DRY BUBBLE DISEASE FACT SHEET

David M. Beyer
Professor of Mushrooms
Penn State University

Dry Bubble Disease is a common fungal disease of the commercial white and brown mushroom *Agaricus bisporus*. Understanding more about the biology of the fungus that causes Dry Bubble Disease may help growers control this disease. With the difficulty in obtaining new or maintaining existing pesticide registrations, the struggle to control this disease will continue for many years. This fact sheet aims to give growers basic biology and practical information about this disease.

Causal Organism

The pathogen (organism causing the disease): *Verticillium fungicola* has been renamed *Lecanicillium fungicola*. For simplicity's sake, I kept the name most growers recognize: Dry Bubble Disease (DBD). The easiest method to identify this pathogen is to culture it on selective media and observe the distinctive whorl branching of the spore-holding structures, conidiophores, Figure 1. This selective media was developed to allow it to outgrow any competitors. Details on how to prepare the media are (Rinker et al., 1993). From a dissemination and disease control perspective, the important morphological characteristic is that the spores are produced in a gelatinous matrix. This gummy material will collect and hold many spores together. This sticky material also attaches the spores to water, flies, people, and equipment. This gelatinous mass of spores is easily attracted by water particles, making anything to do with water especially susceptible to spreading the spores around a farm.

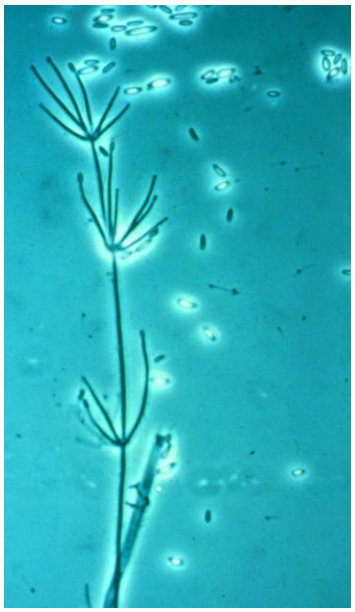

Figure 1. Microscopic view of the fungal pathogen *Lecanicillium fungicola*.

Symptoms

Various symptoms of this disease have been observed. The stage of development at which infection occurs, how many spores start the infection, and knowing the time from spore to symptoms all appear to influence the type of symptom we might find. Therefore, recognizing all symptoms will help to determine when the initial infection occurred, and that information can be used to control this disease. Several good papers have described the relationship between spores and disease development (Sinden, 1971; Gandy, 1973; North and Wuest, 1993).

Figure 2. Mushroom infected with *DBD* showing the mass of tissue symptoms.

Bubble

The most conspicuous symptom found is described as a globe-like mass of mushroom tissue, a dry bubble, Figure 2. The bubble symptom usually indicates an early and severe infection of the mushroom pin or even before the pin is visible. The early infection disrupts the growth of the mushroom's tissue, preventing it from developing into differential shapes of the stem and cap.

Figure 3. Mushroom infected with *DBD* showing split stem symptom.

Split Stipe

When infection takes place after the pin begins to develop and the stem is infected, the stem splits as it matures, causing a symptom described as split stipe or stem blowout, Figure 3. The infection disrupts stem elongation on one side of the mushroom while the healthy side grows normally. The tissue on the infected side shatters, splits, or ruptures, causing this characteristic symptom.

Necrotic Spots

Figure 4. Mushroom infected with *DBD* necrotic spot symptom.

This symptom is described as large brown spots with a fuzzy grayish hue in the center, Figure 4. The fuzzy grayish growth covering these spots is the sporulating fungus, and the surrounding dark brown color helps distinguish it from bacterial blotch disease, which is a lighter, more yellowish-brown color. This symptom usually develops when infection occurs later in the mushroom growth, when pins are larger, or when a low spore load infection occurs at the early pinhead stage.

Spotting

A needle-pinhead-sized brown spotting of the mushroom cap is another symptom. These spots are often confused with spotting from other fungi such as *Trichoderma* or sometimes bacteria pitting, Figure 5. This symptom most likely occurs when a small spore load is present, and infection occurs later in the pinning process.

Figure 5. Mushroom infected with *DBD* showing the spotting symptom.

Symptomless

Some researchers have reported that mushrooms can be symptomless on the bed before or after harvesting, and spotting develops later. These mushrooms may be marketable after they reach the store shelves, but more importantly, they may act to spread spores around the farm. Harvesters would unknowingly touch infected mushrooms and move spores to uninfected areas.

Disease Development

Early Infestation

The earliest infestation by the DBD spores may occur as early as casing time but only after. Generally, spores that land on the spawned compost will not cause a disease problem. It has been suggested that even spores on the compost before casing do not cause disease development. However, it has been recently shown that very high quantities of spores applied to the compost before casing can induce disease development (Beyer and Kremser, unpublished). Once the casing is applied and rhizomorphs begin to develop, then the spores become viable and aggressive around the mushroom spawn.

Secondary Spread by Vectors

The spores of DBD will spread within a production house or from crop to crop. One easy and most common method of spore dispersal is with water. It has been demonstrated that 60 drops of water in a single location splashed spores a distance of 2 feet (0.6 m) (Cross and Jacobs, 1969). Therefore, watering on top of an infected mushroom along the sideboard would splash spores onto watering personnel. Unknowingly, that water person would then spread the spores along the bed and to other crops they watered that day.

Spores are often carried on dust particles and water droplets in the air. Large water droplets are not necessary to carry spores. A fine mist, barely detectable, would be enough to move the spores. Dust particles are the same; the spores will stick to the dust particles, and if disturbed off the floors or roadways, they can land on the casing and infect the pins. Water vapor mist can transport spores rapidly around a room or farm. Flies are also carriers of the spores, and by controlling their populations, the occurrence of DBD can be reduced.

Control

Disease Monitoring

The first step in control is monitoring the crop to determine when the first bubble showed up. The timing of fungicide applications and locating the initial source of infection can only be done by accurately determining when the first symptoms are seen. Harvesters should be trained

to know what diseased mushrooms look like and should alert the grower when the first symptomatic mushrooms are found. Some farms have harvesters place a stick or straw near the bubble, being extremely careful not to touch the diseased mushroom or the mushrooms around it. Using this marking system, the grower will know when the disease is found, and then the salting or disease control crews can find the diseased mushrooms for treatment.

Unfortunately, this disease can rapidly escalate into an epidemic, and it takes weeks to reduce the spore load on the farm gradually to get the disease back under control. Reducing the spore load around a farm and in the houses is an important control component. The problem is how to mitigate this spore load. First, the vector(s) spreading the spores must be identified and stopped. From the time of first symptom development, the grower must look back to who or what was in contact with the crop about 10-14 days earlier; with warmer room temperatures or higher humidity, that time is shortened to about 7-10 days. Most often, dry bubbles spotted before the end of the first break indicated that the crop was infected by something other than harvesting personnel or their equipment.

It cannot be emphasized enough to **keep the farm clean**. Not only does it instill a good mentality in the employees, but it also eliminates breeding grounds for DBD. During warm and moist weather, organic matter and mushroom debris provide an excellent habitat for DBD to grow and rapidly produce spores. Therefore, spores are not only produced in infected crops but additional spores are generated all around the farm.

Many farms have one or more people assigned to search out infected mushrooms and cover them with salt (Figure 7) or spray them with alcohol. This technique is more effective in the early breaks. Do not touch or remove the infected bubble. Heavily infected breaks are difficult to cover, and they are usually too late to be effective. Since the spore load is so high in those rooms, the additional traffic around those crops may spread more diseases. Unfortunately, covering mushrooms that show symptoms does not prevent the spread of spores from "symptomless" infected mushrooms or other sources of infection. This covering or trashing of the bubbles should be

Figure 7. Pile of salt covering an infected *DBD*.

done daily, and the 4-6 inches diameter surrounding the bubble should also be covered. Table or rock salt, powdered 15% HTH, or 80% alcohol can be used to cover or spray infected areas.

Watering hoses and trees, harvesting equipment, flies, mites, harvesters, mice, watering personnel, and growers are the obvious means of transportation for the spores that spread the disease. All equipment that come into a room or in contact with the crop after casing must be thoroughly cleaned and disinfected. A separate water hose should be used for new crops or in each room if possible. Dip hoses in a disinfectant bath between rooms if they must be moved.

Other important procedures include ensuring the room floor reaches 60^{o}C (140^{o}F) for several hours during the peak heat. Often, the compost temperature reaches 60^{o}C (140^{o}F) before the floor or coldest area of the room reaches that temperature long enough to ensure an adequate kill of carry-over spores. After the spawning and casing operations, the floors should be cleaned to remove all bits of compost and casing and then sprayed with a strong disinfectant or chlorine solution. Not getting these chemicals on the compost or casing surfaces is important.

All tools and other equipment that are taken into the house anytime from spawning through to post-crop steaming should be thoroughly disinfected. All harvesting baskets should be steamed or dipped in a disinfectant after each use and before they return to the room for harvesting. Spores of *DBD* and other diseases can be readily carried back into the houses on these baskets. Only an approved food contact disinfectant should be used on these baskets unless thoroughly rinsed off to ensure there is no chemical residue ending up on the mushrooms.

Integrated Pest Management (IPM)

Improving other cultural practices on a farm will help reduce the spread of the spores. Proper composting and Phase II procedures will reduce weed molds, nematodes, and food sources for mites. Keeping the fly population under control is a critical part of control. Sometimes, we "bite the bullet" and steam off heavily infested crops after the second break. This "short-term pain for a long-term gain" is only effective if all other aspects of a control program keep the spores from re-infecting new crops.

Conclusion/Summary

The scientist's goal is to learn more about the fungus. We need to know more about the nutritional and environmental requirements of DBD and the development of this disease. We know that manipulating the environment will affect disease progress, but doing it and

maintaining the crop cycle and mushroom quality is difficult. Are there other cultural practices that encourage or discourage the growth of DBD? Are there biological control agents or compounds that we can use against it? Studying this disease must become a priority for the continued success of mushroom farms.

LITERATURE CITED and OTHER REFERENCES

Bonifacino, S.F. 1980. A Compendium of Major Sporocarpic Diseases of the Commercial Mushroom *Agaricus bisporus* (Lange) Imbach. M.A. Dept. of Plant Pathology, The Pennsylvania State University. 86 p.

Cross, M.J. and L. Jacobs. 1969. Some observations on the biology of spores of *Verticillium malthousei*. Mushroom Sci. 7:239-244.

Gandy, D. 1973. Observations on the development of *Verticillium malthousei* in mushroom crops and the role of cultural practices in its control. Mushroom Sci. 8:171-182.

Nair, N.G. and B.J. Macauley. 1987. Dry bubble disease of *Agaricus bisporus* and *A. bitorquis*, and its control by prochloraz - manganese complex. New Zealand J. of Agric. Res. 30:107-116.

North, L.H. and P.J. Wuest. 1993. The infection process and symptom expression of *Verticillium* disease of *Agaricus bisporus*. Can. J. Plant Path. 15:74-80.

Rinker, D. 1992. Manual for preparing and using a selective medium to detect *Verticillium fungicola*. Ministry of Agricultural and Food. Horticultural Research Institute of Ontario. Vineland Station, Ontario.

Sinden, J.W. 1971. Ecological control of pathogens and weed molds in mushroom culture. Ann. Rev. of Phytopath. 9:411-432.