Soil Contamination Inconsistently Affects Performance of Diphenylamine as a Superficial Scald Inhibitor

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Abstract. Three types of soil were mixed with water containing DPA (2000 mg-liter⁻¹) and benomyl (300 mg-liter⁻¹) at 1% to 5% (w/w). 'Rome' apples (*Malus domestica* Borkh.) were dipped in the mixtures over 8 days. The efficiency of DPA as a scald inhibitor was not consistently affected by soil type, soil concentration, or age of mixture. Chemical names used: methyl[1-[(butylamino)carbonyl]-1H-benzimidazol-2-yl]carbamate (benomyl); diphenylamine (DPA).

Apples are usually treated with the superficial (storage) scald inhibitor diphenylamine (DPA) by postharvest dipping or drenching of bins just before storage. Sometimes entire trucks or carriers are drenched. Frequently orchard soil adheres to bin bottoms and tires. The treatment mixture is recharged and recirculated for days or weeks before the system is drained and cleaned. Considerable quantities of soil can accumulate during the period of use. It has been suggested that soil constituents, particularly the organic fraction, bind DPA and reduce its effectiveness, but we found no experimental data in the literature. Loss of DPA dip effectiveness was found to depend on formulation, but the most

durable formulation retained effectiveness for at least 2 weeks (Little et al., 1980). In the same paper it is reported that bin-flood effectiveness could be retained for at least 100 min, although pumping did cause some formulations to break down. An experiment was designed to estimate the effect of several soil types and proportions on the ability of DPA to reduce scald.

'Rome' apples were obtained from the West Virginia Univ. Experiment Farm, Kearnsyville, 16–22 Oct. 1983, 166 to 172 days after full bloom. On each harvest date, fruit was picked from the same five trees and com-

bined in a bin. Treatments were made in Morgantown, W.Va. Treatment mixtures were prepared by combining 10 liter water, 66 ml 31% emulsifiable DPA (Pennwalt), 33 g benomyl, and soil in 20-liter plastic buckets. Soil was added at 1%, 3%, and 5% (w/w). The soils (Table 1) had been oven-dried and ground to pass a 2-mm screen. Organic matter was determined by oxidation with sodium bichromate (Soil Survey Staff, 1984).

Five replicates of 25 fruits were selected randomly from a bin and placed in plastic pails that had been perforated on the bottoms and lower sides to permit rapid and thorough draining. The treatment mixture was stirred vigorously with a wooden paddle and the fruit immersed for 1 min. After draining for several minutes, the fruits were transferred to new white paper bags that were taken within 5 min of treatment to a storage room held at 1C. The same treatment mixtures were used from 14 through 22 Oct. On 24 Oct. all fruit was transferred to commercial controlled atmosphere storage. The room was sealed on 11 Nov. and an atmosphere of 3% O₂ and 2.5% to 3.5% CO₂ established within 48 hr. The room was opened on 27 Feb. 1984, reclosed on 29 Feb., and opened for the last time 10 Mar. Until examination, the fruit was held at 1C in air. Ten fruits per replicate were rated for scald incidence after 1 day at 20C and again after 7 days at 20C. Fruit was classed as acceptable (10% or less of the surface affected by scald) or unmarketable (> 10% of fruit surface affected). Firmness

Table 1. Soil types and characteristics.

Soil type	Soil components (%)				Textural class
	Sand 2.0–0.05 mm	Silt 0.05–0.002 mm	Clay <0.002 mm	Organic matter	
Dekalb Ap (Typic Dystochrept)	39.9	36.1	24.0	3.8	Loam
Dekalb Bw (Typic Dystochrept)	52.8	29.4	18.8	0.1	Sandy loam
Guernsey (Aquic Hapludalf)	4.7	36.6	48.7	0.3	Clay

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Table 2. Effect of combinations of diphenylamine and soils on superficial scald of 'Rome' apples treated on several dates. Fruits were examined after 146 days of controlled atmosphere storage and 7 days at 20C in air (1983).

Chemical and soil ²	Harvest date				
	10/14	10/14	10/17	10/17	10/22
	Treatment date				
	10/15	10/16	10/18	10/19	10/22
<i>Unacceptable fruit (%)³</i>					
Not dipped	58.7	47.6	66.9	70.9	44.7
Benomyl ⁴	38.4	65.6	57.7	40.0	54.9
Benomyl + DPA ⁵	8.2	10.7	6.0	4.0	2.0
Dekalb Ap					
1%	0.0	2.0	2.2	2.0	0.0
3%	8.4	22.0	0.0	2.0	0.0
5%	0.0	10.0	0.0	5.3	2.2
Dekalb Bw					
1%	6.0	22.2	2.0	4.0	2.8
3%	6.0	8.0	0.0	8.7	2.9
5%	8.2	8.0	0.0	21.1	4.0
Guernsey					
1%	4.0	2.2	4.0	2.2	4.0
3%	2.0	2.0	0.0	0.0	2.9
5%	0.0	4.5	0.0	0.0	2.2
Analysis of variance					
Treatment date (1983)					
	Source	df	F	PR > F	
10/15	Soils	2	4.47	0.02	
	Concn.	2	0.07	0.93	
	Soils × concn.	4	0.47	0.75	
	DPA vs. av. soil	1	1.75	0.21	
	Control vs. rest	1	24.15	0.0003	
10/16	Soils	2	2.68	0.08	
	Concn.	2	0.15	0.86	
	Soils × concn.	4	1.92	0.12	
	DPA vs. av. soil	1	0.04	0.83	
	Control vs. rest	1	28.94	0.0001	
10/18	Soils	2	0.29	0.75	
	Concn.	2	4.57	0.02	
	Soils × concn.	4	0.29	0.88	
	DPA vs. av. soil	1	2.75	0.12	
	Control vs. rest	1	108.72	0.0001	
10/19	Soils	2	7.71	0.002	
	Concn.	2	2.33	0.11	
	Soils × concn.	4	2.14	0.10	
	DPA vs. av. soil	1	0.07	0.80	
	Control vs. rest	1	300.39	0.0001	
10/22	Soils	2	1.01	0.37	
	Concn.	2	0.17	0.84	
	Soils × concn.	4	0.89	0.48	
	DPA vs. av. soil	1	0.04	0.84	
	Control vs. rest	1	73.10	0.0001	

²All soil treatments contained benomyl, 300 mg·liter⁻¹ and diphenylamine, 2000 mg·liter⁻¹.

³More than 10% of fruit surface scalded; mean of five replications.

⁴300 mg·liter⁻¹.

⁵Diphenylamine, 2000 mg·liter⁻¹.

was measured on 10 other fruits in the replicate after 1 day at 20C and on the 10 fruits that had been rated after 7 days at 20C.

Data were tested by analysis of variance to compare effects of soil type, soil concentration, maturity, and age of solution, using the Statistical Analysis System (SAS Institute, Inc. Cary, N.C.).

The incidence of scald increased during holding for 7 days and was not affected by harvest date or any of the treatments. Although concentration had a significant effect on 18 Oct., portioning into linear and quadratic components yielded nonsignificant relationships (Table 2). Fruit firmness was not affected by treatment (data not shown).

Providers of emulsified DPA concentrates suggest that 378 liter of mixture will treat ≈11,450 kg of apples. In this experiment, about one-third of the original 10 liter of treatment mixture remained after the fifth dipping, which would be very close to the use during commercial applications. Apparently, up to 5% of soil may accumulate without affecting the scald-inhibiting potential of DPA.

Literature Cited

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