Movement and Disappearance of Dicloran, Iprodione, and Vinclozolin in Peanut and Nonpeanut Soils

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ABSTRACT

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The movement and disappearance of dicloran, iprodione, and vinclozolin were studied in Woodstown loamy sand (WLS), a peanut soil; and Lodi Loam (LL), a nonpeanut soil, using polyvinylchloride vertical laboratory percolation soil columns and incubated fungicide-amended soils, respectively. Residues were solvent-extracted and detected by an agar bioassay technique. Dicloran moved a maximum of 10 cm in the LL and 15 cm in the WLS, whereas vinclozolin was detected last at a 25-cm depth in the LL soil column but in all sections (35 cm) of the WLS soil column. Iprodione was detected throughout the entire columns (35 cm) of both soils. Fungicide disappearance at lower concentrations (including the labeled usage rate) was faster at 28 than 21 C and in LL than in WLS.

Dicloran (Botran 75WP), iprodione (Rovral 50WP), and vinclozolin (Ronilan 50WP) have been used to control *Sclerotinia minor* (Jagger) on peanut in Virginia and parts of North Carolinia (1,11). Information on their movement and disappearance in soil was needed to develop effective disease control strategies and to prevent their contamination of potable water supplies, not only from routine application but also from accidental spills and spray-tank rinses.

Dicloran is degraded to nonfungitoxic residues by microbes in liquid broth and soil with decomposition increased under low oxygen tensions (12,13), in soils previously treated with dicloran (3), and in the presence of large amounts of organic matter (15). Helling et al (5) classified dicloran as immobile in soil after receiving an R_f value of 0.01 on soil thin-layer chromatograms. Groves and Chough (3,4) also reported that dicloran was strongly adsorbed to soils high in clay content.

Since data on movement and disappearance of iprodione and vinclozolin in soil are rare or lacking and their potential for the control of Sclerotinia blight is great, information on their fate in soil is essential for developing effective disease control strategies.

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MATERIALS AND METHODS

Two Virginia soils were studied: Woodstown loamy sand (WLS), a peanut soil found commonly in the peanut growing region of southeastern Virginia; and Lodi loam (LL), a nonpeanut soil found in the Virginia highlands. Characteristics of both soils are given in Table 1.

Table 1. Characteristics of the A horizon of Lodi loam (LL) and Woodstown loamy sand (WLS)

	Soil type	
	LL[a]	WLS[b]
Bulk density[c] (g/cc)	1.11	1.34
pH	6.00	5.80
Percent sand[d]	29.60	80.50
Percent silt[d]	49.40	12.30
Percent clay[d]	21.00	7.20
Percent OM[e]	1.80	2.10
Nutrients[f] (μg/g of soil)		
P	17.00	49.00
K	91.00	107.00
Ca	492.00	588.00
Mg	59.00	98.00
CEC[g] (meq/100 g)	7.30	4.50

[a] Textural class = loam-silt loam, taxonomic classification: Typic Hapludult; clayey, mixed, mesic (previously classified as a Groseclose loam).
[b] Textural class = loamy sand, taxonomic classification: Aquic Hapludult; fine-loamy, mixed, thermic (previously classified as a Tetotum fine sandy loam-variant).
[c] Values pertain to soil columns only; determined by Munnecke's method (7).
[d] Determined by Day's procedure (2).
[e] Determined by modified Walkey-Black organic matter determination (8).
[f] Determined by Rich's method (9).
[g] Cation exchange capacity as determined by Rich's method (10).

Movement in soil. Air-dried soil was packed into segmented polyvinylchloride sections (5 cm long × 4.5 cm in diam.) to a total height of 35 cm and suspended by a triple layer of cheesecloth. Soil was added in 50-cc lots and lightly tapped with a wooden dowel between additions to achieve approximate field bulk densities. Bulk density, determined by Munnecke's procedure (7), was 1.11 and 1.34 cc for LL and WLS, respectively.

Each fungicide (200 mg a.i., simulating a >1,000× field rate) was applied to the topsoil surface in the column and leached with 400 ml of distilled water. After leaching (12–18 hr), columns were disassembled into sections from which a center core (15 mm in diam.) was removed to avoid possible channeling along the sides of the column. Oven-dry weight averages of the sampled sections were about 20 and 22 g, respectively, for LL and WLS.

Residues were extracted from the samples on a rotary shaker with 50 ml of acetone for 30 min. Extracts were filtered through Whatman No. 1 filter paper, and the soil was rewashed twice with 15 ml of acetone and refiltered. Extracts were combined and allowed to dry. Residues were reconstituted with 1:1 acetone-absolute ethanol and added to 50 ml of cooled (48–50 C) glucose yeast-extract agar containing 200 μg/ml of chloramphenicol (cGYEA) (6) from which two agar plates were poured. An agar plug (6 mm) removed from the outer edge of a 4-day-old actively growing colony of *S. minor* culture grown on cGYEA (6) at 21 C was placed on the test medium. Plates were incubated at 21 C for 13 days and radial growth measurements recorded. Each treatment was replicated three times; columns treated with distilled water served as controls. The data were subjected to an analysis of variance (ANOVA), and mean growth measurements were compared with their respective control for each soil-fungicide-column section by Student's *t* test.

Disappearance in soil. Each soil was amended with aqueous suspensions of the formulated fungicide to yield soil concentrations of 2, 4, 6, 18, and 50 μg/g for dicloran (from 75WP) and 1.5, 3, 6, 18, and 50 μg/g for iprodione and vinclozolin (from 50WP). Amended soils were stored in plastic bags with some perforations to allow gas exchange and incubated at 21 and 28 C along with

Table 2. Movement of dicloran, iprodione, and vinclozolin through soil columns of Lodi loam (LL) and Woodstown loamy sand (WLS) as revealed through inhibition of radial growth of *Sclerotinia minor* by soil extracts (cm)[a]

Depth of sample (cm)	Soil type							
	LL				WLS			
	Control	Dicloran	Iprodione	Vinclozolin	Control	Dicloran	Iprodione	Vinclozolin
0–5	4.23	0.22*	0.00*	0.00*	4.05	0.00*	0.00*	0.00*
5–10	4.73	3.72*	1.11*	0.38*	4.05	1.63*	0.15*	0.33*
10–15	3.92	4.37	1.47*	1.20*	3.80	2.61*	0.43*	0.90*
15–20	4.11	4.66	1.10*	0.68*	3.78	3.91	1.05*	0.65*
20–25	4.43	3.85	1.11*	1.41*	3.68	3.56	1.30*	1.18*
25–30	4.97	3.91	1.68*	4.83	3.95	3.78	1.30*	1.55*
30–35	5.55	4.63*[b]	3.40*	5.23	3.83	3.66	1.55*	1.51*
Amount of leachate (ml)	154.00	167.00	175.00	185.00	209.00	214.00	205.00	226.00

[a] Values represent the mean of three replicates; one replicate represents the mean of two bioassay radial growth measurements. Means in the same horizontal row followed by an asterisk are significantly different from their respective soil control mean by Student's t test at $P = 0.05$.
[b] Not significantly different at $P = 0.01$.

water-treated control soils. Final moisture contents of the LL and WLS were 23 and 15% (about 80% field capacity at −1/3 bar), respectively. Moisture levels were maintained by reamending the soil bags with distilled water on a monthly basis.

Residues were extracted with 30 ml of 1:1 acetone-methylene chloride and detected as mentioned before with the following modifications: the cGYEA (6) was amended with 200 μg/ml of streptomycin (scGYEA) to extend the antibacterial spectrum, and agar plates containing residues were inoculated with *S. minor* and incubated for 9 days at 21 C. Residual quantities were estimated from standard ED_{50} curves constructed from observed fungal growth inhibitions on scGYEA amended with known concentrations of each fungicide. Mean values from each of four 25-ml agar replicate plates were expressed as percent inhibition by the equation: control-treatment/control = percent growth inhibition, which was used to estimate the residual quantity in each soil extract. Non-fungicide-amended (water controls) soil extracts showed some antifungal activity; therefore, separate standard curves were constructed for each soil-fungicide combination.

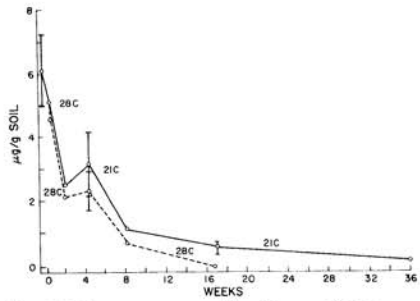

Fig. 1. Disappearance of residues of dicloran in Lodi loam soil incubated at 21 and 28 C after a 6-μg/g soil incorporation.

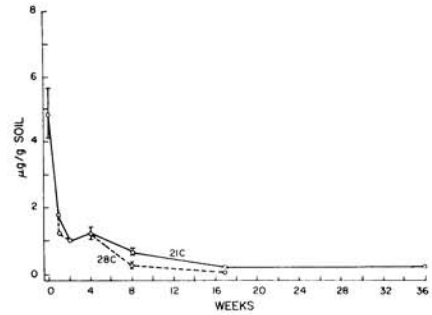

Fig. 2. Disappearance of residues of iprodione in Lodi loam soil incubated at 21 and 28 C after a 6-μg/g soil incorporation.

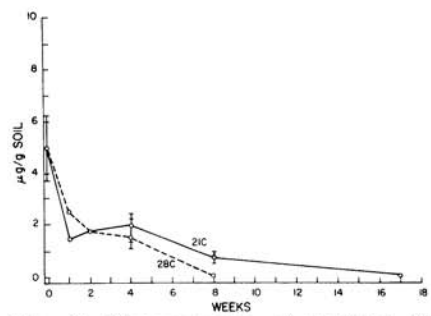

Fig. 3. Disappearance of residues of vinclozolin in Lodi loam soil incubated at 21 and 28 C after a 6-μg/g soil incorporation.

RESULTS AND DISCUSSION

Table 2 shows the results of the fungicide mobility experiments in both soil types. All fungicides moved past the first 5-cm soil section, with dicloran residues immobilized at 10 cm in LL and at 15 cm in WLS. Extracts from all soil sections treated with iprodione in both the LL and WLS soil columns caused inhibition. Higher inhibition occurred in WLS, indicating iprodione may have a high degree of mobility in soil. LL soil treated with vinclozolin showed fungal inhibition to a depth of 25 cm, whereas all soil-sections of the WLS had detectable levels of antifungal activity.

Helling et al (5) also demonstrated poor mobility of dicloran in soil. Iprodione consistently showed detectable residues in each soil type; however, the gradual increase in fungal growth on extracts made from the basal sections of the LL soil columns suggested that iprodione might be immobilized had percolation been allowed to proceed beyond 35 cm. Vinclozolin was also relatively mobile but was filtered out more effectively by the clay soil than iprodione—a phenomenon possibly related to a higher cationic charge associated with the parent molecule. The actual factors governing the movement of vinclozolin in soil are not known. Soil type greatly affected fungicide mobility.

All fungicides disappeared more rapidly in LL than in WLS. Data are presented for LL only; Figures 1–3 illustrate typical degradation patterns of dicloran, iprodione, and vinclozolin, respectively, in the LL soil. Iprodione was reduced from an original 6-μg/g soil application to trace levels (<0.5 μg/g of soil) within 8–17 wk, whereas detectable levels were observed up to 48 wk in the WLS soil. Similar patterns were observed for dicloran and vinclozolin, but only 36 wk were needed in the WLS to degrade a 6-μg/g soil application of dicloran and vinclozolin compared with 48 wk with iprodione.

The time required to reduce fungicides to trace levels was a function of intial concentrations; the lower fungicide concentrations below 6 μg/g of soil (approximate field application rate at 15-cm soil incorporation) were reduced to trace levels in less than 1 mo in the LL and 2 mo in the WLS soil. Detectable levels of iprodione, however, were observed for periods up to 17 and 36 wk for 1.5- and 3-μg/g soil amendments, respectively, in WLS; this suggested a slower degradation of iprodione than observed for dicloran and vinclozolin. Trace amounts of vinclozolin were detected in the LL soil within 2–4 wk when incorporated at 3 μg/g, whereas 8–17 wk were required to reduce a 6-μg/g soil application. When applied at 18 and 50 μg/g of soil, fungicides were still detectable in each soil after 48 wk of incubation at 21 C. Iprodione incorporated at 18 and 50 μg/g of soil persisted in the WLS at and possibly beyond the 48-wk sampling period.

All fungicides disappeared slightly faster after incubation at 28 than at 21 C, but the significance of temperature was minimal. This phenomenon could possibly be attributed to enhanced microbial activity. Van Alfen and Kosuge (12,13), Groves and Chough (3), and

Wang and Broadbent (14,15) agreed that dicloran was degraded primarily by microbial conversions. The modes of degradation of iprodione and vinclozolin have yet to be established, but similar pathways of decomposition may be involved.

Although half-lives of the fungicides were not accurately calculated, they persisted for about 1–4 wk when application was made at the label rate. Disappearance was faster in LL soil, but the initital reduction of residues was about equal in both soils. The faster disappearance of the fungicides in LL soil may be due to the microbial component or to a higher clay content, since Groves and Chough (4) reported that dicloran was strongly adsorbed to high-clay soils. Little or no published information exists on comparative efficacy of residue extraction techniques for these fungicides. Our extraction method may have been marginally effective, thereby giving an incomplete picture of residue status. All our extraction procedures, however, were consistent.

We suggest that at the manufacturers' recommended rates of application, none of these fungicides poses an environmental contamination hazard. Caution should be observed, however, in the disposal of spray-tank rinses or the dumping of other high-quantity wastes.

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