize crops in alternate rows to facilitate irrigation and maintain 60 cm spacing between the beds. The spacing adopted for maize is 25 cm in between the crop and 60 cm between the rows. In each plots (5 x 6m), uniformly 20 beds were placed for experiments. *Field experiments:* The experiments were conducted in a randomized block design with six treatments and replicated four times. The matured mushrooms were harvested at egg stage as shown in Figure 1 and weight was measured on fresh weight basis. Based on the fresh weight of mushrooms, biological efficiency was estimated at the end of the third harvest. The biological efficiency (%) is (total weight of fresh fruiting bodies/25 kg of dry weight of substrate) × 100 (Yue-Lian and Qing-Fang, 2011). The weather variables such as temperature and relative humidity were recorded using portable weather recording instrument (Make: Tinytag, USA).In addition, weed population and dry weight was recorded periodically to study the weed suppressing ability of mushroom beds that act as mulching materials. The data were statistically analyzed based on the method suggested by Gomez and Gomez (1984).

RESULTS

Effect of substrates and locations on yield of paddy straw mushroom

The average yields of paddy straw mushrooms from a single mushroom bed were invariably higher in paddy straw substrates in all the three locations. Among the locations, the average yield of mushroom was significantly higher at Ln3-Erode (4.34 Kg Bed^{-1}) (Fig. 2). The yield of mushrooms grown with maize and sorghum stalks substrates were significantly on par in all the three locations. The yield of mushrooms grown with banana psedostem was significantly recorded lower

Table 1: Influence of mushroom bed on total weed population (No./m^2) in maize field

Substrates	Before laying of mushroom bed			30 Days after treatment			60 days after treatment		
	Ln1	Ln2	Ln3	Ln1	Ln2	Ln3	Ln1	Ln2	Ln3
Paddy straw	15.1	17.2	15.6	14.2	11.4	12.2	7.76	9.75	10.5
Wheat Straw	17.4	17.3	15.4	12.3	9.94	12.7	6.8	8.82	8.15
Banana pseudostem	14.9	16	13.9	13	9.35	8.6	6.21	8.36	6.62
Sugarcane trash	14.1	17.8	15.2	14.3	16.5	8.91	4.77	5.52	6
Maize stalks	14.2	15.9	12.8	14	13.4	8.32	4.63	4.08	5.58
Sorghum stalks	15.2	15.9	15.7	12.1	9.03	7.28	4.53	2.67	5.28
Control	16.1	16.9	17.7	18.9	27.3	21.1	25.3	33.7	21.4
SEd	1.84	2.84	2.58	1.9	1.16	1.24	1.1	1.47	1.13
C.D (p=0.05)	NS	NS	NS	4	2.44	2.6	2.32	3.08	2.37

Table 2: Influence of mushroom bed on weed dry weight (g/m^2) in maize field

Substrates	Before laying of mushroom bed			30 Days after treatment			60 days after treatment		
	Ln1	Ln2	Ln3	Ln1	Ln2	Ln3	Ln1	Ln2	Ln3
Paddy straw	60.5	63.9	60.4	11.4	22	25.9	16.9	15.9	20.2
Wheat Straw	60.5	65.1	62.9	9.9	20.5	23.5	14.9	14.8	18.5
Banana pseudostem	61.1	54.5	48.8	9.4	19.2	13	13.8	12	11.8
Sugarcane trash	49.2	49.8	47.9	14.5	11.1	18.4	8.8	9.8	8.2
Maize stalks	46.3	53	47.2	13.4	10.7	11.2	10.2	7.4	7.9
Sorghum stalks	47.2	61.5	49.9	9	6.9	9.9	10	6.8	7.9
Control	56.5	60	61.4	27.3	42.9	36.2	29.4	48.2	30.1
SEd	6.67	7.98	6.74	1.92	2.25	2.72	1.47	2.64	2.22
C.D (p=0.5)	NS	NS	NS	4.03	4.73	5.71	3.09	5.55	4.66

Figure 1: Egg stage of paddy straw mushroom ready for harvest

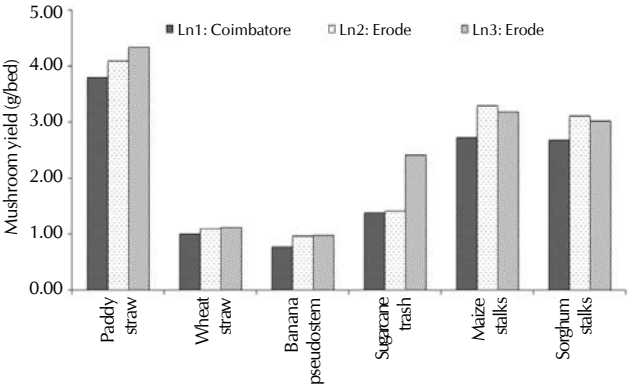

Figure 2: Effect of substrates and locations on the average yield of *Volvariella volvacea* (Kg bed^{-1})

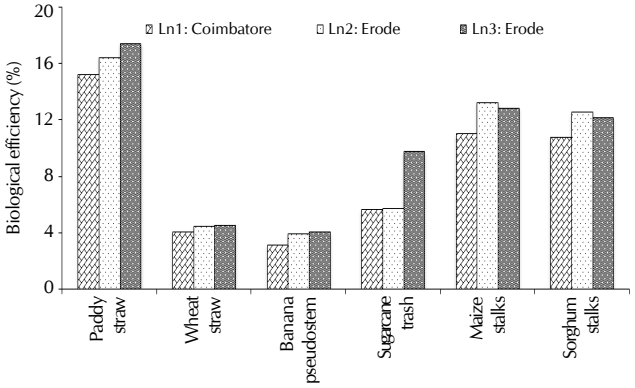

Figure 3: Biological efficiency of *Volvariella volvacea* in different crop substrates

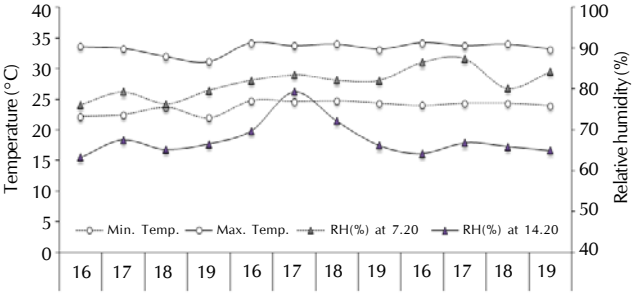

Figure 4: Weather prevailed in maize crop canopy in respective meteorological standard weeks

that ranged from 0.78 to 0.99 Kg Bed^{-1}at the end of the third harvest. The biological efficiency was also higher in paddy straw substrates in all the three locations, which is ranged from 15.2 to 17.4 per cent (Fig. 3). However, the biological efficiency was lower at mushrooms grown with wheat straw substrates that are ranged between 4.0 to 4.5 percent.

Effect of mushroom beds on weed population and weed dry weight

The growing paddy straw mushroom on different substrates as mushroom beds are act as mulching material and thus suppress the weed growth. The results were not significant at the time of laying mushroom beds in all the locations. The paddy straw mushroom grown with sorghum stalks substrate was significantly recorded minimum total weed population in all the locations at 30 days after the laying of mushroom beds. The reduction of weed population at this stage was ranged from 7.28 to 12.1 No.m^{-2} (Table 1). In particular, the weed population was minimum (7.28 No. m^{-2}) at location Ln3 Erode, which is on par with mushroom beds prepared with banana pseudostem, sugarcane trash and maize stalks substrates. In contrast, maximum weed population was recorded under control treatment in all the locations, where mushroom beds was not laid. The average reduction of weed population in all the three locations at 30 days after the placing of mushroom beds are ranged from 42.1 to 65.5 per cent lower as compared with control. Similar results were also obtained in the case of weed population at 60 days after mushroom bed introduction. Similarly, weed dry weight was comparatively lower in the case of growing paddy straw mushroom with sorghum stalks substrates at 30 days after introduction of mushroom beds, where the reduction was ranged from 6.9 to 9.9g m^{-2} (Table 2). In particular, minimum weed dry weight was recorded under location Ln2 Erode (6.9g m^{-2}). Similar results were obtained in 60 days after the introduction of mushroom beds. The reduction in weed dry weight at specific site ranged from 32.9 to73.8 per cent at 60 days after the introduction of mushroom beds.

DISCUSSIONS

Effect of substrates and locations on yield of paddy straw mushroom

The average yields of paddy straw mushrooms were invariably higher in paddy straw substrates in all the three locations. The higher yield was influenced as a result of favourable microclimate condition prevailed in Ln3-Erode under maize crop canopy. The microclimate prevailed in other locations are not equally favoured the growth of mushroom. Thus, yield is comparatively lower in other two locations. The higher temperature and relative humidity prevailed in Ln3-Erode at the time of study would favour growth of paddy straw mushroom. The warm humid climate conditions that are prevailed at Ln3-Erode during study period would favour mushroom growth and yield. The results were clearly indicated that optimum weather requirement are prevailed under maize

crop canopy especially in Ln3-Erode which are not same in other two locations, which are specifically influenced externally by regional weather prevailed during the study period. In location Ln3-Erode, monthly average minimum and maximum temperature was recorded as 22.5and 32.5°C respectively (Fig. 4). Similarly, monthly average morning and evening relative humidity was 77.8 and 65.6 percent respectively. This optimum weather for growing mushrooms is supported by earlier findings (Krishnamoorthy *et al*., 2005). Krishnamohan (1975) also reported that paddy straw mushroom grows well at 30-35°C temperature with humidity of more than 80% throughout the day.

The paddy straw substrates are generally rich in lignocellulose, would support growth of *Volvariella volvacea*. Chang and Yee (1977) and Philippoussis *et al*., (2001) reported that the mushrooms are respond high with lignocelluloses substrates based on their biological efficiency. Although sorghum stalks, maize stalks, sugarcane trash, dried banana leaves and pseudostem contain lignocelluloses similar to paddy straw, the reduced performance of the mushroom in these substrates might be related to high nitrogen content and bulk density; and poor water holding capacity of the substrates. Similar findings were also reported that substrates with higher nitrogen substrates would affect the growth of mushroom fungi (Nallathambi (1991) and Krishnamoorthy (1995). Randle (1981) established a negative relationship between bulk density and water holding capacity of the substrates plotted against mushroom yield. Similarly, biological efficiency of growing paddy straw mushroom under crop canopy was comparatively lower than mushrooms that are grown under specialised growth chambers. Similar finding was also reported in paddy straw mushroom (Manoharan *et al*., 2004).

Effect of mushroom beds on weed population and weed dry weight

The reduction in weed dry weight might be primarily be due to effect of crop substrates as mushroom beds that act as mulching materials. Poor infiltration of sunlight for the growth of weed flora would create unfavourable conditions. Kadirvelu and Rajan (1970) reported that trash mulching controlled the grassy weeds like nut sedge and Bermuda grass. Similar findings were also reported with sugarcane trash mulching (Nagarajan and Wahab, 2001) and crop residues as mulching materials (Purvis *et al*.,1985), which has suppressing ability on weeds and or arrest the germination of different weed seeds from the soil (Singh and Ghosal, 2015). Similarly, suppressing ability of different organic mulching materials on weeds were also reported in potato (Kumar *et al,* 2015) and vegetable cowpea (Sah *et al*., 2015).

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