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MYCELIAL GROWTH PERFORMANCE OF PADDY STRAW MUSHROOM (*Volvariella volvacea*) IN BANANA WASTES

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Abstract — Saba banana (*Musa balbasiana*) is a nutritious and the most popular banana in the Philippine market. Once utilized, its fruit generates a huge amount of agricultural waste. On the other hand, the paddy straw mushroom (*Volvariella volvacea*) was known as one of the most cultivated mushrooms in the world due to its nutrients and pleasant flavor. This study aimed to determine the paddy straw mushroom mycelial production in banana (peeling, leaves, and pseudostem) wastes media. Banana wastes media were prepared by decocting banana parts tap water to produce 50% and 100% concentrations of decoction, adding 20 g of white gulaman bar and 10 g of white table sugar until the homogenous solution was attained; pH was adjusted into pH 8 using NaOH and HCl. For sterilization, the media was autoclaved for 20 minutes at 121°C /15 psi. Mycelial growth and density of *V.volvacea* were evaluated in different banana wastes media namely: T1: Coconut water, T2: Decocted Banana Peeling (50%), T3: Decocted Banana Peeling (100%), T4: Decocted Banana Leaves (50%), T5: Decocted Banana Leaves (100%), T6: Decocted Banana Pseudo stem (50%) and T7: Decocted Banana Pseudo stem (100%). Data was analysed using the Completely Randomized Design. At an average temperature of 28.6°C and 74.77% relative humidity, paddy straw mushrooms showed the highest mycelial run in T4 compared to other banana wastes media. The T2 and T3 were noted with the thickest mycelia among all evaluated media. T4 was recorded with the shortest period of ramification within 3 days and was considered as the ideal culture media for paddy straw mushroom among banana wastes media since the faster the mycelial grows, the quicker the mushroom production. Among the media tested, the T4- 50% of banana leaves extract is the ideal alternative media for *V. volvacea* mycelial production.

Keywords — ***Musa balbasiana*****, mycelial density, mycelial growth performance, *Volvariella volvacea.***

INTRODUCTION

Mushroom cultivation is a very reliable and profitable option to alleviate hunger and malnutrition in the world (Rashid et al., 2016). Various regions, particularly America, Central Europe, and South-East Asia are known to cultivate different species of mushrooms that are used as sources of food rich in vitamins and minerals utilized by the human body. Due to its known benefits both to humans and the environment, production levels of these saprophytes radically increased over the years. The growing awareness for nutritive and quality foods in the health-conscious world population has resulted in the demand for the mushroom to rapidly rise, with its cultivation practice growing worldwide.

Volvariella volvacea, also known as paddy straw mushroom is one species of edible macrofungi that are considered the third most important cultivated mushroom in the world due to its pleasant flavor and taste (Thiribhuvanamala et al., 2012). As stated by Huo et al. (2017), the market demand for *V. volvacea* has rapidly increased because of its unique flavor and texture prompting markets from all over the world to use it as a fresh dietary mushroom. Along with its unique culinary properties, this particular species is known to contain high levels of nutrients and minerals necessary for a balanced diet in humans. For instance, its protein and fat contents range between 25.9–29.6% and 2.24–3.6% per 100 g of dried fruiting bodies of *V. volvacea* (Hung et al. 2010). Additionally, it is rich in amino acids and fiber, and vitamin C content is significantly higher than that of many vegetables and fruits (Han, 2005).

However, problems in cultivating *V. volvacea* are associated with the practice and materials used. Like other species of mushroom, *V. volvacea* requires a specific set of materials and nutrients to support its growth. As reported by Bao et al. (2013), the biological efficiency of *V. volvacea* is only 15% on straw-based substrates and 30–40% on cotton-waste composts. As stated by Ukoima et al. (2009), *V. volvacea* performs a high mycelial growth on fibrous plant extract culture media. Organic materials containing a high amount of holocellulose, cellulose, and fiber are recognized as materials that support the growth and development of the genus *Volvariella.* Taking all of these into account, this study aims to promote the usage of banana wastes in cultivating *V. volvacea.*

Banana is considered one of the most important fruits in the world. In the Philippines, saba banana (*Musa balbasiana)* is the most popular cultivar grown domestically which accounts for 39% of total banana production (Castillo et al., 2015). In the Bicol region, Camarines Sur is known as the top banana producer with a 44.95% share of the region's total production (Philippine Statistics Authority, 2018). De Castro and Arenillo (2016), states that the average annual yield of the Philippines in saba banana is 9.4 ton/ha while big plantations produce about 40 ton/ha. As part of the Filipino diet, these bananas constitute a large part of the local cuisines of the country. Various dishes and desserts are known to use saba banana as an active ingredient due to its high availability and cheap price.

Even with their high economic and nutritional value, these bananas also produce a large quantity of agricultural waste that can be utilized for various biological and ecological endeavors. These agricultural wastes can be considered with significant potential for mushroom cultivation. While viewed as waste, these banana parts contain materials and nutrients that are needed by mushrooms for proper growth and development. This study aims to determine the efficiency of various banana parts including banana peelings, leaves, and pseudostems in

the production of paddy straw mushroom to improve yield and overcome the gap of malnutrition as its cultivation will provide a cheap source of nutrients and minerals needed by mankind.

MATERIALS AND METHODS

Source of Materials

The tissue culture of paddy straw mushroom was obtained from the Laboratory of Central Bicol State University of Agriculture-Sipocot Campus, Impig, Sipocot, Camarines Sur. The *V. volvacea* was cultured in a coconut water culture media and incubated for 7 days to allow mycelial growth. The cultures served as an inoculant in the evaluation of the media.

On the other hand, banana peels were gathered in front of CBSUA-Sipocot Campus from the sidewalk vendors of staple banana cuisine. Then, banana leaves and pseudostem were collected in the vicinity of CBSUA -Sipocot. Banana wastes were taken after the harvest of banana fruits.

Materials Used

This study used banana peeling, banana leaves, and banana pseudostem for culture media production along with coconut water as control media. One liter of tap water was used as a base for banana wastes decoction.

Preparation of Culture Media

Five hundred grams (for 50%) and one thousand grams (for 100%) of banana leaves, pseudostem, and banana peeling (ripe) were boiled for 10 minutes in one liter of tap water. Then, it was strained with clean cheesecloth to remove impurities. Subsequently, it was volume up to attain one liter of solution. Afterward, 20 grams of white gelatin bar and 10 grams of white table sugar were added to the solution. It was boiled until the solution was homogenized. Then each solution was placed in a clean Erlenmeyer flask, sealed with a cotton plug and secured with aluminum foil. Before sterilization, the pH was adjusted to pH 8 since, according to Reyes et al. (1998), paddy straw mushroom grows luxuriantly at pH 8 under dark and sealed conditions. Finally, it was autoclaved for 20 min at 121°C /15 psi.

Also, one liter of matured coconut water was added with 20 g of white gulaman bar. It was boiled until a homogenized solution was attained. Then it was placed in a clean Erlenmeyer flask, sealed with a cotton plug and aluminum foil. Prior to sterilization, pH was adjusted at pH 8. Then it was sterilized for 20 min at 121°C/ 15 psi. Coconut water was not added with white table sugar since according to Santoso et al. (1999), matured coconut water contains 92 % sucrose which makes it suitable for mycelial cultivation. Also, it was used as the control for the study of Bellere et al. (2017).

Plating and Inoculation of Paddy Straw Mushroom

The newly sterilized media was dispensed in a sterilized Petri plate until it solidifies. Then, using a sterile cork borer, seven days old 10 mm mycelial block was inoculated at the center of the media with three replications each. Subsequently, it was sealed with cling wrap.

Incubation and Ramification of Paddy Straw Mushroom Culture

The newly inoculated media was stored in a dark cabinet at room temperature since according to Sahoo (2014), *V. volvacea* grows well in dark conditions. The culture media was incubated until it was fully ramified.

Evaluation of Mycelial Growth Performance of Paddy Straw Mushroom in Culture Media

The mycelial growth performance of paddy straw mushroom in banana waste media was evaluated through its mycelial increment, thickness, and incubation period observed daily along with the temperature and relative humidity every 7:00 am, 12:00 pm, and 5:00 pm. The mycelial increment was determined by measuring the continuous growth of mycelia until it fully ramified the media. Its thickness and incubation period were observed to identify the ideal banana waste culture media. The gathered data were evaluated statistically using T-test and Analysis of Variance (ANOVA) and were presented separately according to the concentration.

Experimental Design

Completely Randomized Design (CRD) was employed in setting up the treatment that was replicated thrice. The treatments are:

T1- 1L CW + 20g GB
T2- 500g BP + 10g WTS + 20g GB + 1L TW
T3- 1000g BP + 10g WTS + 20g GB + 1L TW
T4- 500g BL + 10g WTS + 20g GB + 1L TW
T5- 1000g BL + 10g WTS + 20g GB + 1L TW
T6- 500g BPs + 10g WTS + 20g GB + 1L TW
T7- 1000 BPs + 10g WTS + 20g GB + 1L TW

Note: CW – Coconut Water, BP – Banana Peel, BL- Banana Leaves, BPs- Banana Pseudostem, WTS- White Table Sugar, GB- Gulaman Bar, TW- Tap Water

RESULTS AND DISCUSSION

Mycelial Growth Performance of Paddy Straw Mushroom

Mycelia refer to the vegetative part of a fungus which consists of a mass of branching and thread-like hyphae (Bellere et al., 2017). The nutritional content of the media can affect the growth of mycelia since according to Liebig's Law of Minimum if any of the required nutrients was unavailable, the organism cannot reach its full potential.

At 100% concentration, the first day of observation CW recorded with the highest mycelial run of 13.08 mm. Followed by BL (T5) with 6.08 mm, 2.58 mm of BPs (T7), and BP (T3) with the lowest mycelial run of 2.25 mm. On the second day, CW (T1) has shown the highest mycelial run of 15.34 mm compared to the BL (T5) with 9.25 mm, 6.09 mm of BPs (T7), and BP (T3) with the lowest mycelial run of 3.83 mm. During the third day of incubation, paddy straw mushroom has performed the highest mycelial increment to the CW (T1) with 10.5 mm, followed by BL (T5), BP (T3), and lastly BPs (T7) with 10.34 mm, 6.92 mm, and 3.75 mm respectively. In considering the mycelial density, the BP (T3) was recorded with the thickest mycelia from the first to the third day of observation compared to the other media.

Table 1. Mycelial Growth Increment of Paddy Straw Mushroom (100%).

Treatment	Day 1		Day 2		Day 3	
	Mean	MD	Mean	MD	Mean	MD
T1	13.08	+	15.34	++	10.5	++
T3	2.25	++	3.83	+++	6.92	+++
T5	6.08	+	9.25	+	10.34	+
T7	2.58	+	6.09	+	3.75	+

Note: MD stands for Mycelial Density and the lowest degree marked as + of mycelial thickness, intermediate degree marked as ++, and the highest degree marked as +++ of mycelial thickness (Razak et al., 2012)

During the incubation period, CW has shown the fastest mycelial run among other media. The ability of the coconut water to stimulate fast mycelial growth of paddy straw mushroom can be attributed to its high sugar content since according to Santoso et al. (1999), it contains 92% of sucrose making it suitable for cultivating mycelia. In considering the mycelial density, BP 100% has the thickest mycelia among others which can be associated with its high concentration of Potassium, Manganese, Calcium, and Iron (Anhwange, 2009). The banana peeling's high nutritive value could be the reason for it to sustain the mycelial run.

Table 2. Mycelial Growth Increment of Paddy Straw Mushroom in (50%).

Treatment	Day 1		Day 2		Day 3	
	Mean (mm)	MD	Mean (mm)	MD	Mean (mm)	MD
T2	4.58	++	5.17	+++	11.17	+++
T4	10.42	+	13.25	+	14.33	+
T6	4.67	+	6.58	+	12	+

Note: MD stands for Mycelial Density and the lowest degree marked as + of mycelial thickness, intermediate degree marked as ++, and the highest degree marked as +++ of mycelial thickness (Razak et al., 2012)

On the other hand, during the first day of observation BL (T4) had the highest mycelial run of 10.42 mm. The BPs (T6) followed by 4.67 mm and with the lowest mycelial run of 4.58 mm the BP (T2). On the second day of incubation, the BL (T4) was noted with the highest mycelial run of 13.25 mm. Then, BPs (T6) followed with 6.58 mm and BP (T2) with the lowest mycelial run of 5.17 mm. On the third day, the BL (T4) remained with the highest mycelial run of 14.33 mm followed by BPs (T6) with 12 mm while BP was noted with the lowest mycelial run of 11.17 mm. In the comparison of mycelial density, BP (T3) has the thickest mycelia among other media.

The BL (T4) had the highest mycelial run from first to the third day of incubation. The capacity of banana leaves to sustain mycelial growth to paddy straw mushroom can be attributed to its distinctive nutritional content of cellulose, lignin, starch, and lipophilic extractives in leaf sheaths (Oliviera et al., 2007). Additionally, Rahman (2014, claimed that it contains cellulose, ash, and pentose sugar on the banana stalk. The presence of these chemicals can be the reason for the fast mycelial run of paddy straw mushroom in banana leaves.

Meanwhile, shown in Table 3, the CW (T1) was recorded with the shortest period of incubation within three days among treatments. While the BL (T5), BP (T3), and lastly BPs (T7) were fully colonized within 4, 5, and 11 days respectively. The short period of a full ramification of *V. volvacea* on coconut water media can be attributed to its high sugar content (Santoso et al., 1999).

Table 3. Number of Incubation Period of Paddy Straw Mushroom in Banana Wastes Media (100%).

Treatment	Number of Days of Full Ramification
T1 – Matured Coconut Water	3
T3 – Banana Peel (100%)	5
T5 – Banana Leaves (100%)	4
T7 – Banana Pseudo stem (100%)	11

The data in Table 4 revealed that the Coconut Water (T1), and BL (T4) have a shorter period of incubation within three days while the BP (T2) and BPs (T6) were fully ramifies for five days.

Table 4. Number of Incubation Period of Paddy Straw Mushroom in Banana Wastes Media (50 %)

Treatment	No. of Days of Full Ramification
T1- Coconut Water	3
T2 – Banana Peel (50%)	5
T4 – Banana Leaves (50%)	3
T6 – Banana Pseudo stem (50%)	5

The fast colonization of *V. volvacea* in coconut water and banana leaves can be associated to the nutritional content of banana leaves since it contains higher amount of cellulose, lignin (Oliviera et al., 2007) and sugar (Rahman, 2014) that can support mycelial growth.

Table 5. Summary of the Significant Difference on Daily Mycelial Run of Paddy Straw Mushroom in Banana Wastes Media (100%).

No. of Days	F-Test Value	Decision	Interpretation
Day 1	0.002	Accept	No Significance
Day 2	0.002	Accept	No Significance
Day 3	0.025	Accept	No Significance

Level of Significance= .05
Critical F-test Value = 4.07

Based on the data showed in table 6, the daily mycelial run was found to be not significantly different since the computed F-test value of 0.002 for Day 1, 0.002 for Day 2 and 0.025 for Day 3 showed that it is lesser than the critical F-value of 4.07.

Subsequently, the computed F-test value of daily mycelial run of paddy straw mushroom in banana wastes media with 100% concentration was found to be lesser than the critical F-value. This means that the null hypothesis was accepted that there is no significant difference in the daily mycelial run of paddy straw mushroom in a 100% concentration of banana wastes media.

Therefore, the data proposed that the banana wastes media in 100% concentration can be used as an alternative culture media for paddy straw mushroom production.

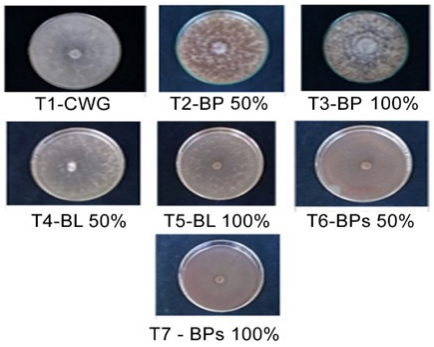

Fig.1. Fully ramified banana waste culture media of paddy straw Mushroom.

Table 6. Summary of the Significant Difference on Daily Mycelial Run of Paddy Straw Mushroom in Banana Wastes Media (50%).

No. of	F-Test	Decision	Interpreta-
Day 1	0.02	Accept	No Significance
Day 2	0.09	Accept	No Significance
Day 3	0.61	Accept	No Significance

Level of Significance =0.05
Critical F-test Value=5.14

It was shown in the Table 6 that the daily mycelial run of paddy straw mushroom in banana wastes media with 50% concentration was not significantly different based from the computed F-Test value of 0.02, 0.09, and 0.61 for Day 1, Day 2, and Day 3 respectively wherein it was noted to be lesser than the critical F-value of 5.14.

The computed F-Test value of the daily mycelial run was found lesser than the critical F-value. Thus, the null hypothesis was accepted that is there is no significant difference in the mycelial run of paddy straw mushroom in 50% concentration of banana wastes media. Thus, these findings suggest that the banana wastes media in 50% concentration can be utilized as an alternative culture media for paddy straw mushroom production.

CONCLUSION

The study elucidated that paddy straw mushroom grows at an average temperature of 28.6°C and 74.8 % relative humidity. Among all banana waste media, banana leaves (100% and 50% concentration) have shown the highest mycelial increment within three days of observation. Additionally, BP (T2) and BP (T3) solution showed the thickest mycelial density as compared with the rest of the banana waste media that elucidated thin mycelial density, likewise, both BL (T5) and BL (T4) generates the shortest days of incubation. Therefore, banana leaves were considered as an ideal culture media for paddy straw mushroom among the evaluated banana wastes in terms of the number of days of incubation. Moreover, evaluated *saba* banana parts can be utilized as an alternative culture media for paddy straw mushroom production.

Some recommendations have been crafted; adjusting the range of temperature within 30-35°C for favorable temperature for paddy straw mushroom during incubation, utilize other variety of banana for cultivating paddy straw mushroom, utilize saba (*Musa balbasiana*) banana leaves as a culture media in the cultivation and production of other varieties of mushroom, and use a mixture of saba banana parts with high amounts of nutrients in producing alternative culture media for cultivating paddy straw mushroom.

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