Contract No. M 34

The Effects of Compost Moulds in Mushroom Compost

Final report 1999

Project Title	The effects of Compost Moulds in Mushroom Compost
Project Number	M 34
Project Leader	Dr. Helen Grogan Horticulture Research International Wellesbourne Warwick CV 35 9EF
Final Report	October 1999
Previous Reports	None
Key Workers	Dr Helen Grogan Ms Lisa Harvey
Location of Project	Horticulture Research International Wellesbourne Warwick CV35 9EF
Project Co-ordinator	Mr. Martyn Dewhurst Tunnel Tech Ltd. The Old Airfield Winchester Street Leckford Stockbridge Hampshire SO20 6JF
Date Project Commenced	1st October 1998
Key words	weed moulds, *Pythium, Trichoderma, Penicillium, Fusarium, Acremonium*

Contents Page

Practical Section for Growers

Background

Two major developments associated with the production of mushroom compost have occurred in recent years. Firstly, as a result of environmental pressures concerning odour pollution, composters are increasingly adopting composting techniques that involve forced aeration of the Phase I process, also called "bunker compost". This results in a different spectrum of environmental conditions and changes in microbial activity compared to compost produced by traditional methods. It is likely that the majority of composts will be produced by this method in the foreseeable future.

Secondly, an increasing amount of compost is being spawn-run in bulk to produce 'bulk Phase III'. This technique is, by its nature, intrinsically vulnerable to contamination by compost moulds, a name suggested to replace out-dated and sometimes ill-defined names such as 'weed', 'indicator' and 'competitor' moulds. Each bulk phase III tunnel is, in effect, a giant 'solid substrate fermentor' concerned with the production of a 'pure' culture (*Agaricus*) after a period of incubation (spawn-run). As with all fermentors, bulk phase III requires strict hygiene practices to maintain the purity of any given batch as any contamination can lead to a reduction in quality or even total loss of a batch.

Routine screening of bulk Phase III and other spawn-run composts by the Mushroom Diagnostic Clinic at HRI has revealed that a number of moulds can and do occur at this stage in the production cycle. These moulds have sometimes, though not always been associated with reductions in yield. The frequency and variety of moulds encountered are such that they have given rise to a concern regarding their possible effects on compost productivity. Even small reductions in yield cannot be sustained in a climate where profit margins are low and costs are always increasing.

This project was commissioned to ascertain if a selected number of moulds had any effect on mushroom yields following their incorporation into compost by various inoculation methods.

Summary

Six moulds were selected for a small scale cropping trial based on their antagonism towards *Agaricus* in laboratory tests. The moulds were inoculated into fresh compost using (a) spore suspensions (b) sterilised rye grain contaminated with spores and (c) compost colonised by mould mycelium. The moulds selected were *Fusarium* sp., *Trichoderma pseudokoningii*, *Acremonium murorum*, *Pythium oligandrum*, *Trichoderma atroviride* and a *Penicillium* sp. known to cause a cropping disorder.

Five out of the six moulds tested had a significant inhibitory effect on the yield of 1st flush mushrooms compared to the uninoculated control treatment (Table 1). The average reduction in 1st flush yield ranged from 8% (*Trichoderma pseudokoningii*) to 84% (*Penicillium* sp.). The 2nd flush yields for all treatments, except *Penicillium*, were similar to the uninoculated controls, while the 3rd flush yields for a number of the mould treatments were higher than the controls. The yield improvement in the 2nd and 3rd flushes was not sufficient to prevent an overall yield reduction by *Acremonium murorum, Pythium oligandrum,* and *T. atroviride* Table 1), whereas the yield from *T. pseudokoningii* inoculated compost fully recovered by the

3rd flush. *Fusarium* sp. did not have any yield reducing effect while *Penicillium* sp. caused almost complete crop failure.

Mould propagules were recovered from all inoculated composts after spawn-run, despite the fact that most spawn run composts looked good to very good with little or no obvious signs of mould presence. The most obvious visible symptoms were produced by *Penicillium*-inoculated compost (spore smoke) and *Pythium*-inoculated compost (black patches). *Acremonium*-inoculated compost produced small grey colonies which were difficult to see in an otherwise well run compost. *Trichoderma* and *Fusarium* growth in spawn-run compost was either very localised or absent.

Table 1. Yield of mushrooms per flush, and total yield, for composts inoculated with different mould species. Yields for each mould are the average of all inoculation treatments. Yields from inoculated composts are expressed as a % of the control yield.

	Yield of mushrooms			
	1st Flush	2nd Flush	3rd Flush	Total
Control (grams or kg/plot)	585 g 100%	504 g 100%	157 g 100%	1.25 kg 100%
Inoculated Mould species:				
Fusarium sp.	99	100	99	100
T. pseudokoningii	92#	102	115#	99
Acremonium murorum	82#	101	111	93#
Pythium oligandrum	82#	96	119#	93#
T. atroviride (T43)	74#	98	110	88#
Penicillium sp (1043D)	16#	3#	0#	9.1#
Least Significant Difference in grams at *P = 0.05*	39.6 (6.8%)	23.6 (4.7%)	17.1 (11%)	43.7 (3.5%)

Yield is significantly different from the control based on statistical analysis of raw data.

Action points for Growers

In this initial trial an attempt has been made to establish whether or not compost moulds can have a detrimental effect on mushroom yield. The results summarised above confirm that some moulds do have a detrimental effect and the research has therefore been justified. With mushroom crops of even shorter duration than three flushes becoming more commonplace, yield losses on the first flush must be considered highly detrimental. The work described here simulated bulk Phase III on a small scale but there is concern that the results from a 'real' bulk Phase III system could be even worse.

The major point is to be aware of the levels of moulds occurring in spawn run compost, whatever the source. A further project is planned to take place in 2000 to survey the situation across the industry. The aim will be to ascertain the range of moulds occurring and the levels at which they occur, before embarking on further work to resolve this problem.

Science Section

1. Introduction

Major developments associated with the commercial production of mushroom compost have occurred in recent years. Firstly, as a result of environmental pressures concerning odour pollution, composters are increasingly adopting composting techniques that involve forced aeration of the Phase I process, also called "bunker compost". This results in a different spectrum of environmental conditions which can alter the degradation of the straw due to changes in microbial activity, compared to compost produced by traditional methods (Evered, Noble & Atkey 1995; Iiyama *et al*. 1995, Fermor & Atkey, 1995). It is envisaged that the majority of compost will be produced by this method within the foreseeable future.

Secondly, an increasing amount of compost is being spawn-run in bulk to produce what is known as 'bulk Phase III'. This process involves spawning a large volume of compost that is then put into a controlled environment tunnel for spawn-running, rather than the more traditional methods of spawn-running in trays, bags or blocks. This technique is, by its nature, intrinsically vulnerable to contamination by compost moulds, a name suggested to replace the out-dated and sometimes ill-defined names such as 'weed', 'indicator' and 'competitor' moulds. Each bulk phase III tunnel is, in effect, a giant 'solid substrate fermentor' concerned with the production of a 'pure' culture (*Agaricus*) after a period of incubation (spawn-run). As with all fermentors, whatever the product, bulk phase III require strict hygiene practices to maintain the purity of any given batch as any contamination can lead to a reduction in quality to total loss of a batch.

In the late 1980's and early 1990's, *Trichoderma harzianum*, strain Th2, caused widespread economic losses to mushroom growers in Britain and Ireland. This mould was an aggressive competitor to *Agaricus* in compost, resulting in very poor spawn-runs and very significant crop losses (Grogan et al. 1996). If such a mould were to contaminate a bulk Phase III tunnel, the financial consequences for the composter would be enormous. *Trichoderma harzianum* Th2 no longer seems to be a major problem in Britain. However, routine screening by the Mushroom Diagnostic Clinic at HRI of bulk Phase III and other spawn-run composts, has revealed that a number of moulds can and do occur at this stage in the production cycle. These moulds have sometimes, though not always been associated with reductions in yield. The frequency and variety of moulds encountered are such that they have given rise to a concern regarding their possible effects on compost productivity. Perhaps many of them are harmless but, in view of the fact that some occur more often and at higher levels than others, it would be very useful to know whether or not they have any effect on the yield potential of the compost. This knowledge is also of importance when considering the vulnerability of the bulk Phase III system, as well as the greater pressure on modern mushroom production units to be economically viable. Small reductions in yield cannot be sustained in a climate where profit margins are low and costs are always increasing.

This project was commissioned to ascertain if a selected number of moulds had any effect on mushroom yields following their incorporation into compost by various inoculation methods.

2. Materials and Methods

2.1 Compost moulds

Six compost moulds were selected for a small scale cropping trial based on their antagonism towards *Agaricus* in *in-vitro* Petri-dish tests. Details of the isolates are listed in Table 1. All moulds were isolated from composts that were exhibiting problems, but they were not all necessarily implicated in the problem.

Table 1. Details of moulds used in cropping experiment.

Isolate	**Number**	**Isolated from:**	**Effect on *Agaricus in vitro***
Acremonium sp.	1003Bi	Spawn-run Compost	*Agaricus* growth inhibited; some regrowth
Fusarium sp.	919A	Spawn-run Compost	*Agaricus* growth inhibited; some regrowth
Penicillium sp.	1043D	Spawn-run Compost	*Agaricus* growth inhibited; some regrowth
Pythium sp.	1004C	Spawn-run Compost	*Agaricus* growth inhibited; some regrowth
Trichoderma atroviride	T43	Spawn-run Compost	*Agaricus* growth inhibited; no regrowth
Trichoderma pseudokoningii	924	Spawn-run Compost	*Agaricus* growth inhibited; no regrowth

2.2 Inoculum preparation and application

Three types of inoculum were prepared for each mould in order to maximise the possibility that one or other would effectively cause the compost to be colonised by the introduced mould. All inocula were applied at spawning and compost samples were taken immediately afterwards to determine the number of propagules present in the compost following each inoculation method.

Spore suspension. Up to 10 cultures of each mould were used to produce a concentrated spore suspension of approximately 1 x 10^6 to 1 x 10^8 spores per ml. A 100 ml volume of spore suspension was then sprayed into a single tray of compost (30 kg) at spawning, for each mould, to give in the region of 30 to 3000 spores per gram fresh weight (gfw) of compost.

Grain inoculum. Grain inoculum was prepared by gently coating 250 grams of sterilised rye grain in spores (and or mycelium) by rolling them in mature cultures of each mould. All 250 grams of the grain inoculum was then applied to a single tray of compost at spawning, by shaking the grain over the compost and gently mixing it through.

Compost inoculum. A small quantity of compost was steam sterilised at 80ºC for 1 hour on two consecutive days and then filled into three sterile honey-jars. For each mould, three honey-jars of inoculated compost were prepared by adding six plugs of mould culture to each

jar, and incubating for up to 2 weeks. By this time most moulds had colonised the sterile compost. Three jars of compost inoculum were then incorporated into a single tray of compost at spawning, by gently mixing the contents of the jars with the fresh compost.

2.3 Compost preparation and crop details

Phase II compost, produced by HRI Mushroom Unit (Batch No. 03/99), was used in this study. Thirty kg of unspawned Phase II was loosely filled into wooden trays measuring 91 cm x 61 cm x 17 cm (l x b x h). Twenty-four trays were prepared, three for each of the six moulds to be tested, and six as control treatments. Each tray was spawned individually with 150 grams of spawn (Sylvan A 15). At the same time, compost was inoculated with one of the compost moulds, using the methods described above. Care was taken to prevent cross contamination through the implementation of strict hygiene measures (changes of gloves, disinfecting vulnerable areas, spraying the air with a fine mist of water to precipitate any spores which may have become airborne). The spawned and inoculated compost was then loosely re-filled into a steamed wooden tray with wide gaps between the bottom boards to allow easy air movement through the compost. Compost was not compressed. This combination of conditions was designed to simulate Phase III conditions as best as possible within the confines of the small-scale nature of this experiment. The loosely filled trays were then spawn run at 25ºC for 20 days. After spawn running, the compost from each tray was gently mixed up, to simulate removal from a Phase III tunnel, and filled into six 260-mm diameter pots at a rate of 3-kg compost per pot. Again, care was taken to prevent cross-contamination from different mould treatments by implementing a strict hygiene regime as before (i.e. changes of gloves, disinfecting vulnerable areas, spraying the air with a fine mist of water to precipitate any spores which may have become airborne). The spawn-run compost was compressed into the pot with the aid of a second (empty) pot, which was pressed firmly down onto the compost. Filled pots were then cased with a commercial casing (Tunnel Tech English) containing casing inoculum. Pots were case-run, aired and cropped according to standard procedures on the HRI Mushroom Unit. Three flushes were harvested.

Statistical design and analysis. This study involved: Three inoculation methods; 7 mould treatments (untreated – double replication, *Fusarium*, *Trichoderma pseudokoningii*, *Acremonium*, *Pythium*, *Trichoderma atroviride*, *Penicillium* sp.); 6 replicate pots of each treatment combination. Pots were placed in a racked cropping chamber with three shelves, each capable of taking 4 x 12 rows of pots, according to a split-plot design. Mould treatments were applied to groups of three adjacent pots within a row, and inoculation methods were randomly allocated within each of these main plots. Each shelf was divided into 16 main plots arranged in 4 rows by 4 columns. Control treatments were arranged to appear once in each row and once in each column on each shelf. The other mould treatments were arranged to ensure as equal an occurrence of treatment pairs within rows and columns and within shelves as possible. Yield data was analysed by the HRI Biometrics department using the method of Restricted Maximum Likelihood (REML) to allow adjustment for any positional effects. Treatment effects were determined using a Wald test and, where significant effects were determined, mould-treatment means were compared to the control mean using the least significance difference (LSD) value at $P = 0.05$, calculated from the standard error of differences (SED) between the means.

2.4 Determination of compost mould population levels.

Compost from all treatments were examined for presence of the introduced mould species with samples being taken at spawning, at casing and at crop termination. Three replicate samples were taken from each inoculation type for every mould species, at each of the sampling times. Each sample was processed as follows:

For each replicate compost sample, a 20-gram sub-sample was taken and placed in a sterile polythene homogeniser-bag (182 x 310 mm x 72 μm), to which 360 ml sterile water was added. After soaking for 1 hour, the sample was homogenised for 1 minute in a 'Stomacher 400' laboratory blender, left to rest for 5 minutes then re-homogenised for 1 minute. The resulting compost extract was then serially diluted to give a concentration range of 1×10^{0} to 1×10^{-5}. A 1-ml aliquot of each dilution was pipetted into a series of sterile Petri-dish, and molten OAES (Ohio Agricultural Experimental Station) medium, held at 50ºC was then poured into each dish. When cooled, the Petri-dishes were placed in a 25ºC incubator, and examined after three and seven days. The number and identity of colonies was recorded for each dilution. The data from each treatment dilution series were analysed using the Genstat program DILUTION (Ridout & Welham, 1997) to calculate the 'Most Probable Number' (MPN) which gives an estimate of the number of propagules/gram fresh weight for each treatment, at each sample time.

Propagules of *Pythium* were difficult to recover using the above technique so an alternative "*Pythium* test" was also carried out on all *Pythium* inoculated compost. This involved placing a small compost sample in a Petri-dish, baiting it with sterilised grass leaves and water and incubating at 25ºC. After one week, the sample was examined for the presence or absence of the very distinctive *Pythium* oogonia. Three replicate tests were carried out for compost from each of the inoculation methods.

3. Results and Discussion

3.1 Effect of compost moulds on Yield.

Five out of the six moulds tested had a significant inhibitory effect on the yield of 1st flush mushrooms compared to the uninoculated control treatment (Figure 1). The average reduction in 1st flush yield was 8% for *Trichoderma pseudokoningii*, 18% for *Acremonium murorum* and *Pythium oligandrum,* 26% for *T. atroviride* and 84% for *Penicillium* sp. (Table 2). The 2nd flush yields for all treatments, except *Penicillium*, were similar to the uninoculated controls, while the 3rd flush yields for a number of the mould treatments were higher than the controls. The yield improvement in the 2nd and 3rd flushes was not sufficient to prevent an overall yield reduction by *Acremonium murorum, Pythium oligandrum,* and *T. atroviride* Table 2), whereas the yield from *T. pseudokoningii* inoculated compost fully recovered by the 3rd flush. *Fusarium* sp. did not have any yield reducing effect while *Penicillium* sp. caused almost complete crop failure.

Table 2. Yield of mushrooms per flush, and total yield, for composts inoculated with different mould species. Yields for each mould are the average of all inoculation treatments. Yields from inoculated composts are expressed as a % of the control yield.

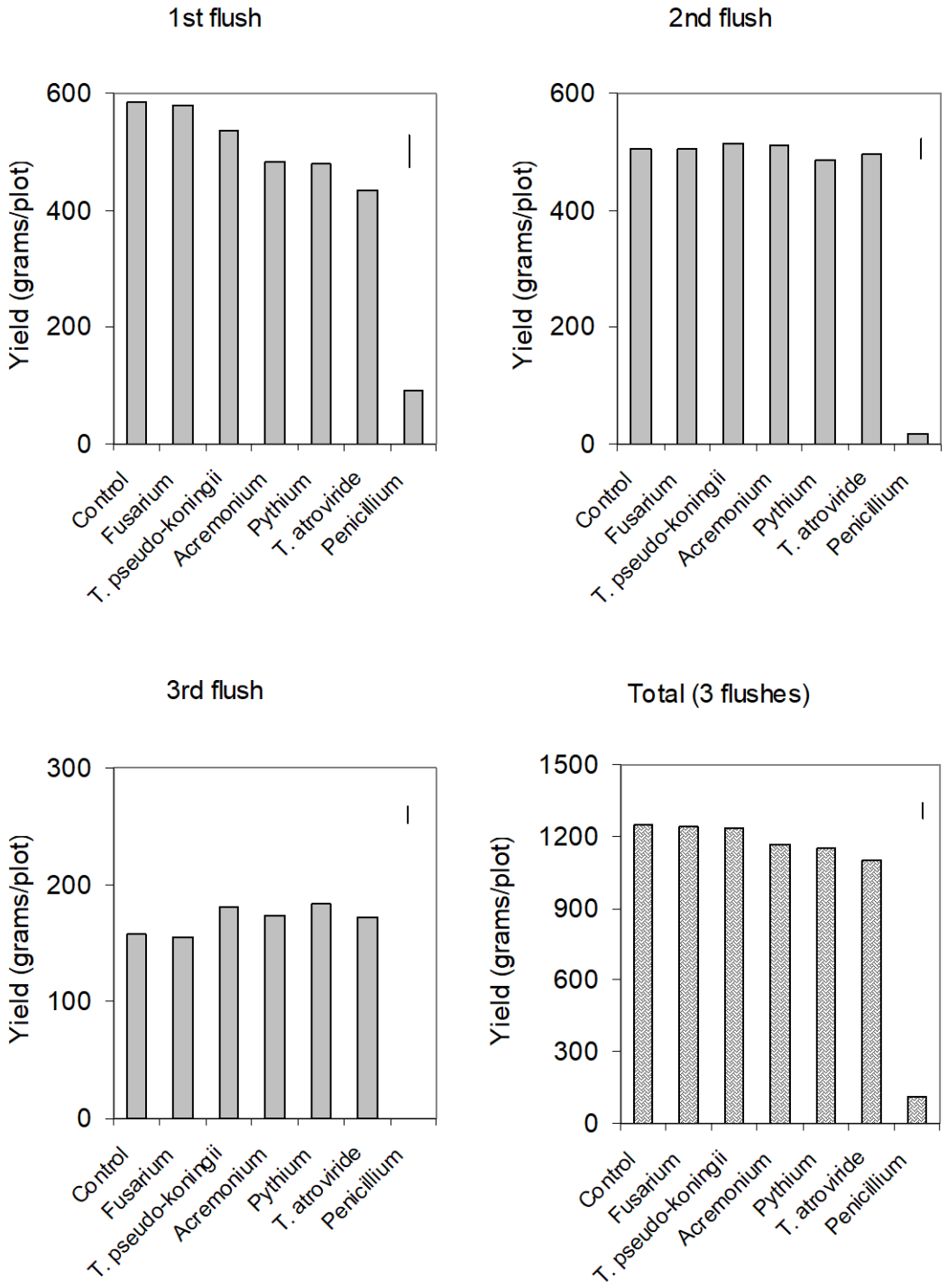
	Yield of mushrooms			
	1st Flush	2nd Flush	3rd Flush	Total
Control (grams or kg/plot)	584.6 g 100%	504.1 g 100%	157.2 g 100%	1.25 kg 100%
Inoculated Mould species:				
Fusarium sp.	99	100	99	100
T. pseudokoningii	92#	102	115#	99
Acremonium murorum	82#	101	111	93#
Pythium oligandrum	82#	96	119#	93#
T. atroviride (T43)	74#	98	110	88#
Penicillium sp (1043D)	16#	3#	0#	9.1#
Least Significant Difference in grams at *P = 0.05*	39.6 (6.8%)	23.6 (4.7%)	17.1 (11%)	43.7 (3.5%)

Yield is significantly different from the control based on statistical analysis of raw data.

3.2 Effect of compost moulds on mushroom quality.

Only *Penicillium* sp. had an effect on mushroom quality. Mushrooms from this treatment were smaller and opened early, compared with mushrooms from the control treatment (Plate 1, Appendix).

Figure 1. Effect of various mould species on yield of mushrooms. Vertical bar in top right hand corner represents the least significant difference from the control at the 5% level of probability.



3.3 Mould populations and their visibility in inoculated composts.

After inoculation. Propagules of all moulds were recovered from inoculated composts shortly after inoculation, indicating that the inoculation methods were successful, though the numbers of propagules recovered varied depending on the inoculation method (Table 3). At this stage the inoculum is largely invisible to the naked eye.

After spawn-run. At the end of the spawn-run, propagules of all moulds were recovered from inoculated composts (except for one *Pythium* treatment) indicating that all moulds had continued to persist in the compost (Table 3). The quality of the spawn-run composts was good to very good for *Fusarium*, *Trichoderma pseudokoningii*, *Acremonium* and *Trichoderma atroviride*, with either little or no sign of the moulds on, or in, the compost. Black patches with no *Agaricus* growth were observed on all *Pythium* inoculated composts, with the grain inoculum producing the poorest spawn-run. *Pythium* propagules were only recovered from spore and grain-inoculated compost despite the fact that black patches had been observed on the surface of all three inoculum treatments prior to the compost being broken up and sampled. A greater number of samples may have been needed to detect the mould at this stage. *Agaricus* growth in *Penicillium*-inoculated composts appeared moderate to good but when the compost was broken up, clouds of spores appeared to be released into the air like puffs of "smoke". This was reflected in the propagule-counts which were all too high to be determined (> 2,000,000 propagules per gram fresh weight of compost).

Propagule numbers after spawn-run were usually highest when grain-inoculum was used. This may reflect the fact that the nutrients in the grain would provide an easily available food source for the growth and sporulation of the different moulds.

At crop termination. Only propagules of *Fusarium* sp., *Trichoderma pseudokoningii*, *Acremonium* and *Trichoderma atroviride* were recovered at crop termination (Table 3) however the quality of these composts at this stage was still very good. Close examination of them however, revealed that small patches of the inoculated moulds were usually present. No *Pythium* propagules were detected using the *Pythium* test and neither was there any evidence of any black patches in the compost at this stage. Yields from *Pythium* inoculated compost had all recovered significantly in the 2nd and 3rd flushes so that by crop termination *Pythium* may have disappeared. No *Penicillium* sp. propagules were recovered from the *Penicillium* inoculated compost despite the fact that clouds of smoke emanated from disturbed compost at crop termination. However, compost analysis indicated that other spore producing moulds (*Doratomyces* sp. and *Trichoderma* sp.) were also present in the compost which, by this time, was black and wet with no *Agaricus*. These moulds may have obscured the inoculated *Penicillium* sp. which was very slow growing.

3.4 Relationship between mould populations and yield reductions (Table 3).

Fusarium. *Fusarium* propagules were isolated throughout the crop cycle. The numbers were generally low except for the grain-inoculum treatment where numbers increased during spawn-run but then decreased again by crop termination. Thus, *Fusarium* sp. had no significant effect on yields, despite being consistently present at low to moderate levels during spawn-run (This does not rule out the fact that other *Fusarium* spp. may behave differently).
Trichoderma pseudokoningii. *Trichoderma pseudokoningii* propagules were recovered at moderate to very high levels after inoculation. In spore and compost inoculum treatments, the numbers had dropped considerably by the end of spawn-run, but they were still recovered

from compost at crop termination. This suggests that it can co-exist with *Agaricus* in compost. When grain inoculum had been used the number of propagules in the compost had increased considerably by the end of spawn-run and they were still present at high levels at crop termination. The grain is likely to provide an independent source of nutrition to the mould, enabling it to grow and sporulate. This presence of *Trichoderma pseudokoningii* in compost caused a significant reduction in the 1st flush yield of 6-12%, with the greatest reduction occurring where the propagule numbers were highest. After three flushes, however, the yields had recovered to a level similar to the controls (Figure 1). Thus, *Trichoderma pseudokoningii* in compost had a significant, but transient effect on mushroom yield.

Acremonium. *Acremonium* propagules were recovered at moderate to very high levels after inoculation, spawn-run and crop termination suggesting that it is well able to co-exist with *Agaricus* in compost. Although for all of the inoculation treatments the growth of *Agaricus* at the end of spawn-run looked good to very good, 1st flush yields were down by 11 to 32%. Subsequent flushes recovered to a certain degree but total yields were down by 3-11% with the greatest reductions occurring where the propagule numbers at the end of spawn-run were highest. Thus, *Acremonium murorum* in compost had a significant negative effect on mushroom yield.

Pythium. *Pythium* propagules were recovered from all inoculated composts after inoculation, from two treatments after spawn run but they were not recovered at all from any treatment at crop termination. Both grain and compost inoculum reduced 1st flush and total yields significantly while spore suspension inoculum only reduced yields slightly. This reflects the quality of the inoculum, which was good for grain and compost inocula, and poor for spore suspension inoculum (Table 3), however black patches were observed on all *Pythium* inoculated compost at the end of spawn-run. The spore inoculum, though low in spores, was still capable of producing black *Pythium* patches. Thus, *Pythium* in compost had a significant negative effect on mushroom yield.

Trichoderma atroviride. *Trichoderma atroviride* propagules were recovered at moderate to very high levels after inoculation, spawn-run and crop termination suggesting that it is well able to co-exist with *Agaricus* in compost. Although *Agaricus* growth in the compost at the end of spawn-run was very good, 1st flush yields were down by 23 to 30% compared to the controls. Subsequent flushes recovered to a certain degree but total yields were still down by 3-19%. The greatest reductions occurred where the propagule numbers at the end of spawn-run were highest. Thus, *Trichoderma atroviride* in compost had a significant negative effect on mushroom yield.

Penicillium sp. Propagules of *Penicillium* sp. were recovered at low levels after inoculation but at exceptionally high levels after spawn-run (Table 3). The growth of *Agaricus* in the compost after spawn run looked moderate to good but a fine cloud of spores was produced when it was disturbed. All inocula reduced yields dramatically throughout the duration of the crop (Figures 2 and 3). *Penicillium* sp. propagules were not recovered at crop termination, although "spore smoke" was produced. Close examination of the wet, black compost revealed the presence of whisker mould (*Doratomyces*) as well as other *Penicillium* spp., both of which produce masses of dry spores capable of producing a spore smoke. This *Penicillium* sp. is a very serious threat to mushroom production.

4. Conclusions

- One of the six moulds tested (*Fusarium* sp.) had no significant effect on *Agaricus* yields, despite being consistently recovered from the compost throughout the cropping period.
- Five out of six moulds tested (*Trichoderma pseudokoningii*, *Acremonium murorum*, *Pythium oligandrum*, *Trichoderma atroviride*, and *Penicillium* sp.) significantly reduced the 1st flush yield of mushrooms, compared with a control treatment, with yield reductions of from 8 to 84% being recorded for individual moulds.
- Second and 3rd flush yields for four inoculated composts were generally similar to or better than the controls, indicating that *Agaricus* growth was recovering. This reduced the effect of 1st flush yield reductions to give total yields of 99% (*Trichoderma pseudokoningii*), 93% (*Acremonium murorum* and *Pythium oligandrum*) and 88% (*Trichoderma atroviride*).
- One mould, a *Penicillium* sp., caused the crop to fail, producing a total yield of only 9% of the control. The quality of these mushrooms was poor due to their small size and early opening.
- Mould propagules were recovered from all inoculated composts after spawn-run, despite the fact that most of them looked good to very good with little or no obvious signs of mould presence. The most obvious symptoms were produced by *Penicillium*-inoculated compost (spore smoke) and *Pythium*-inoculated compost (black patches). *Acremonium*-inoculated compost produced small grey colonies which were difficult to see in an otherwise well run compost. *Trichoderma* and *Fusarium* growth in spawn-run compost was very localised or absent.
- The presence of moderate to high levels of mould propagules in spawn-run compost should always be considered as a potential indicator of a small (or large) 1st flush yield reduction.
- Further experimental work is required to determine which mould species, among those frequently isolated from spawn-run compost, have the potential to reduce yields significantly.

5. References

Evered, C.E., Noble, R. & Atkey, P.T. (1995). Microbial populations and straw degradation in mushroom composts prepared in controlled environments. *Mushroom Science* **XIV**, 245-250.

Fermor, T. & Atkey, P.T. (1995). Microbiology of controlled environment composting. *HDC Project News,* **32,** p9.

Grogan, H.M., Noble, R. & Gaze, R.H. (1996). Control of *Trichoderma harzianum* – a weed mould of mushroom cultivation. *Brighton Crop Protection Conference – Pests & Diseases - 1996*, 337-342.

Iiyama, K., Lam, T.B.T., Stone, B.A., Perrin, P.S. & Macauley, B.J. (1995). Compositional changes in composts during various types of composting and mushroom growth. *Mushroom Science* **XIV**, 235-244.

Ridout, M.S. & Welham, S.J. (1997). Procedure Dilution. In *Genstat 5 Procedure Library Manual Release PL10* (eds. Payne, R.W., Morgan, G.W. & Arnold, G.M.). Numerical Algorithms Ltd., Oxford UK. 371pp.

