MUSHROOM GROWING

PRACTICAL ACTION
Technology challenging poverty

technical brief

Introduction

There is growing interest in developing commercial cultivation of mushrooms throughout Africa. This brief focuses on this practice in Zimbabwe.

Although mushroom growing is not generally regarded as a traditional activity in Africa, the collection of wild mushroom is. Traditionally these were collected at the start of the rainy season and knowledge of which types were good to eat and which were poisonous was shared between young and old within the community.

This knowledge is no longer being passed on, especially in urban areas so people are becoming reluctant to eat wild mushrooms. The uptake of mushroom cultivation has been more noticeable in urban areas.

Figure 1: Growing oyster mushrooms in plastic bags inside a mushroom growing house in Zimbabwe. Photo Credit: Practical Action / Warwick Franklin.

Mushrooms are a valuable source of food and their cultivation can be a viable small-scale business, but investing in a mushroom growing scheme can be risky so a feasibility study looking at potential markets and supply chains should be done before starting. A general understanding of mushroom growing should be obtained through training or literature to ensure the best chance of success. Some expert assistance will help at this stage.

As well as individual small-scale production, set up options include cooperatives and community groups that can collaborate in set-up costs, production costs, harvesting and marketing. It helps not to work in isolation but in joint ventures with regional agro-industries and universities as they can assist with training and extension workshops.

What are mushrooms?

Cultivated mushrooms are edible fungi that grow on decaying organic matter, known as a substrate. Unlike vegetables they do not rely on sunlight to grow. Mushrooms start as very small spawns. The spawns will grow in the substrate to produce a fine white fibrous structure called mycelium. From the mycelium the mushroom fruit is produced. This is the part that is harvested.

Mushrooms have a high nutritional value and are high in protein. They are also a good source of vitamins (B1, B2, B12 and C), essential amino acids, and carbohydrates but are low in fat and fibre and contain no starch. When fresh they have a very high water content of around 90%. Minerals present include phosphorus, potassium, iron and copper.

Mushrooms grow in bursts known as flushes approximately every 7 to 10 days for a few weeks with yields falling over time. The first three flushes yield more than 70% of the total. The growing time will be dependant on type of mushroom and the growing conditions.

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Mushrooms for cultivation

There are two main types of edible mushroom grown in Zimbabwe - the white button mushroom (Agaricus Bisporus) and to a lesser extent oyster mushrooms (Pleurotus ostreatus). Other species have also been successfully cultivated, including wild Reishi mushroom (*Ganoderma lucida*). Under average conditions 50 to 70kg of Pleurotus strain of mushroom can be produced from 100kg of substrate, over a period of a few weeks, and with optimal conditions the yielded can rise to a 100kg.

There has been a great amount of research into mushrooms and their cultivation in temperate climates but relatively little on varieties suitable for tropical climates although interest in this area is growing. Many commercial mushrooms only fruit at around 20°C and are therefore not suitable for tropical regions. Suitable tropical stains are harder to obtain but some commercial strains can be ordered such as strains of Agaricus bitorquis that fruit at 28°C.

Figure 2: Oyster Mushrooms (Plruotus ostreatus). Photo credit: Practical Action Southern Africa.

In Zimbabwe the Chakohwa Voluntary Mothers Group mushroom growing venture started with white button mushrooms but the project was forced to change as button mushrooms needed horse manure in the substrate which was not available in their area so the project switched to oyster mushrooms that can grow on locally available materials.

Where to get your mushroom spawn

Technical skills and a theoretical background are required to produce spawn and literature on the subject is often hard to obtain. Spawn production must be done under sterile conditions which is usually difficult for small farmers. Consequently spawn production is mainly done by laboratories in research institutions and universities.

The amount of spawn needed is equal to 2% to 4% of the weight of the substrate. Rather than weighing the substrate, which can be difficult with large amounts of material, the weight can be estimated from its volume. $1m^3$ of substrate will weigh about 300 to 400kg.

Where to grow your mushrooms

Mushrooms should be cultivated indoors so that the growing conditions can be maintained at their most suitable for the mushrooms. Temperature, humidity, uniform ventilation, carbon dioxide and substrate moisture levels can be controlled to get the best results while unwanted contaminants, moulds and sunlight can be kept away from the crop. Any small room with ventilation and a cement floor can be used. It should be possible to close off the room to the outside by shutting ventilation and doors. The interior should be arranged so that it is easy to carry out complete cleaning at the end of each cropping cycle.

The mushroom house should be well insulated to maintain a steady temperature. Corrugated metal roofing is not suitable, but concrete or clay tiles would be. Insulating materials such as fibre glass wool or expanded polystyrene can be used.

Small rooms can be made from wooden poles with stretched sacking covering the frame. The sacking can be covered with a wet cement and sand mixture that will produce a hard protective skin. When the Chakohwa Voluntary Mothers Group started mushroom production people were reluctant to take part, consequently the few people that were interested had to build their mushroom production house. This was built in one member's yard to ensure security, but this brought about the challenge of ownership of the structure should the project end.

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What to grow your mushrooms in - Substrates

Mushrooms can be cultivated on a wide variety of substrate. The quality of the substrate is the main factor in the success of growing mushrooms as it provides all the energy and nutrients that the mushrooms will use while growing. Different strains of mushroom will require different substrate mixes. The substrate must not be rotten, mouldy and should be kept dry while in storage.

Agricultural wastes are often used as a source of material for the substrate including; cassava stalks, cocoa pods, coffee bean husks, coffee pulp, corn cobs, corn stubble, cotton seed cake, pulse husks, rice hulls, sawdust, sugarcane bagasse, tealeaves, tobacco stalks, wheat straw and water hyacinth.

In many parts of Zimbabwe wheat straw, bush grass and horse manure are commonly used with the addition of chicken manure, cotton seed meal, ammonium nitrate or urea, gypsum (calcium carbonate).

Growing mushrooms on a substrate of water hyacinth was first promoted by the Chinese University of Hong Kong, and has been taken up by the African University of Mutare in Zimbabwe. The advantage of using water hyacinth, which is an unwanted weed that clogs up many waterways in Africa, is that the costs of preparing the substrate can be kept down.

When making the substrate the objective is to provide a uniform material that will provide all the requirements of the mushrooms. Nitrogen content is important. Analytical laboratories can measure the nitrogen content of the substrate to ensure it is sufficient.

The ratio of carbon to nitrogen is also important. The approximate requirement at the time of filling the bags or trays is 20:1. Carbon component is obtained from materials such as straw while the nitrogen comes from manure. Cotton seed meal and castor bean meal contain both elements.

Gypsum is a useful ingredient as it provides calcium to the growing mushrooms, regulates the acidity level of the substrate, counters potassium, magnesium and phosphorus concentration and increases water holding capacity thus decreasing the risk of over wetting. It also improves the physical structure of the substrate.

For some varieties wood logs can be used if available. These should be freshly cut. Shiitake, oyster and tremella are suitable for growing on wood. Shiitake can take 6 to 18 months to sprout and are therefore more expensive to produce. Logs can be difficult to obtain, especially in areas where there is a demand for fuelwood.

Preparation process

A suitable area needs to be set aside for preparing the substrate. For best results it should consist of a large concrete floor which has a slope, so that run-off can be collected and reused. A storage area is needed for the straw, chicken manure etc used to make the substrate, but the longer any manure is stored the more nitrogen will be lost. Another smaller area is required for filling the substrate into its growing bags or trays. This is usually roofed and walled. Lime, gypsum, small tools and chemicals for pest and disease control should be stored separately is a secure area.

The preparation to make a substrate for Pleurotus involves mixing with water. This can be done by

- Spraying the heap of material with a hose
- Making a flat pile and using a sprinkler
- Soaking in a tank of water.

Soaking requires a suitable container for mixing the water and the substrate materials together to allow the straw etc to soak up water. Alternatively a pit can be dug. The size of the

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container will depend on the scale of production. For small scale operation 100 to 200 litres capacity is suitable. It needs to be 60cm deep. If it is not watertight then a liner of thick plastic can be used. A cover is used to help submerge the substrate material that would otherwise float in the water. The cover may need to be weighted down.

Blocks of substrate can be made more easily from material (straw etc) that has been cut into uniform pieces before being submerged. Other materials may not need pre treatment.

The substrate is submerged in water for 10 days, during which time it partially ferments and any insects in the material are killed. During this time the substrate absorbs the water so the level of water needs to be checked. If the substrate is no longer submerged then more water needs to be added along with an appropriate amount of fungicide. The fermentation will take place between 8 to 28°C. After this period the excess water can be drained off. The resulting material may initially smell sour.

The substrate can then be stored in strong plastic bags of around 30 to 40cm diameter which will hold around 20 to 30kg of material.

Another approach to eliminating unwanted pests is to stack the substrate material to the desired height to form a large enough body of material to generate heat but small enough to ensure that air can get to the middle of the stack producing aerobic decomposition (1.5 to 2m wide by 1 to 1.5m high). This kills off the pests. A wooden frame can be used when making the stack to get the right size and keep it uniform.

The prepared substrate is then ready for growing mushrooms, but it is also an ideal medium for other unwanted plants, fungi and bugs. Therefore hygiene is an important element to producing a successful crop. To eliminate any competitor organisms a fungicide can be added to the water to prevent mould but which does not inhibit the growth of the mushrooms.

Alternatively, the substrate can be steam heated to eliminate any microbes. This is especially important when using manure in the substrate. This can be done using a pasteuriser made from an old 200 litre drum with suitable modifications so the substrate can be held above the boiling water which is at the bottom of the drum.

Small-scale producers can benefit by sharing this task. The sterile substrate can be prepared at a central location, to ensure correct production. After filling the plastic bags with spawned substrate, they can be distributed to the mushroom farmers. Subsequent cultivation, harvesting and marketing can be done individually or collectively.

Cultivation Methods

Water is required as the humidity levels are important. Temperatures need to be controlled carefully but will depend on the variety of mushroom being grown. Cultivation techniques will need to be adapted to local conditions. The crop takes about 12 weeks from start to finish.

Once the substrate and the spawn have been mixed they can be packed into plastic bags. Another common approach in Zimbabwe is to use trays. These are usually made by the farmer and can vary in size from 0.5 m^2 to 0.72 m^2. Metal mesh trays with plastic linings have also been used.

Figure 3: Spraying the mushrooms to keep them wet. Photo credit: Practical Action Southern Africa

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The Chakohwa Voluntary Mothers Group grow their mushrooms in plastic bags that are suspended in darkened rooms. Slits are made in the bags to allow the mushrooms to grow. This approach requires very little space and by growing in bags contamination can be can reduced as the plastic will protect the substrate.

It is important to prevent cavities forming within these bags. Any gaps that are left after the filling process can be eliminated by dropping the bag from a low height onto a firm surface a few times. The bags are then hung from the rafters of the growing shed and the colonisation of the substrate by the mycelium begins. This takes about 10 days. Deformed mushrooms appearing under the plastic indicate that the substrate was not compacted enough and the mushrooms are growing in the cavities.

There should be air circulating between the sacks so that the temperature can be regulated. There should also be sufficient humidity to prevent the mushrooms from drying out.

If the substrate in the plastic bags is green or pink in any part and only partly showing signs of white mycelium growth then the ambient temperature may be too high. This may result in competitor moulds growing in place of the desired mushroom crop. If the mycelium has not grown to any extent but there are no signs of growth by other moulds then the temperature may be too low.

If the mycelium has not grown in the bottom of the bag then this indicates that the substrate is too wet. This can happen if the bag has not been drained properly after the fermentation stage so that water remains trapped at the bottom.

If the mushrooms are wrinkled and brown at the edges then it has been too dry during growing and more moisture should have been provided during the growing stage. They need to be sprayed with water on a regular basis.

Equipment options

For small scale production there are limited equipment requirements. For larger operations a steam unit can be used for pasteurising the substrate. These can be made from modified 200 litre drums.

Regulating the temperature is the other main concern – heating and cooling the mushroom house can be controlled with additional equipment. For example; an electric fire could be used to maintain an even temperature if electricity is available; cooling could be assisted by using a table fan blowing over a container of water. Humidity within the growing house can be increased by watering the floor.

Pests and Diseases

There are a whole range of pests and diseases that can attack mushrooms. The longer mushrooms are grown in one location the greater the chance of infection from pests and disease. Therefore it is important to sterilise the growing room and the preparation areas on a regular basis. Even with care there will be times when an infection occurs, so it is useful to be able in identifying the particular problem so that appropriate action can be taken. Record keeping is important to identify where problems arise. Information required includes dates of stages of compost preparation, nitrogen analysis, temperatures, moisture, pasteurisation times, opening and closing times of ventilation etc.

Some of the most likely problems are:

- Thread like worms or nematodes can infest substrates and eat the mycelium. They can appear in substrates that have not been pasteurised properly.
- Mushroom flies. The most common in Zimbabwe is the Sciarid fly. Again pasteurisation kills off the fly's larvae but the flies can enter the growing room if there are holes in the screens. Cleaning between crops is important and sterilising equipment helps to prevent contamination.
- Mites can survive pasteurisation if it is not done for long enough.

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- Bacterial blotch is the most common of diseases. It will show up as pale yellow spots on the cap and these will darken and the cap will become slimy. Over-humid conditions encourage bacterial blotch.
- Fungal Dry Bubble or Verticillium is the most common fungal threat in Zimbabwe. This initially shows up as brown spots on the cap and later on the mushrooms will become deformed. Agricura's fungicide can be used to combat the infection.
- Competitor moulds will show up as unusual colours within the substrate such as green, brown and white moulds which indicate that the growing conditions are more suitable for these moulds than for the commercial mushrooms. There may be too much ammonia present or the substrate may be too wet and anaerobic conditions exist. Directly sprinkling calcitic limestone powder onto the mould will stop further growth and in more extreme cases broad spectrum fungicides can be used.
- False Truffle is resistant to pasteurisation and if these large fruitbodies appear then the substrate should be removed and the equipment sterilised with methyl bromide.
- Virus called Die Back Disease or La France Disease or Mummy Disease can occasionally be a severe problem destroying the whole crop. An infection shows up as absent or disappearing mycelium, deformed fruitbodies, and fruit discolouration that may appear greyish or brownish. All the equipment should be sterilised

Harvesting

Generally mushrooms are harvested by hand using knives to cut the ones that are ready. Pickers should be trained to recognise the appropriate stage for harvesting and be consistent in when the mushrooms are cropped. Handling should be kept to a minimum to reduce the risk of damaging the crop.

The total amount harvested from a stack can be 3 to 4kg. Once the harvest is complete the substrate is depleted and can not support any further crops. It is usually then used as a fertiliser for other crops.

Figure 4: Harvesting
Photo credit: Practical Action Southern Africa.

Processing and marketing

Many mushrooms are sold fresh to retail outlets. Marketing of fresh mushrooms presents particular problems as they should be consumed within three or four days of harvesting to avoid spoilage. Often they are harvested in the day and sold in wholesale markets during the early hours of the following morning, or delivered directly to supermarkets and caterers.

Figure 5: Oyster mushrooms ready for market. Photo credit: Practical Action Southern Africa.

Mushrooms are also suitable for drying, enabling them to be stored for long periods without deteriorating. This can be done using solar drying.

In larger set-ups cold rooms can be used to store the mushrooms before they are sent to market. The optimum temperature for storage is between 5 and 8°C.

Alternatively, they can be frozen and placed in airtight containers but unprocessed mushrooms take up a lot of room and this can be costly way of preserving them.

It is important to identify your market first, before investing in production. Growers should make sure that there will be a demand for the mushrooms once they have been produced.

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Further reading

- *A Mouldy Old Business* Food Chain Number 14 March 1995
- *Making Money by Growing Mushrooms* FAO, 2009
- *Cultivation of the Oyster Mushroom in Traditional Brick Pots* Food Chain 23 July 1998
- *Small-scale Mushroom Cultivation* Agrodok n°40
- *Technical Guidelines for Mushroom Growing in the Tropics* Quimio T H, Chang S T, Royse D J Food and Agriculture Organization of the United Nations (FAO)
  This manual describes how mushrooms are not only good sources of protein, minerals and vitamins but also contain other health promoting substances. The technologies described are largely inexpensive, for mushroom production to be successful in the long term must be supported by a background of scientifically based information. The contents are comprehensive yet aimed at the needs of growers using relatively low cost and low-tech methods.
- *Manual on Mushroom Cultivation: Techniques, Species and Opportunities for Commercial Applications In Developing Countries* Oei P Tool Publications CTA
  This manual provides information on how to cultivate mushrooms in tropical areas. Mushroom growing involves many steps from selecting a suitable technique and strain to spawn manufacturing, growing the crop and marketing the final product.
  ISBN/ISSN: 90-70857-22-7
- *Producing Solar Dried Fruit and Vegetables for Micro- and Small-Scale Rural Enterprise Development: A Series of Practical Guides* Brett A, Cox D R S, Trim D S (et al) Natural Resources Institute (NRI)
  This guide comes in 4 separate handbooks with reference cards. Handbook 1-Assessing Opportunities, Handbook 2-Dryer Construction, Handbook 3-Practical Aspects of Processing, Handbook 4-Business Profitability. Specifically covering bananas, mangoes, mushrooms & pineapples.
- *Mushroom Production in Zimbabwe: A Practical Manual* Tiffin J, 1998
  A practical manual on mushroom production in Zimbabwe which concentrates on the growing methods for the *agaricus* species.
- *Mushroom Cultivation: With Special Emphasis on Appropriate Techniques for Developing Countries* Oei P TOOL Publications 1996, ISBN: 9070857367
  This manual provides information on how to cultivate more than twelve different species of mushrooms. Mushroom growing involves many steps from selecting a suitable technique and strain to spawn manufacturing, growing the crop and marketing the final product.
- *Micologia Neotropical Aplicada*
  Editor-in-chief
  Apartado Postal 701
  Puebla 72001
  Puebla
  Mexico
  A scientific journal containing original papers on the cultivation and use of tropical fungi.

Organisations

http://www.mushroombusiness.com/
International Information for Growers

ATTRA - National Sustainable Agriculture Information Service
P.O. Box 3657
Fayetteville, AR 72702
USA
Tel: 800-346-9140
Website: http://www.ncat.org/
Mushroom Cultivation and Marketing

http://www.attra.org/attra-pub/mushroom.html#Abstract
The National Sustainable Agriculture Information Service is the website of the ATTRA project, created and managed by the National Center for Appropriate Technology (NCAT)

SIRDC - Scientific and Industrial Research and Development Centre
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Website: http://www.sirdc.ac.zw/products/mushroom.htm
The Biotechnology Research Institute (BRI) of the Scientific and Industrial Research and Development Centre (SIRDC) produces and supplies high quality mushroom spawn in Zimbabwe. BRI also provides the supporting services for mushroom growing, e.g. training and consultancy. At the moment, oyster mushroom spawn (*Pleurotus sajor-caju and P. ostreatus*) is being produced.

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