Factsheet 13/08

Mushrooms

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Mushrooms – Improving spawn-running performance

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This factsheet collates the results of several HDC and Horticulture LINK funded projects to provide information on optimising the spawn-running of pasteurised compost in mushroom cultivation. It describes how the rate of spawn-running can be measured and which factors are important in controlling it.

Introduction

Using bulk spawn-run (Phase III) compost is a way for mushroom growers to shorten the cropping cycle, and thereby reduce their energy and capital buildings costs compared with using pasteurised (Phase II) compost. This has to be offset against a higher price of the compost which is produced in expensive, hygienic Phase III tunnels (Figure 1). Availability of a plentiful supply of Phase III compost at a competitive price is seen as key to securing a future for the mushroom industry. Improving the efficiency of this stage of the composting process can be achieved by optimising the conditions for mushroom mycelial growth in the compost. Achieving faster spawn runs can also reduce competition to the mushroom mycelium from compost moulds.

1 Bulk production of Phase III compost in tunnel

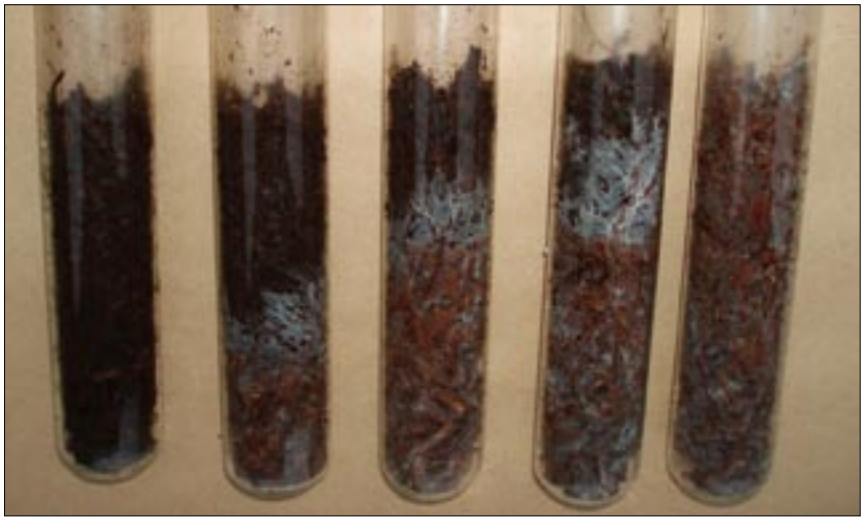
2 Spawn run compost on conveyor

Measuring spawn-running

To produce spawn-run compost efficiently, whether in bulk tunnels or in shelves, trays or blocks, it is vital to be able to measure the progress of mycelium spread. Compost temperatures can give an indication of mushroom mycelial activity by the heat produced. However, dry composts will rise in temperature more than wet composts, for the same amount of heat produced by mycelium. Growth of competitor moulds on compost and supplements can also increase compost temperatures, although the temperature 'surge' is usually earlier than that caused by mushroom mycelium. Growth tubes filled with compost and containing spawn at one end can be used for measuring the rate at which a mycelium growth 'front' progresses (Figure 3). A suitable method is to put rye grains of spawn (8 g) into the end of a 200 x 30 mm boiling tube, which is then partly filled with 30 g of compost to a mark 100 mm from the

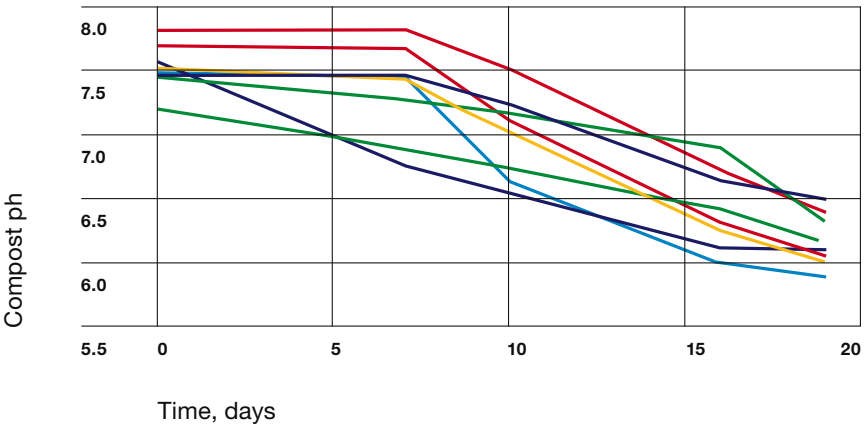
closed end and plugged with cotton wool. The tubes are then kept at 25°C and the distance of the mycelium front in the compost from the closed end of the tube measured every three days, until the mycelium reaches the top of the compost. The mycelial growth rate in mm/day can then be obtained by plotting the distance against time in a graph and measuring the slope. This method can give an indication as to which composts and spawn strains produce a fast or slow spawn-run but does not assess the density of mycelial growth. The results obtained in growth tubes (where compost is maintained at 25°C) will not exactly correspond with results obtained in bulk, where spawn-running composts have different self-heating capabilities, as mentioned earlier.

The most accurate methods for measuring the amount of mushroom mycelium in compost involve determining the concentrations of enzymes (laccase) or other compounds (ergosterol) produced by the mycelium. However, these techniques are time consuming, require specialist instrumentation, and/or the use of toxic reagents and are unsuitable for every-day commercial use. A simpler and more practical method is to measure the compost pH before and after spawn-running. During spawn run, compost pH declines from about 7.6 at spawning to about 6.1 after colonisation by mushroom mycelium (Graph 1). The fall in compost pH is caused by calcium oxalate/oxalic acid produced by the mushroom mycelium, and is related to the amount of mycelium present. It can be an indicator of the subsequent productivity of the compost. The compost pH should therefore be measured before and after spawn running. This can be achieved by measuring the pH of a suspension of compost in deionised water (40 g in 400 mL). It is important to use a pH probe electrode with a good specification that is suitable for use in slurries, and avoids compost proteins coating the electrode and interfering with the reading. Suitable glass bodied combination pH electrodes with an Ag/AgCl reference cell are the Thermo Scientific Ross Sure-flow (**www.thermo.com**) and Jenway 924.002 (**www.jenway.com**). Both probes are also available from Fisher Scientific (**www.fisher.co.uk**).



3 Measuring the rate of mycelium growth in growth tubes, with least growth on the left and most growth on the right

Graph 1 pH of different composts during spawn-running. The lower the pH the greater amount of mycelium and the larger the pH drop the better the spawn run.



Compost and environmental factors

Compost characteristics

Mushroom composts are usually analysed for total (Kjeldahl) nitrogen (N), ammonium N (NH_4+), ash content, moisture content and for pH. Comparing different straw and poultry manure composts revealed that there is an optimum moisture content of around 69% at spawning. However, quite large variations in pH, ash and total N content caused little difference in mycelial growth rates. Compost total N at spawning (2.3–2.65% of dry matter) and ash content had no significant effect. Only when the compost pH exceeded 7.85 and/or the ammonium N content exceed 0.09% of dry matter did the mycelial growth rate decline. These values apply if only horse manure and/or poultry manure are used as compost N sources. If other nitrogenous compost ingredients are used, particularly inorganic N sources, the optimum pH and ammonium N content of the pasteurised compost may be slightly different. By adding urea to the formulation, the pH of the spawned compost may be up to 7.9.

If ammonium sulphate is added, the ammonium N content of spawned compost may be up to 0.12% of dry matter and the pH of the compost will be reduced by up to 0.5 units.

Compost temperature

The compost temperature should be maintained at 25 – 27°C; temperatures above 30°C must be avoided (Figure 4). At least four temperature measuring points should be located in a room or tunnel (more probes for new installations or following changes to compost, supplements, spawn etc) to check variability in compost temperatures. Generally it is better to use cooling with more recirculation than to introduce more fresh air which will increase drying out. The CO_2 concentration in the compost can increase to about 1% v/v. Variable temperatures may indicate uneven airflow, variable filling (in tunnels or trays, shelves and blocks) or variability in compost or supplementation. The probes should be regularly calibrated.

Hygiene

Hygiene and filtration during spawning and spawn-running is of paramount importance and is dealt with in the HDC factsheet 11/07 *'Mushroom Virus X (MVX) prevention'*.

Spawn and supplementary nutrition

Spawn rate and type

Rye grain has largely replaced millet as the substrate for spawn. Experiments have shown no significant difference between different spawn substrates and the rate of spawn run. The rates of spawn used in compost vary widely. In North America, rates of 1% w/w are common. In the UK and Ireland, a rate of 0.5% w/w has been standard for many years, based on earlier research. Lower rates of 0.3% w/w are generally used for 'indoor compost' spawn-run in bulk tunnels in the Netherlands.

Experiments at Warwick HRI compared spawn rates of 0.5% w/w (equivalent to 8 litres per tonne of compost) and 0.8% w/w (equivalent to 13 litres per tonne of compost). Compost was spawned into trays with the strain Sylvan A15. The higher rate resulted in an earlier compost temperature peak, and a greater drop in compost pH during spawn running which meant spawn run time was reduced by one to two days. The higher spawn rate also produced a slightly higher mushroom yield. The effect of increasing the spawn rate should therefore be tested on farms alongside the standard rate of spawn used. Surface spawning trays had no effect on spawn run.

A duration of 16 – 17 days is usually required to obtain a full spawn-run, although this can be shortened by 1 – 2 days if a higher spawn rate is used. Casing of immature spawn run compost can result in high compost temperatures which are difficult to control.

Spawn strains

Large off-white hybrid strains (U1 type) colonise compost more slowly than smooth white hybrid strains (U3 type), and are less tolerant of sub-optimal compost moisture. Mid-range hybrids strains are intermediate in the rate of compost colonisation. The compost temperature surge for brown strains is usually earlier than for white strains although the length of spawn run is slightly longer.

Exotic strains of *Agaricus* mushrooms, such as horse mushrooms (*A. arvensis*) and *A. blazei* are intolerant of compost ammonium, which should be less than 0.03% of dry matter at spawning. The spawning rate, about 1.5% w/w or 24 litres per tonne of compost, also needs to be higher than for *A. bisporus*.

Supplements

Results with supplementation of Phase II are variable and much less predictable than the effects of supplementing spawn-run compost. Supplements usually contain varying amounts of protein (soybean meal, corn gluten meal, vegetable matter), lipids/fats, and/or other nutrients. The nutrients are usually in a delayed release form to minimise heat surges, and to prolong the release of nutrients into the cropping period. This is usually achieved by heat and/or chemical denaturing (eg with formaldehyde) or by coating the supplement. Specific supplements are available for use at spawning which have a more delayed release of nutrition than supplements designed for use at casing. If yield increases are obtained, this is usually reflected in an increase in mushroom numbers rather than in mushroom size or quality. No significant effect of supplementation has been found on the rate of spawn run.

Supplementation of Phase II compost can encourage the growth of competitor moulds in the compost and increases in compost temperature mean that it should not be conducted during warm weather without cooling. If supplements are used in Phase II compost, the benefits (if any) over unsupplemented compost should be regularly assessed.

There is clear evidence that the presence of the naturally occurring thermophilic fungus *Scytalidium thermophilum* is important in enhancing the selectivity of compost to mushroom mycelium. Composts which reach uniformly high temperatures (>70°C) in Phase I bunkers, and are not allowed to re-colonise with a naturally occurring microbiota, including *Scytalidium*, before Phase II, can produce poor spawn-runs. This problem can be avoided by giving the emptied Phase I compost a 'cooling' period of several hours, and/or a small amount of Phase II compost as an 'inoculum', before filling for Phase II. Experiments at several commercial composters have failed to provide conclusive evidence that the cropping performance of normal compost can be further improved by an artificial inoculum of *Scytalidium*.

Compost pressing and fill weight

When compost is spawned in trays or shelves, pressure is applied to increase the amount of compost that can be filled; in the case of blocks it also keeps the substrate in shape. Increasing the quantity of compost pressed into a tray, shelf or block increases the yield per unit area and results in heavier firmer mushrooms than shallower layers of compost. However, increasing the compost fill weight per cropped area reduces the mushroom yield per tonne of compost and increases spawn-running temperatures and requirement for cooling, particularly in warm weather (Figure 4).

Applying pressure for an excessive duration (12 seconds), and thereby reducing compost porosity, resulted in delayed spawn run and reduced mushroom yield, compared with unpressed compost or compost pressed for 6 seconds. Commercial composts are typically pressed for 3–4 seconds so that blocks retain their shape and compost is below the top edge of trays. The optimum duration of applying pressure for individual composts will depend on moisture content and how dense or open their structure is (less duration of pressing for wetter, denser and/or less porous composts). The effect of the duration of pressing compost and compost fill weights should be tested on farms and adjusted according to the properties of the compost and the need and availability of cooling.

4 Pressure applied to compost can affect spawn-running temperatures and mushroom yield

Action points

- Measure the pH of compost before and after spawn run – a larger pH drop indicates a better spawn run.
- Variability in compost temperatures, and calibration of temperature probes, should be regularly checked.
- If the current spawn rate is lower than 0.8% w/w (13 litres per tonne compost), the effect of increasing the rate to this level on spawn run and subsequent cropping should be checked
- If surface spawning and supplementation of pasteurised compost are currently practiced, the benefits over untreated compost should be evaluated.
- The amount of compost and duration of applying pressure to compost in trays, shelves and blocks should be regularly checked in relation to compost moisture content and texture.

Further information

This factsheet has been compiled from the findings of the series of HDC projects M3a, M3b, M3c, M3d and M3e. Further detail on these projects is in the project reports available to HDC members from the HDC website **www.hdc.org.uk** or the HDC office (01732 848383).

Hygiene and filtration during spawning and spawn-running are covered in the HDC factsheet 11/07 *'Mushroom Virus X (MVX) prevention'*.

Suitable glass bodied combination pH electrodes with an Ag/AgCl reference cell are the Thermo Scientific Ross Sure-flow (**www.thermo.com**) and Jenway 924.002 (**www.jenway.com**). Both probes are also available from Fisher Scientific (**www.fisher.co.uk**).

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