Fungal Disease Control in Mushrooms

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Sporgon (prochloraz-manganese) has been the only approved fungicide available to the UK mushroom industry, although when this project started, Vivando (metrafenone) was also approved for mushroom crop disease control in France and Spain. Sporgon provides good control of wet bubble (Mycogone perniciosa), moderate control of dry bubble (*Lecanicillium fungicola*) and weak or ineffective control of cobweb (Cladobotryum species) (Figures 1 to 3). There has been reported resistance in some *Lecanicillium fungicola* isolates to prochloraz. In this project, the efficacy of Sporgon and Vivando in disease control was compared with that obtained with a further fungicide, Shirlan (fluazinam) and a biopesticide, Cedress (*Pseudomonas chlororaphis* MA342).

The project

Fungicide-degrading microbes can break down Sporgon and other pesticides into inactive byproducts, thereby reducing the efficacy of an applied dose. This project aimed to reduce degradation of fungicides by stimulating a microbial population in the casing that is antagonistic to the microbes that degrade fungicides. A series of experiments were conducted to assess the effects of different fungicides, biopesticides and casing additives on fungal disease control, mushroom yield and fungicide residues and degradation. The pathogen isolates used for the tests were obtained from recent disease outbreaks on UK mushroom farms. Casing treatments that are effective in inhibiting degradation of fungicides were then tested against standard casing for control of fungal diseases in experiments on mushroom farms.

Agar plate tests on the sensitivity of pathogen isolates to fungicides were conducted. The plate tests measured the mycelial growth rate and spore germination at a range of fungicide concentrations in the agar. The tests were then compared with disease control results obtained in pot mushroom cultures using the same doses of fungicides in the casing.

Results

A *Lecanicillium* isolate that showed resistance to Sporgon in agar plate tests was also resistant to Sporgon in a pot culture test. However, agar plate test results did not fully reflect potential disease control with fungicides in pot culture tests. At 20 ppm in agar plate tests, metrafenone was less inhibitory to mycelial growth and spore germination of *Lecanicillium* isolates than prochloraz. However, Vivando provided better dry bubble disease control than Sporgon in a pot culture test when used at 20 ppm of active ingredient in the casing. Vivando provided good control of dry bubble disease irrespective of the Sporgon resistance of the *Lecanicillium fungicola* isolate.

Vivando and Sporgon were equally effective in controlling wet bubble disease but Vivando also provided some control of cobweb disease. At the rate used, Shirlan did not control disease or affect mushroom yield. However, Shirlan has potential for disease control if tested at a higher rate since it was very effective in suppressing pathogen growth in agar plate tests at concentrations that did not affect mushroom mycelium. Cedress suppressed wet bubble disease, although the effect was not quite statistically significant, but did not affect dry bubble or cobweb diseases. It did not affect mushroom yield or cause blotch even though it is a *Pseudomonas* species.

When recommended application rates of Sporgon or Vivando were used, prochloraz or metrafenone were found in first flush mushrooms at levels just above their detection limits and well below their EU maximum residue level (MRL) for mushrooms. At the rate used, Shirlan was not detected in mushrooms. The MRLs for prochloraz, metrafenone and fluazinam in mushrooms are 3, 0.4 and 0.05 mg/kg respectively.

During a mushroom crop, Sporgon in the casing degraded by 46% compared with 81% for Vivando and 77% for Shirlan. The rate of Sporgon degradation was reduced by adding 25% recycled, cookedout casing to fresh casing. This did not affect mushroom yield compared with using fresh casing alone.

Salt is widely used for covering patches of diseased mushrooms on growing beds but this has an adverse effect on the subsequent use of the spent compost in casing or growing media by increasing the electrical conductivity (Figure 4). A 70% clay: 30% salt mixture was as effective in suppressing regrowth of pathogens and diseased mushrooms as salt, but with a smaller effect on spent mushroom compost electrical conductivity.

Since the project ended, Vivando has been approved for use on mushrooms in the UK.

Action Points for Growers

1. Resistance of mushroom pathogens to Sporgon is a significant problem for the industry and growers should constantly review their disease control strategies to reduce reliance on fungicides. 2. Where growers suspect that wet or dry bubble is not being controlled by Sporgon they should check the prevalent pathogen(s) on the farm for prochloraz resistance (this can be done in the laboratory). 3. Vivando should be used as an alternative or intermittently to Sporgon to reduce the risks of fungicide resistance and microbial breakdown of prochloraz e.g. in spray tanks. 4. Sporgon should not be used primarily for control of cobweb since it will not give effective control, while increasing the above risks.; Vivando provides some control of cobweb disease. 5. The effect of addition of 25% recycled, cooked-out casing to fresh casing on the efficacy of Sporgon in disease control should be explored since this may reduce the rate of prochloraz break down in the casing. 6. Where there is a market for spent compost, the use of 70% clay: 30% salt as a disease covering material should be considered since it will have a less negative effect on subsequent use than using 100% salt.

Future Developments in Disease Control

Shirlan and fungicides that are approved for other crop uses should be screened at a range of concentrations for efficacy against mushroom pathogens and effect on mushroom cropping. This should broaden the range of available active ingredients and reduce the risk of pathogen resistance to Sporgon and Vivando. This work has also shown that the composition of the casing can be modified to prolong the efficacy of an applied fungicide dose, possibly by introducing competitors to the microbes that break down the active ingredient. The influence of casing additives, such as recycled casing, on fungicide efficacy in disease control, particularly in later flushes, should be investigated further. Biopesticides for control of fungal pathogens in mushroom crops are restricted to bacterial products, since the mushroom is also a fungus. Cedress (*Pseudomonas chlororaphis* MA342) has shown suppression of wet bubble in this project; the efficacy of other bacterial

biopesticides in fungal disease control should also be tested; they may also suppress bacterial blotch.

Figure 1 Dry bubble disease

Figure 2 Wet bubble disease

Figure 3 (a) Cap spotting and (b) cobweb disease caused by *Cladobotryum* species

Figure 4 Salt used for covering diseased areas on beds