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Effect of Substrate Quantity and Shelf Position on Yield of Oyster Mushroom (*Pleurotus sajor caju*)

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Abstract: An experiment was conducted in Harare (Zimbabwe) in 2004 to investigate the effect of substrate (wheat straw) quantity and shelf position on yield of oyster mushroom (*Pleurotus sajor-caju*) using plastic tray culture. The experiment was laid out as a 2-way factorial in a randomized block design with five substrate quantities (2, 4, 6, 8 and 10 kg of wheat straw per tray) and two shelf positions (0.5 and 1.2 m above ground). Mushroom yield increased with an increased substrate quantity of up to 6 kg and thereafter remained constant. Shelf position had no significant effect ($p>0.05$) on mushroom yield and there was no interaction ($p>0.05$) between substrate quantity and shelf position on yield. Biological efficiency decreased with an increase in substrate quantity per tray. It was concluded that 6 kg of substrate per tray (50×35 and 20 cm deep) would result in optimal yields. The height above the ground at which trays are placed in the growing room does not affect mushroom yields.

Key words: Oyster mushroom, tray culture, substrate quantity, yield, biological efficiency

INTRODUCTION

Oyster mushrooms (*Pleurotus* spp.) are one of the choice edible mushrooms that can be cultivated in the tropics (Quimio *et al*., 1990). Oyster is considered to be one of the most efficient producers of food protein, producing about 30% of its dry weight as protein (Ogundana and Okogbo, 1981) and is an excellent source of dietary fibre. The mushroom is not only considered nutritious, but it also has medicinal properties like anticancerous, anticholestral and antitumorous (Shah *et al*., 2004) and is also useful against diabetes, ulcer and lung diseases (Quimio, 1976).

The cultivation technique for oyster is simple and cheap due to the availability of growing substrates (Hal Ju, 1994). Oyster can grow on most of hardwoods, wood by-products (sawdust, paper pulp) and all cereal straws (corn, corn cobs, banana fronds), cotton seed hulls and other forest materials too numerous to mention and difficult to imagine possible (Oei, 2003). After the crop cycle is complete, the remaining substrate can be used as feed for cattle, chickens and pigs and in the end, the remaining myceliated substrate is an excellent ingredient for building composts and new soil and to generate nematicides (Dietzler, 1997).

In Zimbabwe the cost of animal sources of protein (mainly beef and chicken) is high and far beyond the reach of most of the low and middle-income families. There is need to explore technologies that maximise the production of alternative but less expensive, sources of protein. Oyster mushroom has the credentials to be one of the crops that, when made readily available, could play the role of an alternative protein source. This is because oyster mushroom can provide cheap protein when grown on a substrate of locally available low cost inputs. Oyster can be produced in Zimbabwe using plant or crop residues or agricultural and industrial waste. These wastes can be recycled into food and the environment may be less endangered by pollution (Hayes, 1978). In urban areas, sawmill products (sawdust) can be used as the substrate while in the rural areas mushroom producers can utilise veld grasses or graminaceous crop residues. Wheat is grown in most regions of Zimbabwe and wheat straw can provide a cheap and readily available substrate for oyster mushroom cultivation.

As in China, the major producer of oyster mushroom (The Pennsylvania State University, 2003), the common method of cultivating oyster mushroom in Zimbabwe is bag culture which requires bulk substrate. Tray cultivation has been used elsewhere with varying degrees

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of success for the production of Oyster and Shiitake mushrooms (Oei, 2003). The plastic tray culture method offers opportunities to intensify mushroom production in Zimbabwe. Plastic trays are stacked on shelves in the mushroom room from floor to the roof. The amount of substrate required to optimize production has not been established. The objectives of this study were to determine the quantity of substrate that would maximise mushroom production and to determine the effect of tray position (height from the floor) on yield of oyster mushroom.

MATERIALS AND METHODS

The research project was conducted in Harare (Zimbabwe) in 2004. The experiment was organized as a 2×5 factorial in a Randomized Complete Block Design to test the effect of substrate quantity (2, 4, 6, 8 and 10 kg of wheat straw/tray) and shelf position (0.5 and 1.2 m above the ground) on yield of oyster mushroom (*Pleurotus sajor-caju*). The treatments were replicated four times with each side of the growing room being used a block.

A 4×4 m room made of wooden walls and covered with a black plastic sheet on the floor, walls and roof, was used. A layer of 10 cm peat sand was spread evenly on the floor and the room was disinfected with Sodium hypochloride (jik solution). A footbath prepared using Sodium hypochloride was placed on the doorstep. Chopped wheat straw (5 cm long) soaked over night in clean water and pasteurized for three hours (intermittently stirred using sterilized garden fork) was used as the substrate after cooling to room temperature (25°C).

Temperatures were maintained below 40°C to avoid killing the mushroom mycelium. An amount of 240 kg of substrate was thoroughly mixed with 6 kg of spawn. Plastic trays (50×35 and 20 cm deep), sterilized with Sodium hypochloride were filled with the five different levels of substrate quantities and covered with black plastic sheets tied at the openings. Small holes were made on the plastic sheets for drainage and aeration before the trays were placed randomly on the shelves. The room was sprayed daily with clean water on the floor at two hour intervals to maintain a relative humidity of not below 80% so as high to minimize drying of the compost surface or the spawn. The trays were left in a dark room for four weeks after which the black plastic sheets were removed from trays, light introduced using an in florescent bulb and fresh air introduced to lower carbon dioxide concentration. Mature mushrooms were harvested by twisting the fruit body and plucking it from the trays. Mushroom fresh weight measurements were done immediately after harvest.

Analysis of variance (ANOVA) using Minitab Version 12 Statistical package (1998) was performed on yield from the first flush, yield from the rest of the flushes and total yield from all the flushes and on biological efficiency (fresh weight of mushrooms/fresh weight of substrate) (Gaitan-Hernandez and Mata, 2004) of the different amounts of substrate.

RESULTS AND DISCUSSION

Harvesting and yield: Pinhead formation started a day after the removal of the plastic bags covering the trays. The mushroom crop grew in cycles called flushes or breaks. These flushes came in seven to ten day intervals with each successive flush bearing fewer mushrooms. The first flush accounted for about 64% of the total harvested mushroom, with the other three flushes contributing towards the remaining 36%. The fact that the first flush contributed the most towards total yield means that it is the most important in oyster mushroom production. The decrease in yield with successive flushes is well documented (Choi, 2003; Hamlyn, 1989; Shah *et al.*, 2004; Zervakis, 2005). Choi (2003) accredits this decrease to the vitality of the spawn which decreases with successive flushes. This is indicative of the nutrient release pattern: most of the nutrients are released in the first crop and thus, to optimize on yields, these should be well-managed.

Mushroom yield: Shelf position had no significant effect ($p>0.05$) on yield in all the flushes as well as on total yield. There was no interaction ($p>0.05$) between substrate quantity and shelf position for both flushes and on total yield. However, mushroom yield increased with increased substrate quantity of up to 6 kg wheat straw and thereafter remained constant. This trend was consistent for yield from the first flush, yield from the rest of the flushes combined and on total yield. Using lower substrate quantities of either 2 or 4 kg resulted in significantly lower yield compared to substrate quantities of 6, 8 or 10 kg wheat straw per tray. Yield increases of between 33 and 74% were obtained when substrate quantity was increased from 4 to 6 kg wheat straw per tray (Fig. 1-3).

The decrease in mushroom yield when the substrate quantity was lowered below 6 kg wheat straw per tray is most likely attributable to earlier depletion of nutrients with limited substrate quantity as supported by Choi (2003). It is also apparent from the results that increasing substrate quantities above 6 kg per tray did not result in increases in mushroom production and will be wasteful of time and labour. From the results of the study, it would

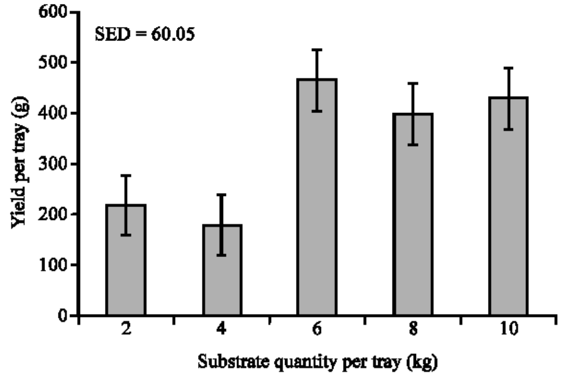

Fig. 1: Effect of substrate quantity on the yield of the first flush [Error bars on the graph are ± standard error of the difference (SED)]

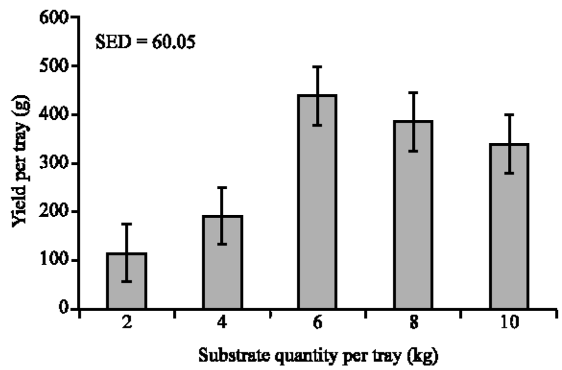

Fig. 2: Effect of substrate quantity on the yield of the rest of the flushes [Error bars on the graph are ± standard error of the difference (SED)]

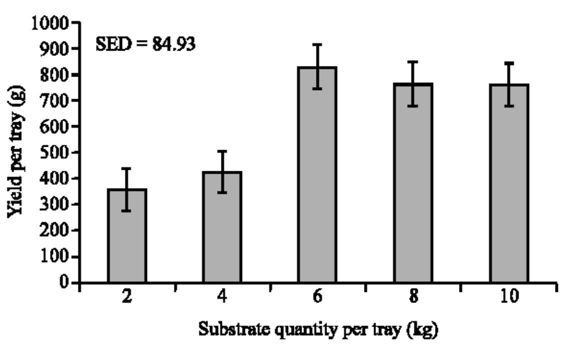

Fig. 3: Effect of substrate quantity on total yield [Error bars on the graph are ± standard error of the difference (SED)]

seem that, with the sizes of the plastic trays and spawn inoculation dosage used, 6 kg wheat straw per tray allowed maximum production of fresh mushroom. When wheat straw quantity was less than 6 kg, organic materials were limiting, hence the total fresh mushroom yield.

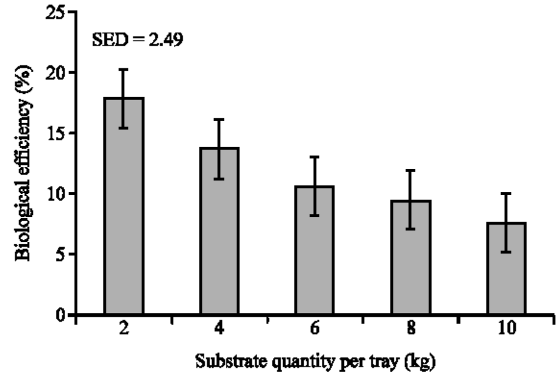

Fig. 4: Biological efficiency of the different substrate quantities [Error bars on the graph are ± standard error of the difference (SED)]

Biological efficiency: Biological Efficiency (BE), the quantity of fresh mushroom produced per unit quantity of substrate, significantly decreased ($p<0.01$) from 17.9 to 7.6% when substrate quantity was increased from 2 to 10 kg per tray (Fig. 4). There was no statistical difference in BE when 4, 6 and 8 kg of substrate were used per tray (Fig. 4). The higher efficiencies at low substrate quantities imply more thorough substrate utilization by the mushroom to produce mushroom fresh weight. As substrate quantities increased, substrate utilization decreased, either because space within the tray became limiting or other factors, like the greater humidity levels within the substrate mass at higher substrate quantities.

Although there were no statistical differences in BE from 6 to 10 kg of substrate per tray, it is noticeable (Fig. 4) that BE decreased as substrate quantity was increased. It would seem from these results, in which mushroom production did not increase with increase in substrate quantity above 6 kg per tray, that decreasing efficiency of the substrate with increasing substrate quantity would mean that less and less mushroom is being produced per unit weight of substrate. This explains why mushroom yield remained statistically similar above 6 kg of substrate per tray. From the results of the study, the decrease in efficiency as substrate quantities were increased above 6 kg per tray, nullified the effect of increasing quantities of substrate beyond 6 kg per tray.

At 6 kg of substrate per tray it was concluded that this quantity of substrate results in optimum utilization of the substrate to produce fresh oyster mushroom in this study. Although higher BE's were obtained with lower substrate levels than the 6 kg per tray, they did not lead to maximum production. This shows that in determining substrate quantities to use for mushroom production in trays, BE must be considered only in relation to the substrate quantities that will result in maximum production. This is because, as observed in this experiment, very low quantities of substrate will result in higher BE, but the organic materials that will be available for conversion into mushroom fresh weight will limit production. An optimum level of substrate quantity, for a given tray size, that will produce the highest yield of fresh mushroom without necessarily achieving the highest BE, must be determined and recommended to farmers.

Shelf position had no significant effect ($p>0.05$) on BE and there was no significant interaction ($p>0.05$) between substrate quantity and shelf position on BE. This may imply that relative humidity was uniformly distributed within the growing room from the ground upwards. It had been expected that there would be more mushroom yield on the bottom shelves, which were nearer to the ground/floor where the water was constantly applied and hence higher relative humidity. This demonstrates that farmers can stack as many shelves as possible without any yield reductions from the trays on different heights from the ground (different shelf positions).

The common method of cultivating Oyster mushroom in Zimbabwe is the bag culture method, which requires bulk substrate of 20 to 25 kg per bag (Tiffin, 2000). This means that a lot of substrate and space is required to successfully grow oyster mushrooms using the bag culture method. The tray culture method, which saves both on the amount of substrate used and space needed, can be a better alternative than the bag culture method. The tray method would effectively use up all the space in a room by stacking the trays all the way to the top of the growing room. Reduced substrate utilization would reduce the competition between livestock (livestock feed) and mushroom cultivation for wheat straw. Less substrate will also mean less time and labour needed to collect, chop and prepare the substrate, hence more economical.

CONCLUSIONS

Since oyster mushroom cultivation using the tray culture method is not affected by the different heights of the trays on the shelves, as many shelves as possible can be used to optimize on the use of space without affecting the yield obtained in the trays from the different heights. However, further investigation in this area is needed and this could include evaluation of yield under different crop residues such as wheat straw, groundnut shells, grass and banana leaves. It would also be very important to carry out research to compare the two methods of oyster mushroom cultivation (the bag and tray culture methods) and see which one is more economically viable.

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