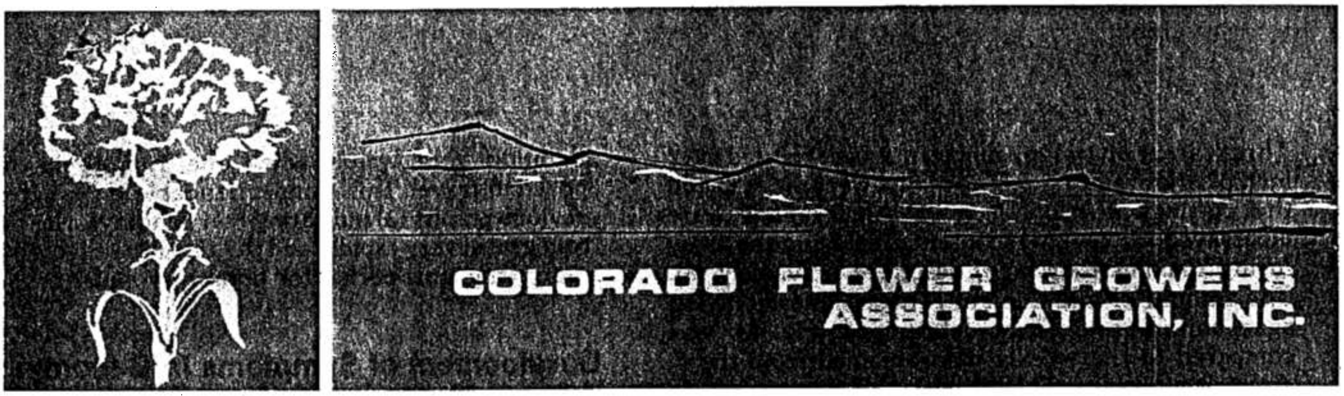

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Fusarium Stem Rot of Carnations: Inhibition of *Fusarium Roseum* in Benomyl Treated Plants

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Previous papers in this series have reported efforts to control Fusarium stem rot in propagation (1,4,5,6) using systemic fungicides. The last paper (3) presented data from experiments on basic aspects of uptake of benomyl by mature carnation plants. The fungitoxin applied to soil or gravel was taken up by roots and became systemic in carnations. Frequent watering required in gravel culture, however, lead to rapid leaching of benomyl.

This paper reports further experiments designed to determine whether systemic uptake of benomyl reaches high enough concentration to effect invasion of carnation tissue by *Fusarium roseum.*

Inhibition of *Fusarium Roseum* Expected in Benomyl Treated Plants

A dosage-response curve was developed to determine the response of *F. roseum* to benomyl. Rapid growth of the fungus on potato dextrose agar, when challenged by different concentrations of benomyl, was recorded. By converting these data to the log-probit transformation, a straight line relationship was obtained as illustrated in Fig. 1.

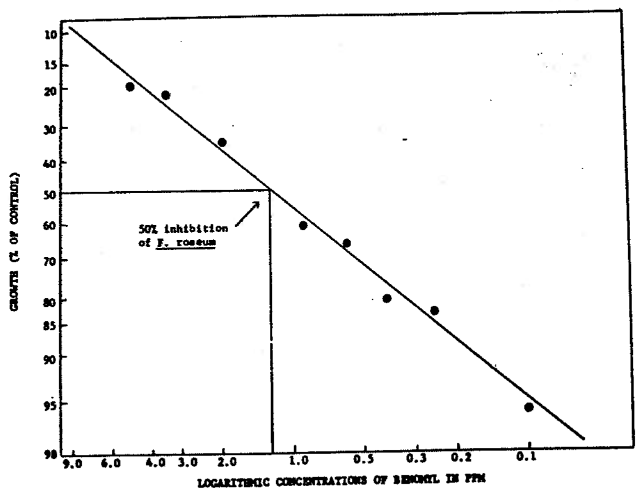

Figure 1. Log — probit dosage — response curve showing the effective dosage required for 50% inhibition of mycelial growth of *Fusarium roseum* by benomyl.

A 50% inhibition of *F. roseum* occurred at approximately 1.2 ppm of benomyl. This inhibitory concentration compares favorably with the ED 50 for other Fusarium species (2).

To determine whether concentrations of benomyl were large enough to influence infection of carnation tissues by *F. roseum*, plants were grown in soil or gravel treated with benomyl. Treatments were applied as follows:

1. Benomyl (50% wettable powder) at 65 ppm (w/w oven dry potting medium) was incorporated around the soil at the root zones. In total, two separate applications were applied, one at the beginning of the experiment and the other six weeks later for a total of 130 ppm of active material.
2. Benomyl was applied as a drench to soil at the beginning of the experiment and six weeks later, each time with 200 ml of a 65 ppm (active) suspension.
3. Drenches (as in 2 above) were applied to gravel.

Three carnation cv Pink Sim plants were planted in 12 inch plastic azalea pots. The plants were pinched and the cuttings developing from axillary buds were bioassayed for benomyl content employing the assay (using *Penicillium expansum*) described previously (3). The amount of inhibition of *F. roseum*, by benomyl in agar culture previously determined (Fig. 1), was compared to the weekly data obtained from the *P. expansum* bioassays. The inhibition of *F. roseum* due to the benomyl treated plant material could be related to the *P. expansum* bioassays carried out during the entire 12 weeks by measuring the zone of inhibition about discs containing known amounts of benomyl. For example, a disc producing a 16mm zone of inhibition in the *P. expansum* bioassays, had a concentration of benomyl (1.2 ppm) great enough to inhibit *F. roseum* by 50%. Thus, the dotted line at the 16mm inhibition zone value in Fig. 2 illustrates the theoretical level of benomyl required to inhibit the pathogen (at ED 50).

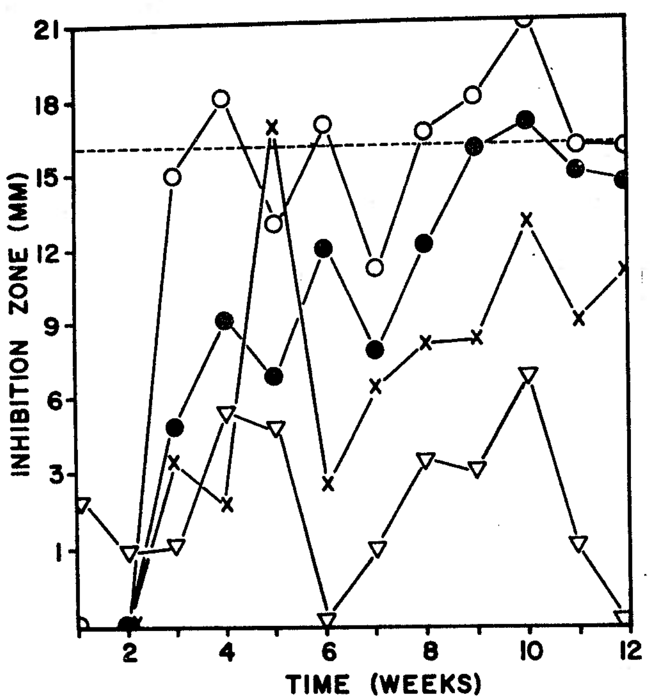

Figure 2. Inhibition, using *Penicillium expansum* bioassay, by benomyl in plant samples from one to 12 weeks after initial applications to soil or gravel. Dashed horizontal line indicates concentration of benomyl producing 50% inhibition of *Fusarium roseum*. X = benomyl tilled in soil, O and • = benomyl applied in drenches to soil, and ▽ = benomyl applied in drenches to gravel.

The results of this experiment presented in Fig. 2 indicated that benomyl occasionally reached concentrations in plant tissues high enough to inhibit *F. roseum* when the fungitoxin was applied to soil. Levels were not as high and never reached the 16mm inhibition zone value when the fungitoxin was applied to gravel. This is understandable in the light of previous results (3) indicating that benomyl is leached from gravel very rapidly and thus is not available over a very long time period for uptake by a plant.

Development of Symptoms in Benomyl Treated Plants

In the final analysis, the effect of systemic compounds on development of disease is the only definitive measurement valuable in determining profitable use. To assess the potential of benomyl in control of Fusarium stem rot in mature plants, inoculum of the pathogen was placed on plants growing in the same pots and receiving the same treatments as previously described. Plants were inoculated one week after the second application of benomyl by puncturing the stems 100mm above the potting media level with a sterile scapel and placing three 7mm discs seeded with conidia of *F. roseum* in the wound. Noninoculated controls received only water agar discs in wounds. After inoculation, the wound was covered with a small square of surface sterilized polyethylene. Both ends of the polyethylene square were wrapped around the carnation stem and secured to provide a moisture tight barrier. Disease severity was rated on an arbitrary scale of 0 to 3: 0 = no symptoms, 1 = wilting of leaves, 2 = die-back of secondary laterals, and 3 = die-back of primary flower stem. Ratings were obtained nine weeks after inoculation.

The method of inoculation provided a highly favorable environment for the pathogen. Further, the inoculum carried in the agar discs was many times higher than that typically encountered in carnation culture. Nevertheless, significant suppression of

Table 1. Disease on carnations inoculated in stem wounds with conidia of *Fusarium roseum* 1 week after receiving two applications of benomyl.[a]

Method of application of benomyl	Mean disease index[b,c]
Incorporated in soil about roots	2.7 A
Drenches on soil	1.8 B
Drenches on gravel	2.7 A
Nontreated soil	3.0 A
Nontreated gravel	3.0 A

[a] *Incorporated in soil at 65 ppm (w/w) or drench 65 ppm active (200 ml suspension) two times at 0 and 6 weeks after the beginning of the experiment.*

[b] *The mean disease index was obtained 9 weeks after inoculation by adding the sum of the disease ratings (0 = no symptoms to 3 = die-back of primary flower stem) and dividing by the total number of plants per treatment.*

[c] *Values in a column followed by the same letter do not differ significantly, P = 0.05.*

symptoms occurred in plants growing in soil that had been drenched with benomyl (Table 1). These results were similar to those of the previous experiment in that benomyl content of cuttings (as determined by bioassay) was consistently highest in plants growing in soil treated with drenches.

Conclusions

The results reported in this and the previous (3) paper of this series are applicable in developing strategy for control of Fusarium stem rot on mature plants. Drenches apparently were effective, if properly applied, for insuring a level of benomyl in the plant effective in control. Benomyl applied to gravel, however, was leached out rapidly and lower concentrations occurred in plants growing in this medium. Thus, the fungitoxin probably should be applied to gravel constantly with the irrigation water to be effective.

Branch rot incited by *F. roseum* on mature plants has been found predominantly where the water from modern irrigation systems hits the stems. Disease incidence is greatest when water is applied most frequently — that is, in gravel culture where automated systems are turned on from one to three times a day for brief periods. Therefore, it would be logical to incorporate a systemic fungicide, like benomyl, into the water (along with nutrients injected with a proportioner) so that it could be applied to the site of infection — in this case, the area on the stem inundated with water during irrigation. If applied constantly with the nutrient solution, benomyl uptake through roots also should occur giving additional protection. The next paper in this series will deal with this possibility.

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