PROMOTION OF MUSHROOM (Pleurotus sajor caju and Pleurotus ostreatus) PRODUCTION AND CONSUMPTION IN NORTHERN NAMIBIA

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ABSTRACT

Experiments on cultivating Pleurotus sajor caju and Pleurotus ostreatus mushrooms (Figure 1) were conducted during the 2003/2004 cropping season at Omahenene Research Station and Ogongo Agricultural College. Mushroom cultivation being a new farming activity for rural farmers, these experiments were used for training purposes for UNAM Students (Ogongo campus), WAD women’s group (Ormusati) and individual farmers who participated in the mushroom cultivation training courses. The experiments focused on the potential utilisation of different crop residues and some other plant material for mushroom production. The following materials were used: pearl millet straw and chaff; cowpea crop residues; cattle manure; maize cobs and straw; mopane pods and some selected woody materials mostly from acacia and mopane trees (bark, small dried branches, and dried leaves). Four different substrates were tried to determine their suitability for oyster mushroom cultivation. A composted substrate was made of mopane pods and leaves, woody materials, cattle manure, dry grass, millet straw and chaff, and maize straw and cobs. Three non-composted substrates were as follows: a straw substrate of maize and millet straws, maize cobs and cowpea haulm; a millet chaff substrate and a grass substrate. Promising results were obtained from the composted substrate. This combination yielded 2 kg per substrate bag of high quality mushrooms from the first flush as compared to 0.5, 0.7 and 1.8 kg from non-composted substrates. Results showed that the best time for fruiting is during rainy and cloudy days when the humidity is very high and the temperature relatively low. Considering the arid nature of Namibia, mushrooms could be considered as a future crop for Namibia in terms of achieving self-reliance for food production and agricultural development, as the crop can be grown with a minimum amount of water.

INTRODUCTION

Pleurotus sajor caju and Pleurotus ostreatus (oyster mushroom) are two of the choice edible mushrooms which can be cultivated in the tropics (Quimio et al., 1990). The Pleurotus are regarded as easy to grow and have broad adaptability, which is the reason why they are cultivated worldwide and their production has increased rapidly (Chang and Miles, 1997). Mushrooms in general are well known among Namibian farmers and are widely consumed in the northern regions during the rainy season, although no formal scientific mushroom cultivation in Namibia has been attempted. It is widely acknowledged that scientific research has a major role to play in poverty reduction and hunger alleviation through active promotion and encouragement of crop diversification. Mushrooms are thus best suited for introduction to Namibian farmers as an alternative source of income and nutrition. It has been suggested that because of their high protein content, they should be produced in greater quantities to alleviate protein deficiencies in places where the prospect of starvation is a life threatening problem (Chang and Miles, 1997). Mshigeni and Chang (2000) have also reported that Pleurotus mushrooms play a very important dietary role in human nutrition and health worldwide when used as a dietary supplement. On a dry weight basis, mushrooms are made up of about 30% protein (Oei, 1996) and this protein is endowed with all the essential amino acids. Mushrooms are low in calories and carbohydrates, are almost cholesterol free and are high in vitamins and minerals, all of which serve as important essential requirements for human health (Chang and Miles, 1997). Their medicinal value, such as for healing wounds, and their ability to promote body immune enhancing and tumour-retarding effects, is another significant benefit (Chang et al., 1993). Mushrooms are highly nutritious and contain 20-40% protein on a dry matter basis, which consists of all the essential amino acids required in the human diet. Their taste and delightful aroma make them a delicious and popular food in restaurants throughout the world (Mshigeni and Chang, 2000).

Mushrooms are macro fungi belonging to the kingdom fungi. They do not possess green pigments and therefore cannot produce their own food. However they derive energy from complex organic materials found in dead or living tissues of plants and animals. Mushrooms are therefore called saprophytic fungi due to their mode of feeding (Campel, 1996). According to Chang and Miles, 1997), the Pleurotus belong to the family Tricholomataceae, order Agaricales and class Basidiomycetes.
The cultivation of mushrooms, like any other agricultural undertaking, requires hard work and dedication. Modern mushroom cultivation equipment is said to be very costly, however, simple and locally available materials can be used to produce mushrooms (Oei, 1996). Once enough mushroom cultivation experience is gained, then this modern equipment can be sourced. Mushrooms can be grown for own consumption and for income generating purposes. As indicated by Chang and Miles (1997), some species of Pleurotus can produce very high yields and can convert 100 g of dry matter in dry waste plant material into 50 to 70 g of dry matter in fresh fruiting bodies. The whole process takes about 42 days or less in favourable environmental conditions in which the humidity and temperature are well controlled and maintained. Local crops take more time than this. Production can continue throughout the year as long as the temperature and humidity are kept close to optimum levels (Chang et al., 1993).

These experiments, therefore, focused on Pleurotus sajor caju and Pleurotus ostreatus (oyster mushroom) cultivation and promotion among the farming communities in the Northern Communal Areas of Namibia, using locally available materials. The spawn used during these experiments originated from Fujou City, China, where a training workshop was attended. Experience from these experiments suggests that mushroom production does not require a lot of water but does require a humid environment. This means that the production house should be kept moist at all times. This will require less water compared to ordinary field crops and vegetables. Considering the arid nature of Namibia, mushrooms can be considered as a future crop for Namibia in terms of achieving self-reliance for food production and agricultural development, as the crop can be grown with a minimum amount of water.

METHODOLOGIES

Locally and readily available crop residues such as straw and other agricultural waste were used as substrate for mushroom (Pleurotus sajor caju and Pleurotus ostreatus) cultivation. For the purpose of these experiments, crop residues from the field and grasses and barks from the wild were used in substrate absorb excess water to bring the water content to the required level of 60%. Thereafter a calculated amount of agricultural lime was added to bring the acidity level of the substrate to a pH of 8-10 (alkaline) using an indicator strip. According to Kadhila (2003), lime is calculated as 1.5% of the substrate's dry weight. Substrates were well mixed with a garden fork and spade to obtain uniformity. After mixing and checking the moisture (Figure 2), substrates were placed in vacuum plastic bags (Figure 3) of 2 kg or 1 kg for pasteurisation. A drum was used to pasteurise the substrate by means of steaming the bags (Figure 4). A layer of diamond mesh wire was used as a barrier between the plastic bags and the water to prevent the substrate cooking. Substrates were heated for two hours in the drum and taken to the shade to cool.
After cooling, the bags were inoculated. At Omahenene a cleaned bench sterilised with methylated spirit was used. At Ogongo an autoclave was used to sterilize the bags and inoculation was done aseptically in the laboratory. Hands were first cleaned with soap and then sterilised with ethanol before handling of inoculation materials. A burner was kept on and every tool used was first sterilized in the flame. Each bag was spawned or inoculated with two spoonfuls of spawning materials. The bags were labelled with the species name, date and the inoculator’s name before being placed in a dark room for the mycelia to invade the substrate fully. The spawning temperature ranges between 15-30°C while the fruiting temperature is 20-28°C.

Inoculated bags were kept in a dark room at a temperature between 15-30°C even though the recommended temperature for fruiting ranges between 20-28°C. Fruiting was also done within the same range (15-30°C) as the spawn run. This is because the temperature could not be regulated easily and we did not have adequate houses for each condition. However the bags were covered with a black polythene sheet during the spawn run and the sheet removed after the spawn run was completed. Three openings of about 20cm in diameter, depending on the size of the house, should be made on top of the house to let both light and air in during fruiting. In order to compare production performance of mushrooms under different housing regimes, two different types of mushroom house were used; one constructed from local materials and the other the cave-like bomb shelters. Provision was made for the control of light and ventilation in the constructed house. However, in the bomb shelter house an opening was made in order to allow some light and air into the house. Care was also taken that the opening was covered with a clear glass that could be closed to maintain the moisture in the house. In mushroom production, humidity plays an important role as outlined by Oei (1996), who states that the humidity in the fruiting house should be maintained at 95% at the beginning of the fruiting process and be adjusted to 89% when the mushrooms are about 1 cm long. However, due to lack of a hygrometer, humidity parameters could not be taken into consideration during the experiment and so personal observations were used. The bags were monitored daily and contaminated bags were isolated from the others. After a period of 45 days in the dark, most bags turned white, showing that the mycelium had fully invaded the substrate, after which the bags were ready to be opened.

In order to allow fruiting, vertical cuts were made through some of the bags in a way similar to that outlined by Oei (1996), while some bags were totally uncovered leaving the substrate exposed. Light is also very important in fruiting body formation. According to Chang and Miles (1997), a light of about 50 to 500 lux intensity is required for healthy fruiting bodies. Since there was no equipment to measure the intensity of the light, the light was kept at a low level, just high enough to read the newspaper inside the house as stipulated by Oei (1996).

Four substrates were tested: millet chaff; dry grass; straws, cobs and haulm; and a composted mixed substrate.

**Pleurotus grown on millet chaff**

In this experiment 5 kg of millet chaff alone was soaked in water overnight. It was removed from the water and excess water drained off. An additional 5 kg of dry millet chaff was added to absorb the excess water. An amount of 0.15kg agricultural lime was added to the mixture in order to bring the acidity down. The substrate was placed in 1 kg bags and pasteurised for one hour in the drum.

**Pleurotus grown on grass**

In this experiment 5 kg of dried grass alone was soaked in water overnight. It was removed from the water and excess water drained off. An additional 5 kg of dry grass was added to absorb the excess water. An amount of 0.15 kg agricultural lime was added to the mixture in order to bring the acidity down. The substrate was placed in 1 kg bags and pasteurised for one hour in the drum.

**Pleurotus grown on straws, cobs and cowpea haulm**

In this experiment a 50 kg mix of dried maize and millet straw and maize cobs was soaked overnight in water. After removal from the water, excess water was drained off and 10 kg of cowpea haulm was added to absorb the excess water. An amount of 0.97 kg agricultural lime was added to the mixture in order to bring the acidity down. The substrate was placed in 2 kg bags and pasteurised for one hour in the drum.
Pleurotus on composted substrate

In this experiment, 5 kg mopane cones and leaves, 5 kg woody material and bark, 5 kg cattle manure, 5 kg dried grass, 5 kg millet straw, 5 kg millet chaff, 5 kg maize cobs and 0.6 kg lime were used. The woody material included bark, small dried branches and leaves, mostly from acacia and mopane trees. These residues were layered in the form of a sandwich to make a big heap on a cemented floor (outdoors). The layering of materials was repeated until all the materials were piled up. Lime was spread on top of the heap and water (1.5 l/kg) was applied until the heap was thoroughly moistened. The heap was then covered with a black polythene sheet and left covered for one week. After a week, the compost was turned and watered (1 l/kg) again and covered for another two weeks. After two weeks, the compost was opened and smelled good although it had not turned into finer compost. The materials were found to be soft and it was easy to fill the bags (Figure 3). Composting was done with the aim of observing whether or not it really does increase the yield of the Pleurotus as indicated by Oei (1996), who advised that in order to increase the yield the materials should be composted for at least 6-30 days before use, depending on the type of materials used. The 2 kg bags were pasteurised in the pasteurising drums for two hours and inoculated after cooling. Inoculated bags were then transferred to a dark room until fully invaded by the mycelia. Fully invaded bags that appeared white were moved to a fruiting house. A sharp knife was used to cut the bags open to prepare for fruiting. In the fruiting house, conditions of dim light, good ventilation, and humidity through water supply and keeping the doors closed were maintained. Oei (1996), advised that the humidity in a fruiting house should be maintained between 80-90% by spraying water several times per day. In this experiment, about 5 l of water was applied on the floor and walls three times a day. The floors were kept moist at all times to maintain the humidity. The walls were lined with a polythene sheet and a fine sprayer nozzle was used to water the house. Care was taken to make sure that no excess water came into close contact with the mushroom fruiting bodies as stipulated by Quimo et al. (1990) who advised that to provide moisture, daily watering is required on the substrate but this should not be so excessive that the substrate becomes waterlogged.

RESULTS

The fruiting pinheads appeared 3-5 days after the bags were cut open and the substrate watered. During the first day, the pinheads were so small that it was difficult to see them with the naked eye. It took 3-4 days for the pinheads to develop into mature mushrooms ready for consumption. A total weight of 2 kg was harvested from the composted substrate during the first flush and 1.5 kg in the second flush. The best time for fruiting was found to be during rainy and cloudy days. This could be attributed to the high humidity that is usually preferred by the Pleurotus for fruiting as outlined by Quimo et al. (1990), who said that fruiting of the Pleurotus requires an appropriate temperature range from 20-28°C, ventilation, light, moisture and a humidity of 80-95%. Results from all substrates are presented in Table 1.

DISCUSSION

The fruiting bodies appeared 3-5 days after the bags were opened. This is similar to the findings of Quimo et al. (1997) that the primordia begin to form 3-4 days after opening the bags, while the mature fruit start to develop within 2-3 days after the primordia. Promising results were obtained from the combination of woody materials, straw and cobs composted for a period of three weeks. The composted combination yielded 2kg of high quality mushrooms as compared to 0.5, 0.7 and 1.8 kg from non-composted substrates in the first flush. According to personal observation and experience on the two housing regimes (bomb shelter and local material constructed) used in this experiment, the local material constructed house could provide a good environment for both spawning and fruiting. This is because the ventilation

<table>
<thead>
<tr>
<th>Treatment/Substrate used</th>
<th>Bag size</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; flush</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; flush</th>
<th>Total</th>
<th>Adjusted total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composted substrate</td>
<td>2-kg bag</td>
<td>2.00</td>
<td>1.50</td>
<td>3.50</td>
<td>3.50</td>
</tr>
<tr>
<td>Straws, cobs haulm</td>
<td>2-kg bag</td>
<td>1.80</td>
<td>1.49</td>
<td>3.29</td>
<td>3.29</td>
</tr>
<tr>
<td>Millet chaff</td>
<td>1-kg bag</td>
<td>0.70</td>
<td>0.65</td>
<td>1.35</td>
<td>2.70</td>
</tr>
<tr>
<td>Grass</td>
<td>1-kg bag</td>
<td>0.50</td>
<td>0.60</td>
<td>1.10</td>
<td>2.20</td>
</tr>
</tbody>
</table>
is good and the light inside is enough as outlined by Chang and Miles (1997), that as long as the light is enough for one to read a newspaper, then it should be enough for fruiting. The humidity in the house could be maintained by the polythene sheet around the walls of the house and using a hose pipe to wet the house. This was impossible in the bomb shelter house where the fruiting bodies died during hot sunny days despite spraying water on the walls of the house and on the floor. However, well developed fruits were obtained during rainy and humid days.

It was also observed that when the bags were cut vertically to allow the fruiting bodies out, big fruits were harvested but some remained trapped between the plastic sheet and the substrate where no cut was made. This was not the case in the exposed substrates where the plastic was removed and many smaller fruiting bodies were growing from all over the substrate. It was also observed that the exposed substrate dried out quickly. This was solved by soaking it in a water bath for an hour.

Considering the arid nature of Namibia, mushrooms could be considered as a future crop for Namibia in terms of achieving self-reliance for food production and agricultural development, as the crop can be grown with a minimal amount of water. Growing environment conditions can be provided as described by Microsoft Encarta Encyclopedia (1999) - mushrooms are cultivated commercially in caves, dark cellars, or specially constructed mushroom houses in which the proper humidity and temperature are maintained.

According to Chang and Miles (1997), it has been suggested that because of their high protein content, Pleurotus should be produced in greater quantities to alleviate protein deficiencies in places where the prospect of starvation is a life threatening problem.

These experiments demonstrated that Pleurotus sajor caju and Pleurotus ostreatus (oyster mushroom) could be successfully grown on crop residues, straw and other agricultural wastes that are readily available in Namibia. It was also demonstrated that Pleurotus sajor caju and Pleurotus ostreatus could be successfully produced with little or no modern technology as has been proven in other developing countries (Chang and Miles, 1997). Results indicate that grass and millet chaff produce a small quantity of mushrooms probably due to insufficient cellulose and lignin in these substrates.

CONCLUSION

The objectives of this experiment were to make use of locally available materials in the production of Pleurotus sajor caju and Pleurotus ostreatus in the communal areas of Namibia, and also to get an idea whether or not farmers in the communal areas would be interested in mushroom cultivation. The results show that it is possible to grow Pleurotus mushrooms under local conditions using locally available substrates. The research was participatory research in which potential users of the technology were successfully involved. Further research is recommended. Equipment will be needed, for example instruments to measure light and humidity, in order to come up with conclusive data. However, it has been demonstrated that farmers can produce mushrooms for own consumption and local markets using locally available material to prepare the substrates and construct the mushroom house. If, as anticipated, the technology is taken up and spreads, experience and capital will accumulate and there will be a possibility for some capital intensive village enterprises needing support from research under controlled environments.

ACKNOWLEDGEMENTS

The author would like to thank all the people who participated in these experiments, especially the workers and the management team at Omahenene Research Station, E Sheya in particular, for managing the experiments. Many thanks to all the farmers and women's groups who showed interest in the project; Dr. Kosina of UNAM Crop science Department for his assistance in the tissue culture and spawning materials production; Mr. Dayot-Kahuure from NOREESP for the supply of training material; and Paulus for the mushroom house construction. The author highly appreciated all your efforts and encouragement. I would also like to extend my appreciation to the following people: lipinge A. Sheehamandje, Mark Thomas and P.N Kadhiia for the effort and time they spent in editing this document.

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