I. COTTON PRODUCTION: Disease and Nematode Control

STUDIES WITH TWO SYSTEMIC FUNGICIDES, BENLATE AND THIABENDAZOLE

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Preliminary laboratory studies with over 60 commercially available and experimental fungicides and fumigants indicated that two relatively new fungicides, Benlate (1-butylcarbamoyl)-2-benzimidazole carbamic acid, methyl ester) and Thiabendazole [2-(4-thiazoyl) benzimidazole], were highly active against the two major cotton disease pathogens in Arizona, Phymatotrichum omnivorum (Texas Root Rot) and Verticillium albo-atrum (Wilt). This information was considered to be significant because of known systemic characteristics of the chemicals; results from preliminary studies in our laboratory that indicated long persistency in plants and soil, the low degree of fungicidal activity of most of the other tested chemicals, and knowledge of a long history of discouraging results with chemical control of diseases caused by both pathogens. In order to determine if the chemicals could be used for disease control, a number of laboratory, greenhouse, and field studies were initiated on persistency and movement of the chemicals in cotton and in soil and their biological activity against P. omnivorum and V. albo-atrum. Because of the unusual characteristics of these fungicides, it was thought of value to summarize the results of some of these studies.

Soil persistency, movement, and activity against Phymatotrichum omnivorum and Verticillium albo-atrum - Laboratory "in-vitro" studies demonstrated that Benlate and Thiabendazole were highly active against P. omnivorum and V. albo-atrum. Minimum concentrations in agar necessary to prevent mycelial growth of both fungi was less than 1.0 ppm (active). Phymatotrichum omnivorum did not grow from planted sclerotia or fungal strands in non-sterile Gila silt loam containing as low as 5 ppm (active) dry-weight soil basis of Benlate. Original incorporations as low as 10 ppm of Benlate persisted for 16 weeks in sufficient concentration to prevent growth of P. omnivorum in non-sterile field soil held at field capacity at temperatures ranging from 16 to 40°C. In replicated field plots at Marana, Benlate when raked 3-4" deep in surface plots at 10 lbs./A (active) or higher, persisted through a cycle of irrigated cotton in sufficient concentration to prevent growth of P. omnivorum. In greenhouse studies Benlate drenches applied three times at 0, 4, and 6 weeks at 50 ppm (active) soil-weight basis controlled Verticillium wilt in one-year-old diseased cotton plants. The chemical was detectable in the soil and in the plants 22 weeks after the last application when the tests were terminated. Benlate and Thiabendazole were detectable in soil at concentrations of 2 - 5 ppm and 5 - 110 ppm respectively with a developed bioassay technique using the fungus, Penicillium expansum. Studies in soil columns demonstrated that wettable powder or water soluble formulations did not move in the soil when applied as drenches to the soil surface (Table 1).

Studies in Gila silt loam demonstrated that Benlate and Thiabendazole were more active in preventing growth of P. omnivorum than a number of broad spectrum

soil fungicides including captan, nabam, PCNB and thiram. Only mercury containing fungicides were more active (Ceresan M and Panogen). At concentrations ranging from 0.1 to 10 ppm (active) in soil, Panogen prevented sclerotial germination at 1 ppm; Ceresan M, Benlate, and Thiabendazole at 5 ppm; whereas captan, nabam, PCNB, and thiram were inactive at the concentrations tested. Data on growth of P. omnivorum and sclerotial viability in soil containing the chemicals is shown in Table 2. It was determined that fungicide activity to sclerotia in the soil was related to exposure length and concentration. Longer exposure periods and higher fungicide concentrations resulted in higher sclerotial death. Sclerotia exposed to 10 or 100 ppm (active) of Benlate in non-sterile soil for two or five days at 27C did not germinate but were 100% viable when removed to water agar. After eight days of exposure at 10 ppm, sclerotial germination after removal to water agar, was similar to the check. Germination from 100 ppm treatments, however, was reduced to 15 - 20%.

Chemical uptake in cotton from foliage, soil and seed treatments: A number of replicated field trials were established at Marana at approximately one month intervals to determine systemic activity in cotton from foliage applications. Varying rates and application methods were studied and assays were made periodically from roots, stems and leaves. Benlate was translocated into non-sprayed, developing new foliage. Downward movement was shown to be related to age of plant at time of foliage spray (Table 3). Benlate was only recovered from roots of plants sprayed at eight weeks of age. Translocation into roots from foliage application is significant from the standpoint of possible disease control because P. omnivorum is a root parasite and V. albo-atrum gains entry into the cotton plant through the root system. When cotton was grown in non-sterile Gila silt loam containing varying concentrations of Benlate, the chemical was detected five days after planting in roots and stems of plants growing in concentrations as low as 1 ppm (active) dry-weight soil basis. The chemical was detectable in large quantities in cotton stems, roots, and leaves 22 weeks after three soil drench applications of 50 ppm in greenhouse studies, indicating long persistency. In replicated field trials at Marana, Safford, and Kansas Settlement a band of Benlate formulated as 5% active in silicacious sand applied 6-8" deep on both sides of the cotton bed at time of seedling emergence (total chemical applied equivalent to 0.23 gms active/linear row foot) was not detectable in roots or stems after varying time periods. Little success was had with rototilling at lay-by as a method of obtaining systemic activity in cotton as only high rates (2 gms active Benlate/linear row foot) were detectable in roots and stems in replicated tests at Marana.

Several varieties of acid delinted cotton seed were treated with 20, 10 and 5 oz. (active) Benlate/100 lbs. seed. Bioassays of roots, stems, and leaves made in greenhouse tests at one, five, and nine weeks after planting indicated the chemical was systemic from seed treatment. At nine weeks the chemical was detected in roots and stems of the 10 and 20 but not the 5 oz. rate. A 2-hour seed soak in 5,000 ppm (active) Benlate or higher also resulted in detectable quantities of chemical in roots, stems, and leaves.

Studies are continuing with these two chemicals. Information learned this last year will be helpful in designing further studies in the use of these fungicides for plant disease control.

Table 1

Movement of Benzimidazole Fungicides in Gila Silt Loam

Depth of Soil Assayed	Inhibition Zone (mm) in Assay Plates[1] Resulting From a 100 PPM Drench			
	Benlate (W.P.)	TBZ (W.P.)	TBZ (H_2O sol.)	CONTROL
surface	46	31	25	0
25 mm	0	0	0	0
50 mm	0	0	0	0
75 mm	0	0	0	0
100 mm	0	0	0	0

[1] Bioassays made with the fungus Penicillium expansum. Numbers are the average of five replications.

Table 2

Effect on Growth and Viability of Sclerotia of *Phymatotrichum omnivorum* of Several Chemicals Incorporated into Non-Sterile Soil

Chemical	Concentration[1] (PPM)	Fungicidal Activity[2] growth	viability
Captan	10	+	20/20
	5	+	20/20
	1	+	20/20
	0.1	+	20/20
Nabam	10	+	20/20
	5	+	20/20
	1	+	20/20
	0.1	+	20/20
PCNB	10	+	20/20
	5	+	20/20
	1	+	20/20
	0.1	+	20/20
Thiram	10	+	20/20
	5	+	20/20
	1	+	20/20
	0.1	+	20/20
Panogen	10	--	0/20
	5	--	0/20
	1	--	0/20
	0.1	+	20/20
Ceresan M	10	--	0/20
	5	--	0/20
	1	+	20/20
	0.1	+	20/20
Benlate	10	--	20/20
	5	--	20/20
	1	+	20/20
	0.1	+	20/20
Check		+	20/20

[1] PPM of active material based on air-dry soil weight; mercury determinations based on mercury equivalents.

[2] Sclerotia were placed in soil containing the indicated fungicidal concentrations at 27 C and observations made on fungal growth at five days. Sclerotia were then removed to water agar to determine viability. A + indicates normal sclerotial growth, a -- indicates no growth. 20/20 indicates that all sclerotia were alive; 0/20 indicates that all sclerotia were dead.

Data based on two different experiments with ten sclerotia per treatment.

Table 3

Effect of Age of Cotton Plant at Time of Foliage Application on Systemic Activity of Benlate

Date of Foliage Application	Plant Age (Weeks)	Assay Period (Days After First Foliage Spray)	Chemical Detection		
			Roots	Stems	New Growth
May 21	4	2 days	--	+	N.S.[1]
		10 days	--	+	+
		30 days	--	+	+
June 18	8	3 weeks	+	+	+
		4 weeks	+	+	+
		8 weeks	--	--	--
July 19	12	30 days	--	+	+
July 19, July 26, August 1		30 days[2]	--	+	+

[1] N.S. indicates no sample taken, -- indicates negative results, and + positive results.

[2] Assays were made 30 days after the August 1 application.

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SEED TREATMENT FOR SEEDLING DISEASE CONTROL

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Various fungicides were compared as treatments on acid-delinted seed, variety Stoneville 7A, in replicated trials at Phoenix and at Marana in plantings made March 26 and April 18, respectively. At both locations the tests were planted under favorable conditions as regards soil moisture and temperature. Subsequent air temperatures were slightly below average in both tests. In one experiment we compared 16 treatments, and our surviving stands at 35 days ranged from 61 to 68% of seed planted at Phoenix and from 42 to 56% in the Marana planting. The differences in stands between the 16 treatments were not statistically significant at either location.

In a companion experiment we compared 12 treatments, most of which were combinations of fungicides. The 35-day stand counts at Phoenix ranged from