

Mushrooms

Projects M6a, M14b, M14c, M31, M33, M33a and CP4

Identification and control of dry bubble disease of mushrooms

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This factsheet is a summary of the most important information currently available on dry bubble disease of mushrooms (*Verticillium fungicola*). Its objective is to provide guidance to the recognition, prevention and control of the disease.

Introduction

Dry bubble disease is a common and potentially serious disease wherever mushrooms are cultivated. Most farms will have experienced outbreaks of this troublesome disease at one time or another and once established it

can become a persistent and severe problem if it is not controlled early on.

Dry bubble disease results in direct crop losses due to aborted and malformed mushrooms. Indirect losses occur due to spoilage of a proportion of the crop due to cap spotting, stipe splitting and wart-like

growths on mushroom caps. See Figure 1. Increased labour costs are incurred to cover the extra human resources needed to inspect and treat crops for disease. In addition there is the cost of the pesticides used to combat the disease.



1 Dry bubble infection causing crop loss and spoilage

Symptoms

The type of symptom that occurs will depend on the stage of development of the mushroom when it is infected. If initials become infected, the result is small undifferentiated 'bubbles' of mushroom tissue, a centimetre or less in diameter as shown in Figure 2. If left these can grow into much larger distorted bubbles as shown in Figure 3. If an infection occurs when the mushroom has already been formed it can lead to a range of symptoms and abnormalities depending on the developmental stage of the mushroom at the time of infection.

These symptoms can vary between grotesque sporophores that are barely recognisable as mushrooms (see Figure 3) to only slight distortions, split stipes or caps with wart like growths as shown in Figure 4.

If *Verticillium* spores are deposited on the cap of a growing mushroom then cap spotting symptoms will develop. The spots are at the first greyish, turning brown as they age. The bubbles are characteristically creamy/grey and dry but they can be similar to the 'wet bubbles' caused by *Mycogone perniciosa*, which lacks

the grey bloom and will sometimes ooze droplets of liquid.

Laboratory identification is required in some cases to distinguish between dry and wet bubble or to isolate the infectious agent from mushrooms showing atypical symptoms. Cap spotting, unaccompanied by any obvious source of pathogen spores, is also best identified in the laboratory to ascertain which of the many possible pathogens is causing the symptom. Clinic Services can be obtained from the CSL Plant Clinic in the UK and Teagasc in Ireland – see 'Further Information' section.



2 Infected pin forming small bubble



3 Mushrooms severely malformed by *Verticillium*



4 Wart like growths on cap



5 Spotting on caps from water splash

Biology and epidemiology

Dry bubble disease symptoms occur when spores of *Verticillium fungicola* var. *fungicola* germinate near or on mushroom sporophores. The pathogen does not grow through compost or casing. It seeks out *Agaricus* initials, pins and mushrooms and it will penetrate and grow inside them, disrupting their development to form bubbles of undifferentiated tissue, malformed mushrooms or spots,

eventually producing masses of spores on infected tissue as a means of dispersal.

Verticillium spores are produced in a mass of sticky mucilage and will adhere to pickers, flies and mites and anything that comes into contact with them. Water splash will spread the spores onto the surrounding mushroom bed and any run-off water will contaminate the cropping house floor. Eventually the spores become an integral part of the farm dust fraction. By these various routes the disease is readily spread

within a crop and into younger, uninfected crops.

All stages of production, from casing onwards, are vulnerable to infection by dry bubble disease. Casing contamination is particularly important as the resultant diseased mushrooms are often the nucleus for infection in that particular crop. Diseased mushrooms resulting from casing contamination can appear in the first, second or even third flush, depending on how much background contamination there is on the farm.

Monitoring crops – Vigilance

Close and assiduous scrutiny of the mushroom beds should be constantly carried out in the apparent absence

of disease as it is often small, undetected and untreated pieces of diseases that trigger an outbreak.

- Disease symptoms must be continually searched for, identified and salted before watering takes place.

- Failure to do this successfully will result in a widening area of disease caused by run off and water splash.

Prevention

The need to prevent this disease becoming established on a farm necessitates many control measures being permanently in place. The exact source of any disease outbreak is often a matter of conjecture but in all probability it will be a contamination of casing material by dust and debris from the farm. This will give rise to a small number of diseased mushrooms or bubbles which, if subsequently overlooked, will allow the disease to spread within the crop. To prevent disease establishment, a grower must prevent casing contamination.

Before casing application

- Reception areas for casing deliveries should be cleaned and disinfected immediately before the casing arrives.
- If the casing is to be stored for any time, the storage area must be protected from wind-blown dust.

During casing application

- All machinery used to handle and apply casing should be thoroughly washed and disinfected prior to use.
- The application of casing to shelves is often particularly exposed. Any adjacent concrete surfaces from which dust may be blown before and during the application process should be damped down **prior** to the casing operation but power washing concrete surfaces should **not** be done when casing is in progress.
- Casing operators should wear clean overalls, boots and gloves and should not have been in growing rooms prior to casing.

remains vulnerable to any residual disease that may be in the house.

- Casing debris on the floor should be scraped up rather than power washed or brushed.
- Floors should not be allowed to dry out but dust should not be splashed onto beds by over zealous washing.
- Floors should never be swept when dry as this will raise dust which may be contaminated.

Prevention of contamination of casing

Contamination of casing can take place during delivery, storage, application and on the mushroom beds. All surfaces such as concrete aprons, application machinery, even cracks in growing room floors should be considered as likely places where dust and debris carrying Verticillium spores can lodge. The following are key steps in preventing casing contamination.

After casing and during cropping

- Once the casing is on the bed and the house closed, the casing

Effective sealing

- The first pieces of dry bubble are often located near the front and back ends of the mushroom house suggesting that the contamination has occurred due to unfiltered air entering the room via gaps or holes around doors, air handling equipment and exhaust outlets, especially during dry windy conditions.
- All gaps and holes should be repaired and doors should be kept shut during case-running and airing.

- Leaving doors open unnecessarily during watering operations will also let unfiltered dust-laden air enter growing rooms.

At the end of cropping

- The final major preventative

measure is to cook out all crops in situ at crop termination.

- Ideally, temperatures should reach 65–70°C in the compost and be held for 12 hours to ensure that cooler parts of the house reach adequate temperatures.

Adherence to these major preventative measures should permanently exclude dry bubble disease but disease may occasionally take hold if there is a breakdown in following them.

Control

When attempts to exclude the disease have failed and it has expressed itself by the appearance of disease symptoms, the exclusion practices should be re-examined and deficiencies rectified. Under these circumstances, early identification and subsequent treatment of disease becomes of paramount importance if the disease is not to spiral out of control.

never be allowed to take place over untreated disease. Figure 6 shows spotting from infection spread by water splash.

- Spores from diseased mushrooms and bubbles that are watered over will spread first out into the adjacent casing and then onto the floor, both as water runoff and as casing debris.
- Run off from affected areas will augment the level of *Verticillium* spores in the farm dust fraction and thus exert more disease pressure on the already imperfect processes of exclusion.

- If symptoms are severe not watering crops between flushes should be considered as it is unlikely that all diseased mushrooms and bubbles will have been identified and treated.

Limiting contamination and spread

- Clean crops should be harvested before diseased ones as harvesters will pick up spores and contaminated debris on their clothing and footwear and move them, initially around the infected house, then out into corridors and onto the farm in general. Here,

Watering

- Watering is a major cause of disease spread so watering should



6 *Verticillium* spotted caps following spread by water splash

traffic is heavier and opportunities will arise to pick up and spread *Verticillium* spores to 'clean' rooms or rooms in the process of being cased.

- Due to the sticky nature of *Verticillium* spores, anything or any person passing through infected rooms or along the corridor can potentially pick up spores and carry them around the farm, building up the background level of contaminating dust on the farm.
- Disinfectant foot dips should be placed at the entrances to every house and should be used both on entering and exiting growing rooms to minimise the spread of contaminated debris on footwear.
- Central corridors and communal concrete areas should be disinfected each day, especially when an outbreak of disease occurs.
- Dedicated harvesting knives and overalls should be used for each house and not used elsewhere.

- Picking trolleys, especially the wheels and parts in contact with shelf or tray sides, will also spread contaminated debris around the house, on the floor and along shelves or trays.
- Care should be taken when washing picking trolleys from infected houses at the end of cropping as the wash water will be laden with *Verticillium* spores.
- Picking trolleys and other potentially contaminated equipment should not be power washed outdoors when casing is in operation or when freshly cased houses are open, as the fine spray generated during power washing travels easily.

Fly control

A substantial fly infestation will negate all other attempts to control dry bubble disease as flies move easily around the farm carrying the sticky *Verticillium* spores from crop to crop (see Figure 7). Phase III

compost is much less susceptible to fly infestation due to greater process controls. Thus the increasing use of Phase III compost should help to keep fly numbers to a minimum, and minimise the spread of the disease within and between crops.

- If flies are a problem their control is a matter of some urgency. Fly control chemicals and/or nematodes should be used and growing rooms need to be made fly-proof.

Salt application

There are many techniques for treating diseased mushrooms. One of the simplest and arguably most efficient is careful covering with fine grained salt. Salt kills the diseased area and is a visible indication of where an outbreak of the disease has occurred.

- Clearly mark all infected areas of crop for treatment (see Figure 8).
- There is no need to cover *Verticillium* with tissue paper as



7 Sciarid fly spreading *Verticillium* spores through crop



8 Marking infected area for treatment

the spores do not easily become airborne, unlike cobweb spores.

- The salted area should extend several centimetres beyond the visible area of disease as shown in Figure 9.

Removal of diseased material

Physical removal of diseased material should be considered only in extreme circumstances if pieces of bubble are too large to be covered with salt.

- Extreme care is needed to ensure the disease is not spread further.
- Large pieces of bubble should be removed by experienced personal using a plastic bag as a glove.
- The piece of bubble is removed then the plastic bag is turned inside out to enclose it in the bag, without the operator touching it.
- The area where the bubble had been should then be treated

immediately with salt as otherwise the location may be missed, watered over and lead to an extended area of disease in the subsequent flush (See Figure 1).

Cooking out

Once disease is present on a farm it is essential to ensure that diseased crops are cooked out, and that the cook out is effective. Uncooked out, diseased crops will, on emptying, contribute very substantially to the background reservoir of infective material on the farm.

Chemical control

The use of prochloraz (Sporgon 50WP) still offers some considerable control despite varying degrees of pathogen insensitivity and a tendency for pesticide degradation to occur during the life of the crop.

- It is therefore very important to ensure that the fungicide is applied when the disease first appears,

that the correct dosage is used according to the label and to avoid wastage during application.

- Thoroughly clean out application equipment after use as any spray solution remaining in equipment can allow bacteria to degrade the prochloraz and these bacteria can then be spread onto the crop and casing when the equipment is next used.
- Even when treated with Sporgon 50 WP, crops must still be examined for disease prior to watering and any pieces of bubble that occur should be dealt with as described above.

In practice most of the control measures described here are adhered to on most farms to a greater or lesser degree. Experience has shown, however, that careful detective work is often required to identify the specific weak links on any particular farm when disease occurs despite taking the precautions outlined above.



9 Salt placed over bubble patch to limit spread

Key action points for control of dry bubble

- Protect casing from spore laden dust, debris and water splash.
- Do not power wash dirty areas or equipment when casing is in operation or adjacent to stored casing or casing machinery.
- Ensure that growing rooms are well sealed and that doors are kept shut during case run so as to prevent the entry of unfiltered air.
- Constantly examine crops for disease.
- Apply prochloraz (Sporgon 50WP) when disease first appears (be alert to under dosing, pesticide degradation and resistance)

- Treat disease with salt prior to watering or harvesting
- Ensure good human hygiene such as foot dips, order of picking, changes of overalls, gloves etc
- Control flies to prevent them spreading diseases into new crops
- Do not water heavily infected crops
- Terminate heavily infected crops early
- Cook out diseased crops *in situ* with steam
- Examine work practices to establish the weak links in the system

Exclusion of contaminating farm debris and dust from new crops becomes virtually impossible if there is a high level of disease on a farm, irrespective of whether

or not the diseased crop is cooked out. If disease levels are very high then the following three curative measures should be taken as a technique of last resort to dramatically reduce disease levels in a short space of time:

1. Reduce cropping to two flushes
2. Do not apply **any** water between flushes
3. Disinfect all common concrete areas **daily**.

Further information

In the UK identification and clinic services can be obtained from:

Plant Clinic
Central Science Laboratory (CSL)
Sand Hutton, York YO41 1LZ

Submission forms are available from:
www.csldiagnostic.co.uk
Customer helpline. (01904) 462324
Email. diagnosis@csl.gov.uk

In Ireland identification and clinic services are available from:

Dr. Helen Gorgan
Horticultural Development Unit
Teagasc
Kinsealy R & D Centre
Malahide Road, Dublin 17
Ireland
Tel. 01 845 9023
Email. helen.grogan@teagasc.ie

Useful Publications

- HDC Project report M6a – Review of biological control of mushroom disease.
- HDC Project report M14b – Survey of fungicide resistance in the mushroom pathogens *Verticillium fungicola* & *Mycogone perniciosa*.
- HDC Project report M14c – Mushrooms: *in vivo* reponse of prochloraz resistant *Verticillium* to Sporgon.
- HDC Project report M31 – Evaluation and interpretation of recent research data and production of a factsheet on the control of mushroom diseases.
- HDC Project report M33 – Screening fungicides for potential

control of primarily *Verticillium* and also *Mycogone*, *Dactylium* and *Trichoderma*.

- HDC Project report M33a – Screening new chemicals for *Verticillium* control.
- HDC Project report CP4 – Disinfection in commercial horticulture: a review of chemicals, disinfectants, soil treatment with formalin and water treatments for controlling plant pathogens.
- HDC Factsheet 17/00.
- HDC Factsheet 02/98.

Additional information:

Further information: Full copies of the final reports for HDC projects M6a, M14b, M14c, M31, M33, M33a and CP4 are available from the HDC office (01732 848383) or website www.hdc.org.uk

July 2008

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Design and production: HDR Visual Communication