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HDC Project M26a

Evaluating the efficacy of various Sporgon application regimes in controlling *Dactylium*

Final Report

by

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PRACTICAL SECTION FOR GROWERS

Summary

A small scale cropping experiment was carried out to evaluate the efficacy of various Sporgon application regimes in controlling *Dactylium*. This work was done in parallel with another HDC project (M26) which looked at the fate of Sporgon in casing following various application regimes. That report found that the active ingredient in Sporgon was present at higher concentrations in the surface of the casing when the fungicide was drenched on as opposed to a uniform concentration throughout the casing when it was incorporated at casing preparation. Furthermore, if the fungicide dose was applied in 90 litres of water/100m^2 instead of the maximum recommended volume of 180 litres/100m^2 then significantly more of the active ingredient remained in the top layer compared with the 180 litre treatment. The difference was small but significant. Results from the cropping experiment, where *Dactylium* had been introduced into casing treated with Sporgon, indicated that the least effective Sporgon treatment was when the fungicide had been incorporated. This result was exagerated due to the fact that only slightly more than half of a 120 gram dose appeared to have been applied (likely cause was settling out of the fungicide in the container used to apply it to the casing mix). When Sporgon was drenched on in the first watering after casing, using 180 litres/100m^2, *Dactylium* growth was recorded during the 2nd flush despite a second application after the 1st flush. The best control of *Dactylium* in the second flush occurred when both Sporgon doses were applied in 90 litres/100m^2 or when the first dose was applied at airing, preferably in 90 litres/100m^2. Selected results are shown overleaf. In general, *Dactylium* growth occurred in all sporgon treatments in the third flush. This probably relates to a decreasing concentration of active ingredient in the casing during the third flush which was demonstrated in the related project M26.

CONCLUSIONS

1. Expression of *Dactylium* symptoms can be affected by the way in which Sporgon is applied to the casing with the best control of *Dactylium* growth in casing being achieved when individual fungicide doses were made up in 90 litres/100m^2.
2. Sporgon applied at airing appeared to give better control of *Dactylium* symptoms.
3. The appearance of *Dactylium* in the third flush, following two Sporgon applications, probably reflects a decreasing concentration of the active ingredient in the casing.

Growth of *Dactylium dendroides* in casing following two 120 gram doses of Sporgon applied in various way (Not all treatments shown).

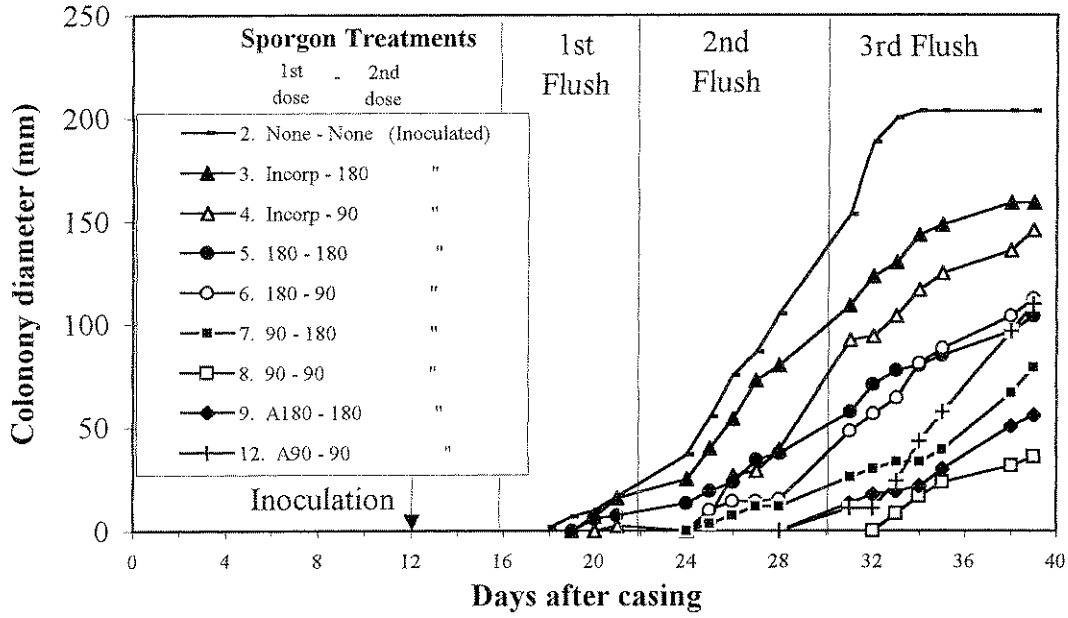
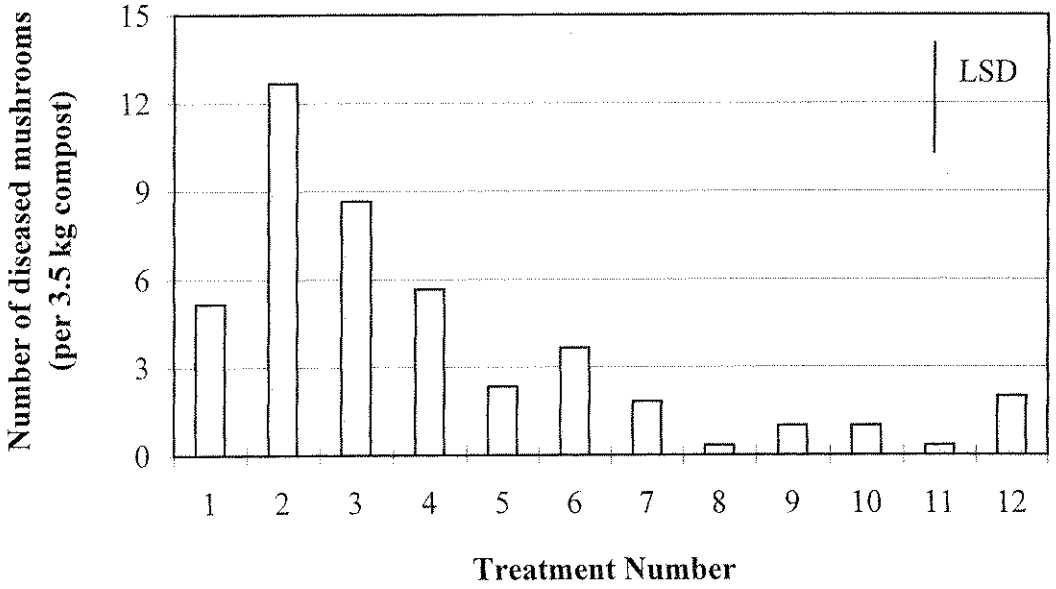


Figure 3. Mean number of spotted/diseased mushrooms harvested following various Sporgon treatments (details in Table 1); Least significant difference (LSD) at $P = 0.05$.



EXPERIMENTAL SECTION

Evaluating the efficacy of various Sporgon application regimes in controlling *Dactylium*

A. INTRODUCTION

One of the most important and effective crop protection chemicals available to mushroom growers is the product Sporgon which was developed for use on mushrooms in the late 1970's. Due to the development of fungicide resistance by some pathogens or pathogen isolates, Sporgon is often relied upon heavily and sometimes it is the only effective chemical available. In recent years there have been many severe outbreaks of cobweb disease throughout the UK and growers have been reporting difficulties in controlling the disease despite the use of fungicides.

HDC report M14a surveyed over 57 different cobweb isolates for resistance to commonly used fungicides and found that 41 of them (72%) of them were resistant to thiabendazole (Hymush). Carbendazim (Bavistin) appeared to be effective but HDC report M14a also showed that this fungicide had been reduced to very low levels in the casing by day 28 (end of 2nd Flush) so that it was unlikely to be effective at this stage unless isolates were ultra sensitive to this product. The fungicide resistance profiles of the majority of isolates also indicated that Sporgon should give significant control providing that the concentration of the active ingredient in the casing was 20 parts per million (ppm) or above. HDC project M26 examined the fate of the active ingredient in Sporgon, prochloraz manganese, in casing following different application regimes as there is no information available on this topic. There is some information regarding the efficacy of one prochloraz application rate (2 x 30 g doses of prochloraz manganese/100m^2 = 2x 60 g Sporgon) in controlling cobweb (Fletcher *et al.* 1983) however the spawn strain, casing type, cultivation conditions and fungicide rate were considerably different to what is currently in place in the UK mushroom industry. At that time, *Dactylium* isolates were not resistant to thiabendazole and it is possible that the pathogenicity of recent isolates is different to those of the 1980's. In addition, little information was given on the progression of cobweb within the crop following inoculation. Good control of disease expression was achieved but the yield from the treated crop was not significantly different from an untreated inoculated crop. In view of this it was decided that

more detailed information was required about disease progression following different methods of fungicide application. This would enable an objective assessment to be made of the most effective fungicide application method in terms of cobweb control.

The aim of this project is to run a small scale cropping experiment in parallel with project M26 in an attempt to examine the relationship between different Sporgon application regimes and actual control of the pathogen *Dactylium dendroides*, which causes cobweb disease.

B. MATERIALS AND METHODS

Small pots, 260 mm diameter, were filled with 3.5 kg of spawn-run compost and cased with the same deep dug black peat/sugar beet lime casing (Harte Peat Ltd.) used in M26. Ten Sporgon application treatments were examined along with two untreated treatments (Table 1). The same casing from project M26, in which Sporgon had been incorporated at mixing, was used in treatments 3 and 4. Sporgon drenches were applied using a hand held Hozelock Spraymist sprayer. All treatments, except treatment 1, were inoculated with a thiabendazole resistant isolate of *Dactylium dendroides* (Isolate 192B1). Mycelial plugs of the pathogen were taken from an agar culture, placed into the centre of each pot on Day 12 after casing (pinning stage) and covered lightly with casing. Six replicate pots were prepared for each of the 12 treatments in Table 1. The growth of *Dactylium* in the casing was measured (colony diameter) for each of the treatments over three flushes. Mushrooms were harvested over three flushes. The number of diseased and spotted mushrooms was also recorded for each treatment.

Table 1. Details of Sporgon and inoculum treatments.

Treatment Number	Sporgon treatments (2 doses of 120 g Sporgon/100m^2) 1st Dose	2nd Dose	Inoculum treatment
1	none	none	None
2	none	None	Inoculated with 192B1
3	Incorporated*	180 litres	Inoculated with 192B1
4	Incorporated*	90 litres	Inoculated with 192B1
5	180 litres	180 litres	Inoculated with 192B1
6	180 litres	90 litres	Inoculated with 192B1
7	90 litres	90 litres	Inoculated with 192B1
8	90 litres	180 litres	Inoculated with 192B1
9	A180 litres	180 litres	Inoculated with 192B1
10	A180 litres	90 litres	Inoculated with 192B1
11	A90 litres	180 litres	Inoculated with 192B1
12	A90 litres	90 litres	Inoculated with 192B1

* Analysis of prochloraz levels after this treatment indicated that the concentration was in the region of 10-12 ppm. This treatment should have given a concentration of 17-20 ppm. It would seem that a significant amount of the product was lost between fungicide preparation and incorporation, probably settling out in the container used for mixing prior to incorporation. Results for this treatment should be considered with this in mind.

C. RESULTS

Growth of Dactylium *in non-fungicide-treated casing*

In the absence of any fungicide in the casing, *Dactylium* growth was observed towards the end of the first flush as a result of inoculation on Day 12 (Figure 1; Treatment 2). Colony diameters continued to increase steadily during the second and third flushes by which time the casing surface was completely covered. When neither inoculum or fungicide was present initially (Figure 1, Treatment 1), cobweb growth due to contamination did not occur until the beginning of the third flush. Growth then progressed rapidly, at a rate similar to the inoculated treatment, to completely cover plots by the end of the 3rd flush.

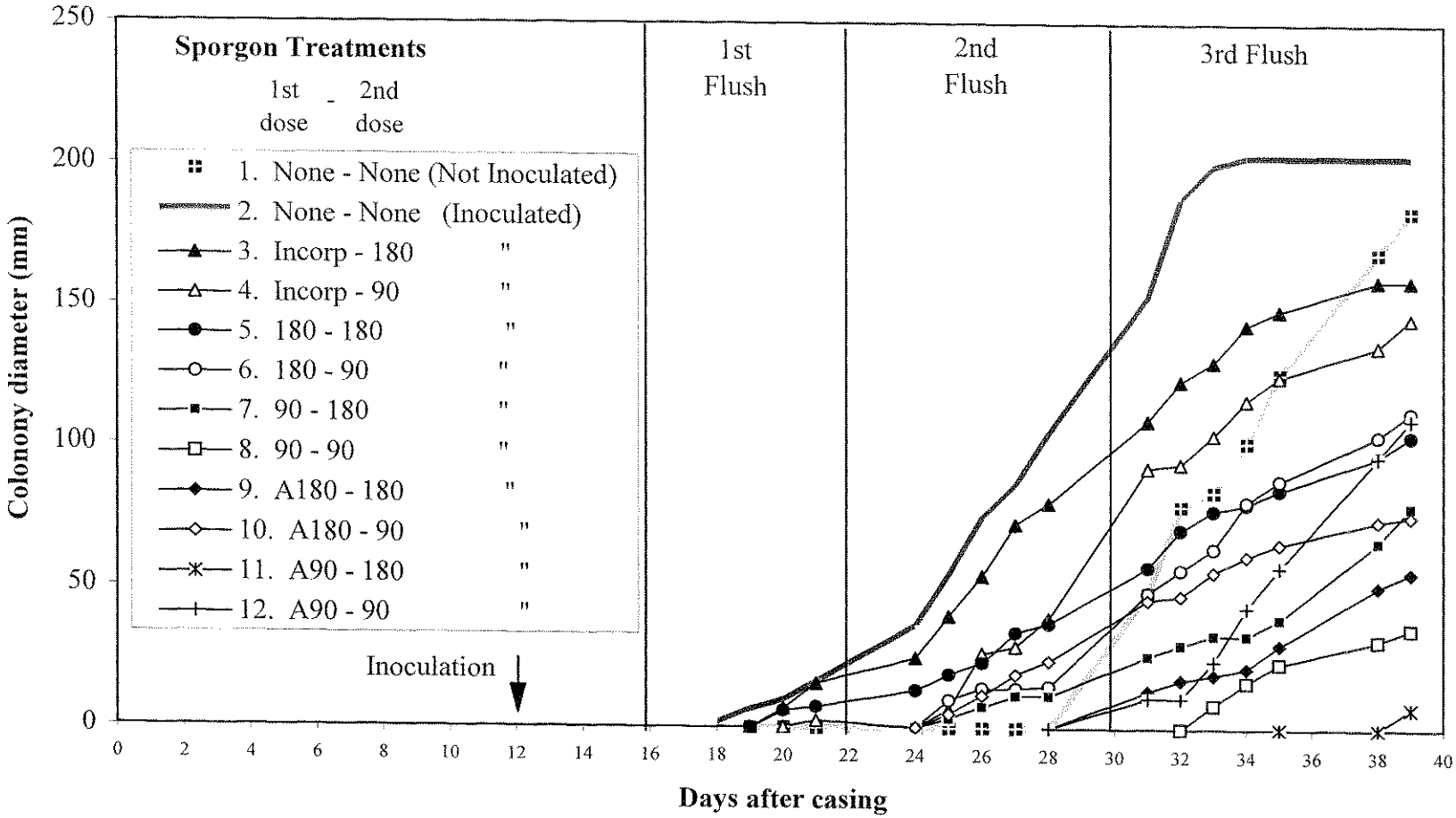
Growth of Dactylium *in prochloraz-treated casing*

The growth of *Dactylium* on casing receiving various prochloraz treatments is presented in Figure 1. None of the treatments totally prevented the growth of *Dactylium* in the third flush but some treatments were much more effective in delaying the onset of growth.

INCORPORATION. The least effective treatments were when the first Sporgon dose was mixed into the casing (Figure 1, Treatments 3 and 4). This is probably not surprising considering that little over half the intended amount of active ingredient was present. This demonstrates how important it is to get ALL of the product-dose into the casing. However, when the second dose was applied in 90 litres/100m^2 rather than 180 litres/m^2, the growth of *Dactylium* proceeded more slowly, lagging behind that in the 180 litre/100m^2 treatment.

FIRST DRENCH IN 180 litres/100 m^2. A small amount of *Dactylium* growth had started to occur by the end of the first flush in casing where the first prochloraz drench was applied using 180 litres/100m^2 (Figure 1, treatments 5 and 6). Subsequent growth was reduced, but not eliminated, when a second dose of prochloraz was applied after the first flush. During the second flush this growth was largely arrested when the second dose was applied in 90 litres/100m^2 but not when applied in 180 litres/100m^2. By the third flush however, growth in both treatments was similar achieving mean colony diameters of 112 and 104mm, respectively, which were just over 50% of the inoculated control.

Figure 1. Growth of *Dactylium dendroides* in casing receiving 2 x 120 gram doses of Sporgon (a.i. = prochloraz) applied in various ways; see text for details.



FIRST DRENCH IN 90 litres/100 m^2. No *Dactylium* growth was recorded during the first flush in casing where the first prochloraz drench was applied in 90 litres/100m^2 (Figure 1, Treatments 7 and 8). Some growth occurred towards the end of the second flush when the second dose had been applied in 180 litres/100m^2 and this progressed during the third flush to achieve a mean colony diameter of 79 mm, about 40% of the control. No growth occurred in the second flush following a second prochloraz dose in 90 litres/100m^2 but significant growth occurred during the third flush achieving a mean colony diameter of 36mm which was about 18% of the control.

FIRST DRENCH AT AIRING IN 180 litres/100 m^2. No *Dactylium* growth was recorded during the first flush in casing where the first prochloraz drench was applied at airing in 180 litres/100m^2 (Figure 1, Treatments 9 and 10). In contrast to the results for the treatments described above, some growth occurred towards the end of the second flush following the second dose in 90 litres/100m^2 but not following the 180 litre/100m^2 treatment. Growth progressed steadily however in both treatments during the third flush with mean colony diameters of 76 and 56 mm, respectively, being achieved, representing about 38 and 28% of the control.

FIRST DRENCH AT AIRING IN 90 litres/100 m^2. No *Dactylium* growth was recorded during the first OR second flush in casing where the first prochloraz drench was applied at airing in 90 litres/100m^2 (Figure 1, Treatments 11 and 12). Again in contrast to most treatments, more growth was recorded in the third flush when the second dose had been applied in 90 litres/100m^2 where a mean colony diameter of 110mm was achieved representing about 55% of the control.

Mushroom yield from prochloraz-treated casing.

The yield of healthy mushrooms recorded from each of the 12 treatments is presented in Figure 2. Substantial yield reductions occurred in only two treatments: treatment 2 (inoculated control), and treatment 3 (first dose: incorporated, second dose: in 180 litres/100m$^{2)}$. These were the treatments in which *Dactylium* growth was most advanced by

Figure 2. Yield of healthy mushrooms from three flushes following various treatments with Sporgon (treatment details in Table 1); Least significant difference (LSD) at P = 0.05.

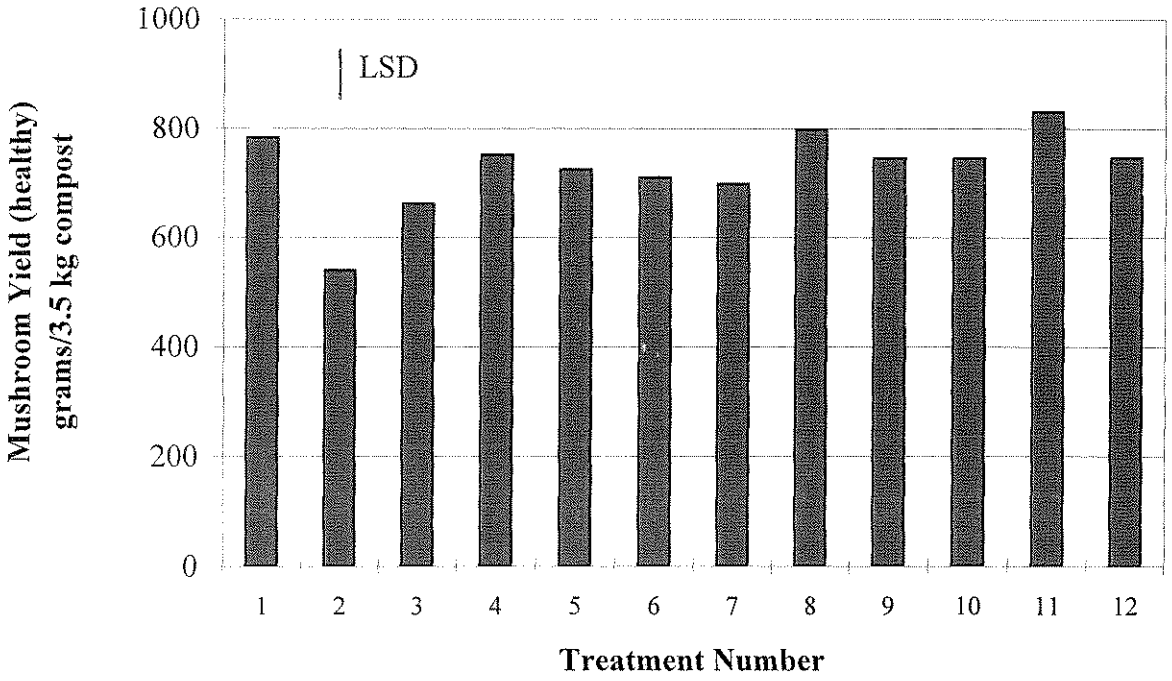
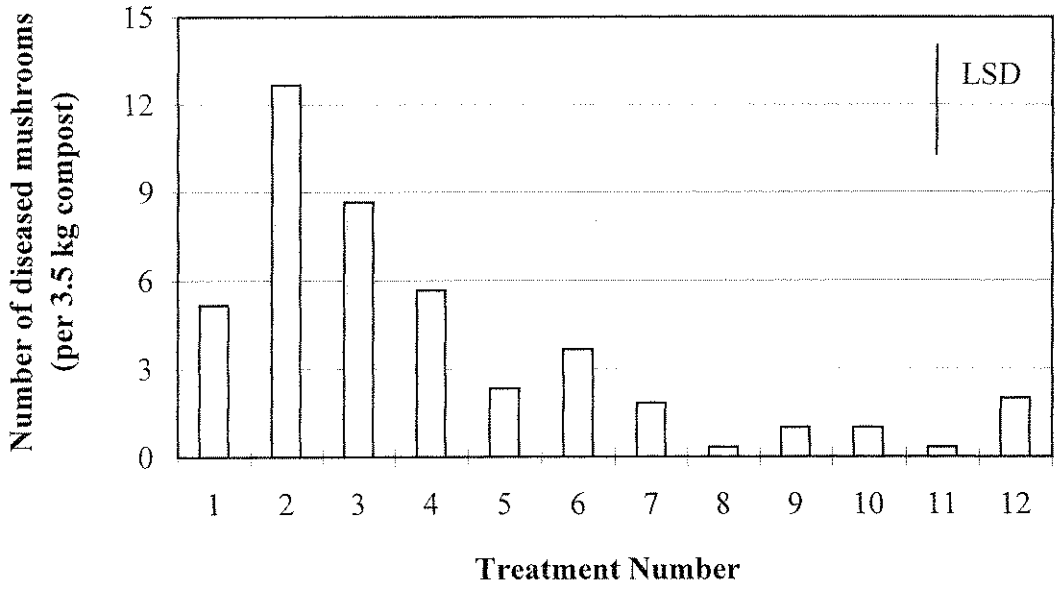


Figure 3. Mean number of spotted/diseased mushrooms harvested following various Sporgon treatments (details in Table 1); Least significant difference (LSD) at $P = 0.05$.



the end of the 2nd flush so that there was a significant loss of cropping area in the third flush compared with other treatments. These treatments also had the highest number of spotted mushrooms. The best yields were from treatment 8 (both prochloraz doses applied in 90 litres/100m^2), and treatment 11 (a 90 litre/100m^2 treatment at airing followed by a 180 litre/100m^2 treatment. These treatments also had the least number of spotted mushrooms (Figure 3).

D. DISCUSSION

Dactylium colonies appeared during the first flush when casing containing no prochloraz had been inoculated with *Dactylium* mycelium at pinning. Colonies continued to grow steadily through the second and third flushes. Uninoculated casing in the same house, also untreated with prochloraz, picked up "secondary" infections. These occurred largely during the third flush and, once established, they grew steadily to form colonies with an average diameter of 184 mm within a period of 10 days. In the inoculated treatment, sporulating *Dactylium* growth occurred primarily in the second flush and it is most likely that this was the source of infection for the uninoculated treatment. Thus it would appear that there can be a rapid spread of infection within a crop from one flush to another, especially if the primary source is not identified and treated.

When prochloraz-treated casing was also inoculated with *Dactylium*-mycelium at pinning, the subsequent growth of *Dactylium* colonies varied considerably depending on how the fungicide had been applied. In six out of ten cases, the application of two 120 gram Sporgon-doses did not prevent cobweb symptoms developing in the second flush. Four out of the ten treatments tested delayed *Dactylium* growth until the third flush of which three involved applying the first prochloraz dose in 90 litres/100m^2 instead of the more usual 180 litres. In addition three of the most effective treatments were applied at airing but with the second dose applied after the first flush rather than after the second flush, as is recommended on the label. This would seem to imply that prochloraz applications in 90 litre/100m^2, or airing applications in either 90 or 180 litres/100m^2, are more effective in preventing the growth of *Dactylium* when the pathogen is present in the early stages of the crop.

Dactylium growth occurred in all prochloraz treatments during the third flush. The results presented in HDC report M26 illustrate how the concentration of the active ingredient in a deep dug black peat/sugar beet lime casing steadily declined following the second application to levels of about 50% of what had been applied (Appendix I). The reasons for this are not yet known but such a reduction in the concentration of active ingredient by the third flush may explain why cobweb growth occurred in all prochloraz treatments by this time. In view of this, it might be worthwhile to examine the efficacy of a prochloraz application treatment where the 1st dose is applied at airing and the 2nd applied after the 2nd flush with both being applied using the reduced volume rate of 90 litres/100m^2.

Results in HDC report M26 also suggest that the concentration of active ingredient in the top half of the casing layer is slightly higher when prochloraz is applied in 90 litres/100m^2 as opposed to 180 litres (Appendix II). This may account for why the 90 litre application treatments in the inoculation experiment were more effective in controlling cobweb symptoms.

E. CONCLUSIONS

1. Expression of *Dactylium* symptoms can be affected by the way in which Sporgon is applied to the casing.

2. The best control of *Dactylium* growth in casing, by Sporgon, was achieved when individual fungicide doses were made up in 90 litres/100m^2.

3. The application of the first Sporgon dose at airing in either 90 or 180 litres/100m^2 appeared to give better control of *Dactylium* symptoms following inoculation with mycelium at pinning.

4. The appearance of *Dactylium* in the third flush, following two applications of Sporgon, is probably related to the reduction in the concentration of the active ingredient in the casing which occurs at this time.

F. RECOMMENDATIONS

- It is **essential** to apply **both** Sporgon applications to minimise the growth of cobweb on casing in the first and second flush.

- There would seem to be advantages in applying the fungicide in less than the maximum permitted quantity of water suggested on the label in order to achieve maximum control of cobweb, particularly in the second flush. EXERCISE CAUTION. There is clearly a danger of unacceptable phytotoxicity and growers should proceed carefully in this area. Project M30 will explore this further but in the meantime if water quantity is to be reduced it should be done progressively, in stages, and assessed for phytotoxic effect.

- It should be recognised that at the moment the drench used at the last watering before **airing** and **after the first flush** is not a label recommendation. The label states that the second dose should be applied **after the 2nd flush**. Treatment after the 2nd flush is recommended if cobweb symptoms occur in the third flush.

- Care should be taken to ensure that the correct Sporgon dose is used in the correct volume of water for a known bed area. Ensure adequate agitation in the spray tank to prevent fungicide being precipitated out before application.

G. REFERENCES

HDC Report M14a (1996). Survey of fungicide resistance in the mushroom pathogens *Dactylium, Trichoderma* and *Aphanocladium*.

HDC Report M26 (1997). The fate of Sporgon in mushroom casing.

FLETCHER, J.T., HIMS, M.J. and HALL, R.J. (1983). The control of bubble diseases and cobweb disease of mushrooms with prochloraz. *Plant Pathology*, **32**, pp123-131.

Figure 1. Concentration of Prochloraz-Mn (a.i. in Sporgon) in the top and bottom layers of a deep-dug Black Peat/Sugar beet lime casing following two 120 g doses of Sporgon applied in various ways.

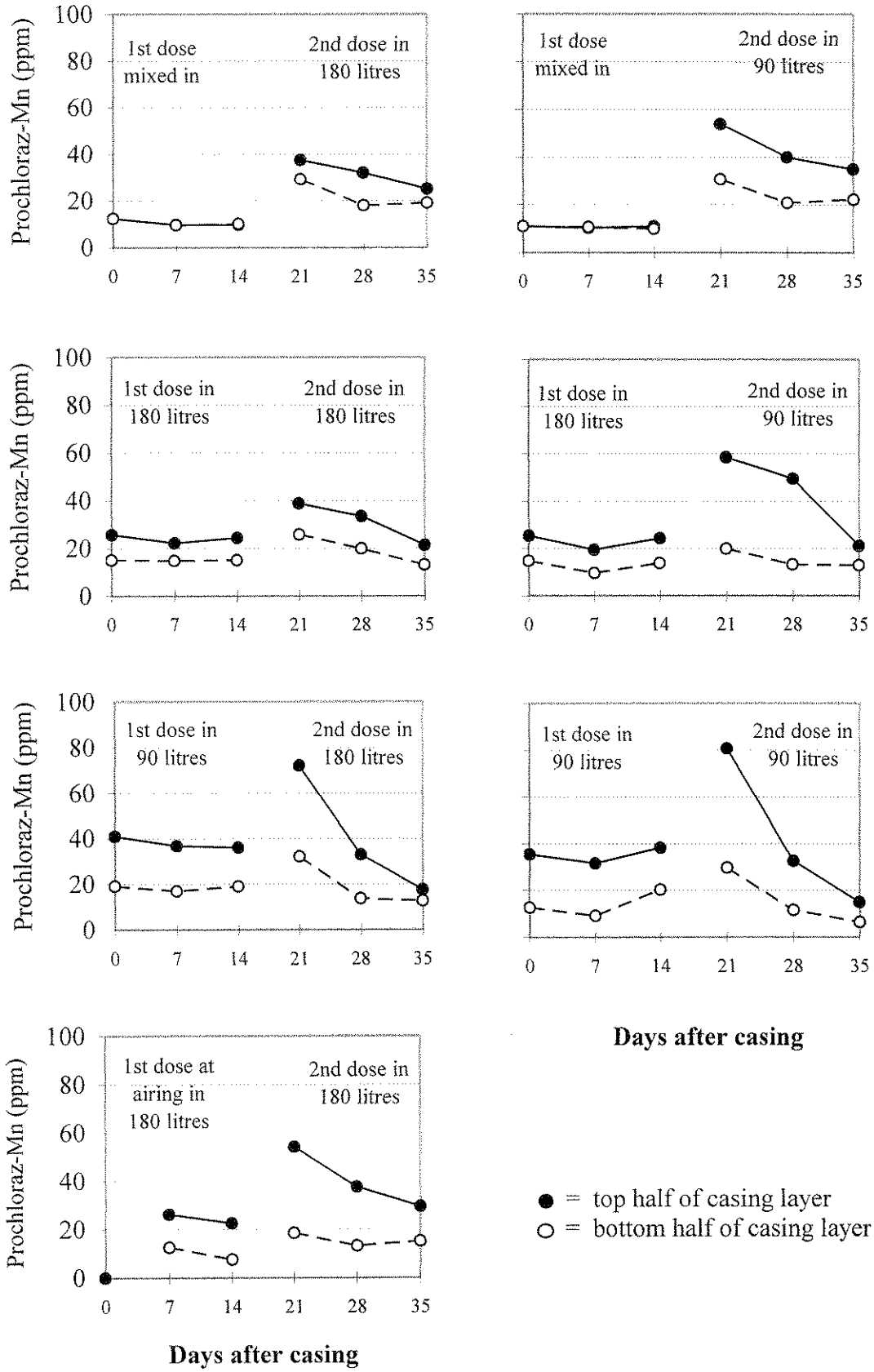


Figure 3. Percentage of active ingredient in top half of a deep dug black peat & sugar beet lime casing following two 120 g doses of Sporgon applied in various ways (M = mixed in; 180 = 180 litres/100m^2; 90 = 90 litres/100m^2; A180 = applied at airing in 180 litres); data are means ± standard error of the mean