EXAMINATION OF PRODUCTION SYSTEMS FOR MUSHROOM CULTIVATION IN IRELAND

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FINAL REPORT

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Introduction

The plastic bag growing system used in Ireland is very labour intensive requiring considerable manual labour input. This has several very undesirable consequences including:

(1) Bags on delivery are flattened and compressed. They have to be shaped for standing and the surface of the compost made flat for casing. This repetitive manual labour can have harmful effects on the vertebrae in the lower spine (information obtained through consultation with medical staff in the Health and Safety Authority), leading to chronic back pain, and thus becomes a health and safety issue. As people get older this becomes an increasing problem.

(2) Manually transferring compost from one bag to another to achieve uniform bag height poses a threat of disease transfer between bags. It also poses a threat to the health of the operative as there is a risk of mushroom lung developing from inhalation of Actinomycete spores in the compost (an appropriate mask should be worn).

(3) Emptying the tunnel after cropping also poses risks to the operative from lifting, from spores and from inhalation of disinfectants used to kill off the surface of the bags. Disposal of spent compost in bags is difficult and there is the threat to the environment from plastic bag disposal.

Any alternative to the bag growing system must have the possibility of eliminating the problems stated above whilst retaining its very significant competitive advantages. These include:

a) The ability to produce a high percentage of prime quality mushrooms using the plastic bag and tunnel system. This is because the single layer cropping system allows ease of control of the important environmental factors effecting mushroom quality and the ease of inspection and harvesting.

b) The versatility and flexibility of the system in relatively small growing units.

c) The reduced risk of disease spread in the compost from bag to bag and the lack of need to sterilise the growing containers for reuse as in tray and shelf growing.

d) The delivery of spawned or spawn-run compost in plastic bags fits in very well with the structure of the industry with specialist composters supplying compost to small growing units.

It was because of these considerations that it was considered important to examine possible feasible alternatives to plastic bag production for the Irish Mushroom Industry. This project was set up at Kinsealy Research Centre to examine possible alternatives. Part of this consisted of examining commercial systems both at home and abroad.

Methods

The experimental work for this project was done in the mushroom research unit at Kinsealy Research Centre. The growing tunnels used were the same design as those used commercially but shorter in length.

The compost used in the trials was sourced from commercial suppliers as was the casing.

The mushroom strains were the same as those used by commercial growers.

Growing procedures were the same as those used commercially as outlined in the Teagasc booklet " An Introduction to Production of Mushrooms in Plastic Bags and Tunnels".

Some of the work in this project entailed examination and analysis of growing systems used by some growers both at home and abroad.

Results and discussion

Tray growing

Mushroom production in large wooden trays, stacked in rows usually five trays high, with a 22 - 30cm space between trays, was one of the earliest traditional growing systems. It is still the system most used in the UK but is no longer used in Ireland.
There are many problems associated with mushroom growing in a multi-tiered tray system. These include:

(1) The most important point is the great difficulty in moving air over the cropping surfaces as the trays cause considerable impediment. This makes production of a high percentage of top quality mushrooms very difficult. In addition there is the difficulty in crop management, watering, harvesting and in disease inspection and control. All these faults have led to tray growers having great difficulty in competing with the bag growing system.

(2) Considerable investment in handling machinery is required.

(3) There is the difficulty and cost of having to disinfect reusable containers (particularly of wood).

With this knowledge and experience it was felt that there was little point in any further testing of that system and it is concluded that it has little future for mushroom production in Ireland.

Shelf growing

This system using multi-tiered metal or wooden shelves running the length of the house, widely used in Holland and the USA, has the advantage of being very mechanisable using nets and winches to fill and empty the shelves. In addition it facilitates mechanical harvesting. However it has the disadvantage of requiring very high capital investment. In addition there is the difficulty, as in the tray system, of achieving a high percentage of top quality. This is because of the impediment presented by the shelves to air movement. There is also an enhanced risk of rapid disease spread through the compost down the length of the shelf as there are no barriers. This is particularly pertinent with the seemingly high risk from *Trichoderma* green mould infection in compost in Ireland and from

mummy disease. The present plastic tunnels used in Ireland do not have sufficient height to accommodate the five tiered structures commonly used and if it is to be adopted some modification in the tiering and air movement system will be required. This is currently under study at Kinsealy and elsewhere.

Trough growing

The concept with this system is that the compost would be delivered in bulk and put into a deep trough (approx. one metre wide and deep). This system has been widely researched in the UK, Northern Ireland, France and the USA. Despite this there is still, to our knowledge, only one commercial trough grower in the UK.

Trough trials at Kinsealy

A number of trough growing trials were done at Kinsealy . The trough used measured 1m wide, 1m deep and 6m long and was constructed mainly of polythene. The following problems were identified in these trials:

(a) The compost, in bulk, in the trough, overheated very quickly during spawn-run and the compost temperature was impossible to control. In addition it became anaerobic (lacking in oxygen) at the base. These problems were overcome in later trials by blowing air through a perforated flexible pipe placed in the base of the trough, forcing air up through the compost. (There is increased risk of introducing pathogenic fungal spores into the compost using this method).

(b) The compost placed in bulk in this way, shrinks, leaving a substantial lip on the trough which interferes with air movement over the cropping surface, thus reducing quality. Also, there is the tendency for the casing to become detached from the compost. These problems are inherent in any system using solid containers.

(c) There was an extreme risk from disease - particularly *Trichoderma* green mould. In some of our trials when green mould occurred it spread rapidly through the compost in the trough. There is also enhanced risk from the more uncommon bacterial mummy disease.

Production in Large Bins

First trial

To overcome some of the problems associated with troughs, mentioned above, two smaller (1.5m long, 0.8m deep and 0.8m wide) troughs or bins were constructed. They were made of sheet steel with an angle iron framework and an expanded metal mesh bottom and short legs (15cm). These could thus be handled by means of a fork lift truck. These containers were filled with 340 kg of spawned compost and spawn-run in the normal way. Very quickly the temperature in the compost went above 50^0 C and was impossible to control. The mycelium in the compost was killed and the trial had to be terminated.

Second trial

Compost which had been fully spawn-run in bags was placed in the bins as it was felt that the temperature should not rise in that situation and the compost was cased immediately. A flexible coil of 10cm diameter corrugated plastic drainage pipe with holes was placed in the base of one of the bins and attached to a pump which drew air down through the compost. The other bin was left as in the first trial. The temperature in the compost in this bin again rose rapidly above 50^oC a few days after filling and the mycelium was killed. In the ventilated bin the temperature went up slowly and peaked at 50^oC before breaking. This was probably because the base of the bin was not sealed and air was short-circuiting. After that the temperature was controllable in the compost. This bin only yielded 81 kg of mushrooms / tonne of compost.

Third trial

The open mesh bottom in the base of one of the bins was sealed with plastic. A flexible 10cm diameter plastic pipe with holes was placed in the bottom of the bin to act as a ventilation system and the bin filled with spawned compost. Air was pulled down through the compost by means of a fan. This was attached to a time switch which was adjustable for running time as required. Generally about five minutes fan per hour was found to be sufficient to control the temperature. It was found to be important to pull the air down rather than push it up. Warm air being pushed up this resulted in condensation when the warm air from the compost met the cooler air at the casing surface. With this system it was possible to keep the compost temperature under control using both spawned and spawn-run compost. There was a temperature surge for a few days in spawn-run and after that the temperature was controlled reasonably well. A method of improving this would be to control the fan by means of a thermostat placed in the compost. This bin yielded poorly as eventually it succumbed to *Trichoderma* green mould.

In commercial practice it is difficult to envisage how such a system would operate as many extraction fans would be required and there would be great difficulty in emptying the bins and cleaning the ventilation system.

Problems solved with this system

(a) The whole process is mechanisable

(b) The efficient disposal of spent compost to a central disposal unit is facilitated.

Problems remaining

(a) Compost shrinkage resulting in a lip between the edge of the bin and the cropping surface leading to difficulty in moving air over the mushrooms. Detachment of the casing from the compost in the latter stage of cropping may also occur.

(b) The risk from disease in the larger bulk of compost is increased by comparison with bags. This was obvious in this trial where there was a low background level of *Trichoderma* green mould disease in the compost in bags which became a major problem in the large bin..

(c) The containers must be sterilised before reuse.

Plastic Containers (Dust Bins)

To reduce the problems, stated above, associated with the use of larger containers (bins or troughs) it was decided to examine the possibility of using smaller rigid containers. Initially dustbins with and without holes in the base were tried. They were filled with 30 kg of spawned compost and spawn-run as normal. These overheated during spawn-run and only yielded 150 kg / tonne. The holes in the base did not have any effect.
In a subsequent trial using spawn-run compost to fill the bins the temperature in the compost did not rise and it yielded 254 kg / tonne. There was a tendency for the casing to become detached from the compost towards the end of cropping due to compost shrinkage. This was made worse by the inwards sloping angle of the side walls of the dustbins. In addition shrinkage of the compost resulted in

the development of a lip of 15 cm or more between the casing surface and the dustbin rim. This resulted in poor air movement over the mushrooms and consequent loss of colour (bacterial browning).

Woven Plastic Bins (laundry baskets)

These were filled with 19 kg of spawned and spawn-run compost. There were no temperature problems in the compost in either of these treatments. However, both yielded poorly. This was probably because of drying of the compost and loss of CO_2. This finding was is in line with previous results from Kinsealy which showed that perforating bags reduced yield.

Block Growing

This growing system has being used to a small extent in some countries (mainly Holland) for many years. Generally the blocks of compressed compost are delivered in shrink wrapped plastic and placed on their flat sides on shelves to form a continuous bed. Because there is a low compost fill per unit area with this system it is necessary in expensive cropping facilities to have multi-tiered cropping beds.

Trials at Kinsealy

In the past many trials on block growing were done at Kinsealy using 25kg of compost in blocks measuring 56 x 38 x 33 cm. The effect of cropping these on their base, edge or sides on yield was examined. These were cropped either singly or pulled together to form a bed. The effect of cropping position on floor space fill is shown in Table 1.

Table 1: The effect of cropping position of compost blocks on floor fill

Cropping position	Fill (kg/m^2)
Base	216
Edge	147
Side	128

The cropping position had no effect on yield per tonne of compost except with dense wet compost.

When blocks were pulled together on their base (ie. standing upright) to form a bed, on a wooden pallet, serious overheating in the compost during spawn-run and cropping occurred, and it was impossible to control, resulting in a poor yield.

Trial with spawn- run blocks

The effect of using spawn-run blocked compost in a bed (blocks standing upright) was examined. However this also resulted in overheating and reduced yield. It appears therefore that the only way these rectangular blocks can be successfully used to form a bed is when they are on the flat in a shelving system as is done commercially.

Commercial experience with blocks

Some Irish growers have used blocks over the past few years. The earlier blocks were imported from the UK but latterly the Irish composters have the capacity to make them. One of the earlier block growers cropped them in two tiers supported by corrugated iron on steel trestles. The blocks were placed side by side on their flat surfaces to form a 1 m wide bed. They were spawn-run as normal and cased as a bed. The upper plastic surface was removed by knife before casing. A board had to be used to stop the casing falling off the side at casing.

The first crop did well and yielded 250 kg / tonne and the grower was very satisfied with quality. The second crop performed less well but the reason for this was not clear as he also had a blotch and cobweb problem.

Some growers are using a bed of blocks over bags on staging while a few have installed a Dutch shelving system.

Comments

It is doubtful if their is much saving in labour with beds made with blocks as the bed has to formed and filling and emptying are awkward. In addition casing is more difficult and almost twice as much casing is used by comparison with the same amount of compost in bags. When the beds are being removed at emptying there is much spillage of compost and casing which constitutes a severe threat in

case of disease epidemic in the crop.

In general it appears to us that if one is going for shelving then the delivery of loose compost as in the Dutch system is the only logical way to proceed. The use of spawn-run compost would also seem the most logical procedure.

Venti - Blocks (Mega block (TM))

These are highly compressed blocks in the shape of a capital E produced by using a patented system in the UK. They measure approx 100cm square and contain 250 kg of highly compressed compost. These can be stood directly on the floor of a tunnel side by side to form beds the length of the tunnel. The air spaces underneath allow ventilation for cooling. They could also be placed on pallets to allow mechanisation. This system appears to work reasonably well but there are reports of difficulty in achieving good quality grade outs. Another problem is the hazard from disease spread and emptying the tunnel can be a dirty procedure. The casing tends to dry out at the sides but this could be overcome. The system is highly mechanisable using a fork lift truck or similar machine both for filling and emptying. The necessity for manual levelling of the compost is gone and the fact that compost is not transferred reduces the disease risk.

Phase Three Compost

The advent of phase three compost in the Irish industry will provide increased opportunities for use in an alternate growing system. Because the compost is spawn-run under precisely controlled conditions the productivity of the compost is likely to be greatly enhanced. In plastic bags or any such discrete system there are considerable gradients in temperature and moisture created during spawn-run. This undoubtedly has some effect in reducing the potential productivity of the compost. Phase three spawn-run compost used in any of the systems discussed would overcome some of the problems, most notably temperature, and would result in a more productive system. However, the economics of this should also be considered.

Conclusions

This project has been very interesting and informative and will help in enabling

the industry make informed decisions on the way forward. The problems, identified in the introduction, associated with bag growing as presently practised, are very real and must be confronted. The advantages of the bag system listed are also very real. The Irish industry therefore with its present very competitive production system should be slow to change unless a better system is clearly identified. The obvious alternatives of tray or shelf growing systems used in other countries do not meet the requirements identified.

- Trough growing has been well researched both here and elsewhere does not seem to offer a viable alternative.

- The possibility of using rigid containers, of various sizes, examined here, does not seem very promising. Problems identified with any such containers include: overheating during spawn run and cropping, compost shrinkage resulting in detachment of the casing from the compost and leaving an area of stagnant air over the mushrooms, the greatly increased risk of serious loss from diseases such as *Trichoderma* green mould when a bulk of compost is used and the difficulty in adequately sterilising any reusable containers.

- The use of plastic shrink wrapped rectangular blocks of compost is attractive because it is mechanisable with reduced manual labour input. However, the system also has some serious disadvantages including:

(a) Because the blocks must be cropped on their flat surface (ie. 15 cm deep) they must be put in tiers to provide the same level of tunnel fill. This has consequent difficulties for filling and emptying, harvesting and air movement to produce best quality.

(b) There is enhanced risk of disease occurrence and spread because of the continuity of the bed formed and also the increased risk from disturbance of the compost and casing at emptying.

- The Ventiblocks or Megablocks with channels provided for natural cooling seemed very promising and overcome many of the problems raised with other systems. However this system is to some extent still in a developmental stage and the economics of its use are still not clear. Commercial experience in the use of these has not been very promising.

- The advent of phase three compost in Ireland also provides increased opportunities for providing a viable alternative to bag growing.

- Probably the most promising and viable alternative to the present plastic bag system is the use of a modified three-tier shelf system using phase three compost. However there are a number of possible undesirable consequences of adopting such a system, these include; increased cost of production because of high capital investment, reduced quality and greater disease risk. These are being examined in a new project (ARMIS 4456).

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Dissemination

The results from this project have been widely disseminated to Teagasc mushroom advisers and to mushroom growers both at home and abroad by means of publications in Proc. 12th National Mushroom Conference, Farmers Journal, Food and Horticulture (goes to all growers) and the British Mushroom Journal (goes to mushroom growers worldwide). Teagasc research and advisory personnel, in conjunction with An Bord Glas and IMGA/NEP, organised a series of mushroom demonstration farms, showing systems, in 1997. A booklet on this was produced and distributed to all growers.

Significant publications

Staunton, L. and Cormican, T. 1997. Mushroom production systems for Ireland - An Assessment. Proc. 12th Teagasc National Mushroom Conference, Dublin. 23-30.

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Systems. Teagasc - An Bord Glas - IMGA/NEP. pp 28.