Control of Verticillium Wilt of Cotton by Spraying Foliage with Benomyl and Thiabendazole Solubilized with Hydrochloric Acid

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ABSTRACT

When HCl solutions of 2-(4-thiazolyl)benzimidazole (TBZ) and methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate (benomyl) (pH 2.7 and 1.5, respectively), were sprayed twice on foliage of cotton plants at concn of 2,500-10,000 ppm, *Verticillium* wilt was prevented following subsequent stem inoculation. Neither solution was phytotoxic. Both solutions also induced curative effects when sprayed on inoculated plants showing initial symptoms of *Verticillium* wilt. Thiabendazole and methyl 2-benzimidazolecarbamate (hydrolysis product of benomyl) were detected by bioassay and chemical analysis in xylem tissue and in nontreated stems and leaves above the place of application. Phytopathology 61:433-434.

Additional key words: Verticillium albo-atrum, translocation, systemic fungicide, *Gossypium hirsutum*.

Verticillium wilt of cotton (*Verticillium albo-atrum* Reinke & Berth.) has been experimentally controlled by treatment of soil in the glasshouse with the systemic benzimidazole fungicides, 2-(4-thiazolyl)benzimidazole (TBZ) (1, 4) and methyl 1-(butyl carbamoyl)-2-benzimidazolecarbamate (benomyl) (1, 3, 5, 6); however, control in the field has not been as efficient because the roots of cotton rapidly grow past the zone of application (5). To obtain a 20% yield increase by benomyl soil treatment in the field, dosages required were too high to be economical (2). In this paper we report the control of *Verticillium* wilt of cotton by the use of foliar sprays with hydrochloric acid (HCl) solutions of TBZ and benomyl, both of which had preventive and curative effects.

Staron et al. (8) reported that "TBZ hydrochloride" (pH 5.5) was taken up in higher amount than TBZ by lettuce roots and by fruits of apple and bean. Solel (7) reported that a dichloro-derivative of TBZ (not TBZ HCl) applied to the underside of a leaf reduced the severity of infection by *Cercospora beticola* inoculated on the upper side of the leaf more effectively than TBZ.

Cotton (*Gossypium hirsutum* L.) plants (cultivar SJ-1) 4-5 weeks old were inoculated with the severe defoliating *V. albo-atrum* isolate V-3H (5×10^4 spores/ml) by stem puncture at the first node (1). Thiabendazole was used as either the 100% (E-grade) or a 60% wettable powder, and benomyl as a 100% technical grade or a 50% wettable powder. Each chemical (5.0 g of active ingredient) was partially dissolved in 50 ml acetone followed by addition of 60-70 ml of 3% concn HCl (0.345 normal solution) and brought to 1 liter with distilled water (5,000 ppm). The pH of the TBZ solution was 2.7-3.0, and of the benomyl solution, 1.5-1.7. The nonacidified TBZ or benomyl contained the same concn of acetone as the acidified solutions. Lower concn were prepared by dilution.

Foliage was sprayed to run off in late afternoon to retain moisture on the foliage as long as possible. Foliage was resprayed immediately to ensure thorough coverage. None of the treatments were phytotoxic. Fungicides were prevented from contaminating the soil by the placing of paper towels on the top of each pot before spraying. Experiments were repeated 2 to 3 times, and treatments replicated 4 to 5 times.

Fungitoxic chemicals were detected in 10-mm leaf discs above the area of treatment or in 1-cm sections of xylem tissue by the agar diffusion bioassay method (1). A zone of inhibition (ZI) of *V. albo-atrum* growth on a petri dish sprayed with spores indicated presence of a fungitoxic substance. The minimal in vitro inhibitory concn of both TBZ and benomyl on a similar paper disc bioassay was 0.3 μg/0.1 ml.

Preinfectional foliar sprays (2 and 5 days before stem inoculation) with TBZ plus HCl and benomyl plus HCl (each fungicide at 10,000 ppm) completely prevented symptom expression, but sprays with the nonacidified compounds had no effect. Foliar treatments with a lower concn (2,500 ppm) of TBZ plus HCl and benomyl plus HCl 2 and 4 days before inoculation reduced and delayed symptom expression, but benomyl was more effective than TBZ. Subsequent experiments indicated that 2,500 ppm applied twice was near the minimal effective concn necessary for control.

Both compounds also had curative effects. When foliage was sprayed with benomyl plus HCl and TBZ plus HCl (5,000 ppm) on the 10th and 12th day after inoculation, at which time epinasty and leaf symptoms were present, the treated plants continued to grow whereas the inoculated nontreated plants ceased to grow. At the end of the experiment, the incidence of disease was greatly reduced in treated plants.

Translocation of TBZ and methyl 2-benzimidazole carbamate (MBC) (6) from sprayed leaf and stem surfaces upward to nontreated foliage was indicated by bioassay. Fungitoxic material was not detected in leaves of plants sprayed with nonacidified TBZ and benomyl. Fungitoxic material in xylem sections of stems was detected by bioassay in plants sprayed 3 times with benomyl plus HCl or TBZ plus HCl (5,000 ppm) 26 days previously, but not in plants sprayed with nonacidified TBZ or benomyl. When xylem tissue of plants sprayed 3 times (13, 22, and 24 days pre-

viously) with benomyl plus HCl or TBZ plus HCl (10,000 ppm), was chemically extracted and purified, 27 ppm of each chemical was detected by ultraviolet light spectrophotometry. Spectra from benomyl plus HCl-treated tissue were comparable to those of the hydrolysis product of benomyl, MBC (6), and from TBZ to authentic TBZ. Details will be reported later.

The use of HCl solutions of TBZ and benomyl on leaves has many practical implications for control by foliar spray of other vascular wilt diseases for which translocation of a relatively large amount of fungicide in the plant is required. Likewise, for control of leaf diseases the HCl solutions should be more effective as eradicants and more persistent than the neutral compounds.

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