DISSIPATION OF DISLODGEABLE FOLIAR RESIDUE FOR CHLORPYRIFOS AND DICHLORVOS TREATED LAWN: IMPLICATION FOR SAFE REENTRY

By

Keith T. Maddy, Chief/Staff Toxicologist
Kean S. Goh, Environmental Hazards Specialist
Susan Edmiston, Environmental Hazards Specialist III
Sheila Margetich, Agricultural Chemist II

HS-1279(a) July 31, 1986

California Department of Food and Agriculture
Division of Pest Management, Environmental
Protection and Worker Safety
Worker Health and Safety Branch
1220 N Street, Sacramento, California 95814

Bull. Environ. Contam. Toxicol. (1986) 37:33–40
© 1986 Springer-Verlag New York Inc.

Environmental Contamination and Toxicology

Dissipation of Dislodgeable Foliar Residue for Chlorpyrifos and Dichlorvos Treated Lawn: Implication for Safe Reentry

K. S. Goh,[1,2] S. Edmiston,[2] K. T. Maddy,[2] and S. Margetich[3]

[1]Department of Entomology, Comstock Hall, Cornell University, Ithaca, NY 14853, [2]Division of Pest Management, Environmental Protection and Worker Safety: Worker Health and Safety Unit, California Department of Food and Agriculture, 1220 N Street, Sacramento, CA 95814, and [3]Chemistry Laboratory Services, 3292 Meadowview Rd., Sacramento, CA, 95832

The reentry interval is the time elapsed after a pesticide has been applied before a worker can safely reenter the field for cultural or harvesting activities while wearing normal clothing. The safe reentry interval for a pesticide is determined by monitoring the dissipation of its dislodgeable foliar residue (Iwata et al. 1970) until it reaches the established estimated-safe-level (Knaak et al. 1980). Reentry standards have been established for selected pesticides on various tree fruits by EPA and more stringently by the California Department of Food and Agriculture.

Recently, because of concern for the safety of children playing on chlorpyrifos and dichlorvos treated lawns, a field trial was instigated. An initial study on Kentucky bluegrass, using the maximum recommended rate of 3.79 liters Dichloron (TM) for 508.18 m^2 of lawn and irrigating with 12.7 mm of water post-spray, was found to be safe to reenter after two hours at which time the spray had dried (Goh et al. 1985). Dichloron (TM) is a lawn insecticide containing 3% chlorpyrifos [0,0-diethyl 0-(3,5,6-trichloro-2-pyrifinyl) phosphorothioate] and 2.6% dichlorvos/DDVP (2,2-dichlorovinyl dimethyl phosphate) as the active ingredients. These organophosphorus insecticides are cholinesterase inhibitors with moderate toxicity: chlorpyrifos acute oral (rat) LD_{50} = 82-155 mg/kg, dermal LD_{50} = 202 mg/kg; dichlorvos oral LD_{50} = 56-80 mg/kg, and dermal LD_{50} = 75-107 mg/kg (Gaines 1960, 1969). In California the estimated safe levels of dislodgeable foliar residue for chlorpyrifos and dichlorvos are 0.50 ug/cm^2 and 0.06 ug/cm^2, respectively (Maddy et al. 1984).

This study reports the dissipation of chlorpyrifos and dichlorvos on a clover and fescue lawn used under both recommended conditions and a possible worse-case situation (using half the recommended amount of water with no irrigation after spraying). To prevent the loss of dichlorvos (vapor pressure 0.01 mm Hg at 30°C) in the samples during transit and holdover prior to extraction and analysis, this study was conducted on a lawn in the premise of the chemistry laboratory to facilitate immediate residue analyses.

METHODS AND MATERIALS

Lawn plots were located at the California Department of Food and Agriculture's Chemistry Laboratory, Meadowview Road, Sacramento, CA during November 1984. The plots consisted of 80-90% clover, Trifolium sp. and 10-20% fescue, Festuca sp. Correlation of leaf weight to surface area was obtained by taking 12 leaf samples ranging from 2 to 18 grams (weighed to the nearest centigram). The single surface leaf area was measured with a LI-3100 leaf area meter (LI-COR, Nebraska) to within ± 0.001 cm^2 for each sample of known fresh weight. A linear regression of surface area (both sides) to fresh weight was generated from the data.

The experimental plot was a 2 x 2 factorial design: full (613.24 liters for 508.18 m^2 of lawn) and half the recommended rates of water with (12.7 mm) and without post-spray irrigation. All treatments (0.61 m x 2.4 m) were replicated four times and sprayed at the maximum recommended rate of 3.79 liters Dichloron TM for 508.18 m^2 of lawn. Application was made at 0700 hours (ambient temperature 11.1°C; relative humidity 90%; calm conditions) with a two-gallon Hudson hand-held sprayer under low pressure equipped with a nozzle producing coarse droplets. Immediately after spraying, half the treated plots were irrigated with 12.7 mm of water as per label directions. Leaf samples were taken before, immediately after spraying, and at 2, 6, 8, 24, 48, and 72 hours post-spray. One random sample per plot, as demarcated by a wire template of 10 x 10 cm, was taken at each sampling interval and immediately taken into the laboratory for weighing and analyses.

Dislodgeable residues were extracted by rotating the leaf samples three times for 30 minutes each at 30 cycles/minute in: 1) 50 ml of water with 0.2 ml of 2% Sur-Ten (American Cyanamid) solution; 2) 50 ml of water with Sur-Ten; and 3) 50 ml water only. The 150 ml aqueous solution was extracted three times with 50, 25 and 25 ml of ethyl acetate. The solvent was dried over sodium sulfate and analyzed by HP 5880-A gas chromatography with a 25 x 0.2 mm id, SE-54 fused silica coated capillary column. Sample solutions and appropriate standards were injected using the following instrument parameters: pressure 15 psi; oven temperature 170-240°C; injector temperature 225°C; helium carrier gas flow rate 25 ml/min; septum purge rate 2 ml/min and split vent rate 50 ml/min; retention time dichlorvos = 2.45 min and chlorpyrifos = 6.58 min. The detection limit of chlorpyrifos and dichlorvos was 1 ug/sample.

RESULTS AND DISCUSSION

The linear regression of total leaf surface area of clover and fescue (both sides) to fresh weight was $Y = 55.27\ x$ ($r = 0.99$) This correlation again demonstrated, as in our previous study on Kentucky bluegrass (Goh et al. 1984), a quick and accurate way for estimating leaf surface area from any sample of known weight without tedious measurement of leaf area each time. Contrary to first impression, Kentucky bluegrass with regression of Y = 79.28 x (r = 0.99) has more surface area than clover and fescue for a given fresh weight. However, in terms of retention of spray residues, it was probably compensated by the flat trifoliate nature of clover which offer more available surface than the upright and narrow leaves of bluegrass.

Two methods of leaf surface area measurements were used in the calculation of foliage dislodgeable residue (ug/cm^2): 1) total leaf surface area as obtained by regressing sample of known weight on the established regression line; and 2) leaf area represented by lawn area sampled, 100 cm^2 in this case. The latter method probably reflects more accurately the actual area that could be contacted in the course of human activities on lawn.

The dissipation of dislodgeable dichlorvos residue was remarkably similar to our previous trial on Kentucky bluegrass. Foliar dichlorvos residue, as measured by Method 1 for the treatment with the recommended rate and followed with 12.7 mm of post-spray watering, never exceeded the estimated safe level of 0.06 ug/cm^2 (Maddy et al 1984); all other treatments were below the safe level within six hours post-spray (Fig. 1). Using the Method 2 calculation, the foliar residues reached safe levels within four hours in irrigated plots; in the worse-case situations (non-irrigated plot) it took 14 hours for dichlorvos to dissipate to the estimated safe level (Fig. 2). Dichlorvos was not detected at 48 hours and beyond (detection limit 1 ug/sample).

Residue levels of chlorpyrifos were well below the estimated safe level of 0.5 ug/cm^2 (Maddy et al 1984) except in the non-irrigated plots (Fig. 3). Using the lawn area calculation, it took six hours for chlorpyrifos to dissipate to safe levels (Fig. 5). In the course of the experiment, Dichloron (TM) was phytotoxic to clover at 10 to 30 percent in the post-spray irrigated and non-irrigated plots, respectively.

In general, the dilution rate of Dichloron (TM), i.e. using full or half the recommended rate of water, did not significantly alter the rates of dissipation for dichlorvos and chlorpyrifos. However, post-spray irrigation significantly increased the dissipation of dichlorvos and particularly chlorpyrifos foliar dislodgeable residues. Chlorpyrifos never exceeded the estimated safe level and dichlorvos dissipated to safe levels within four hours post-spray when used in the formulation Dichloron (TM) unfder Northern California's cold and wet winter. When post-treatment irrigation was not applied, 14 hours and 6 hours were required for dichlorvos and chlorpyrifos, respectively, to dissipate to the estimated safe levels.

The derivation of elapsed time required before safe entry to the treated lawn is based on the estimated safe levels for chlorpyrifos and dichlorvos established separately. The estimated safe level for simultaneous exposure to more than one toxicant as in

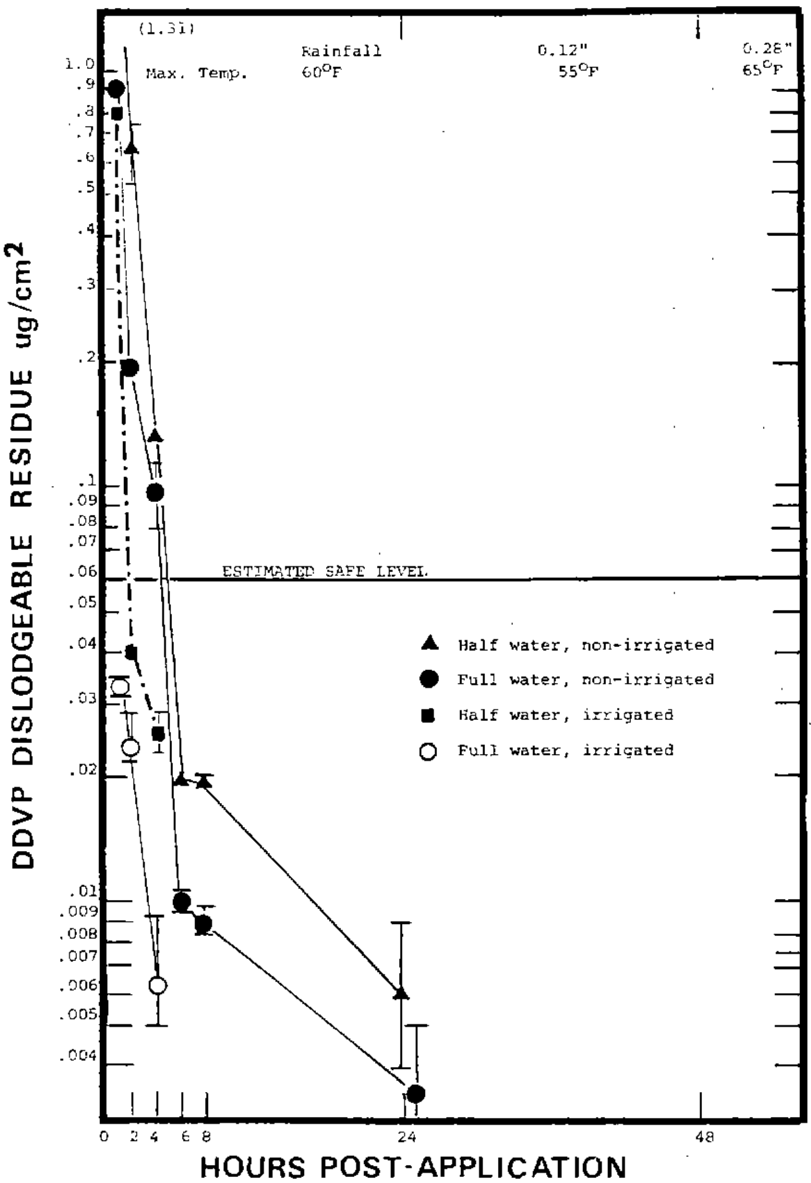

Figure 1. Dissipation of DDVP Foliar Dislodgeable Residue (± S.E.) as Measured from Total Leaf Surface Area of Clover and Fescue Lawn. Sacramento, California, November 1984

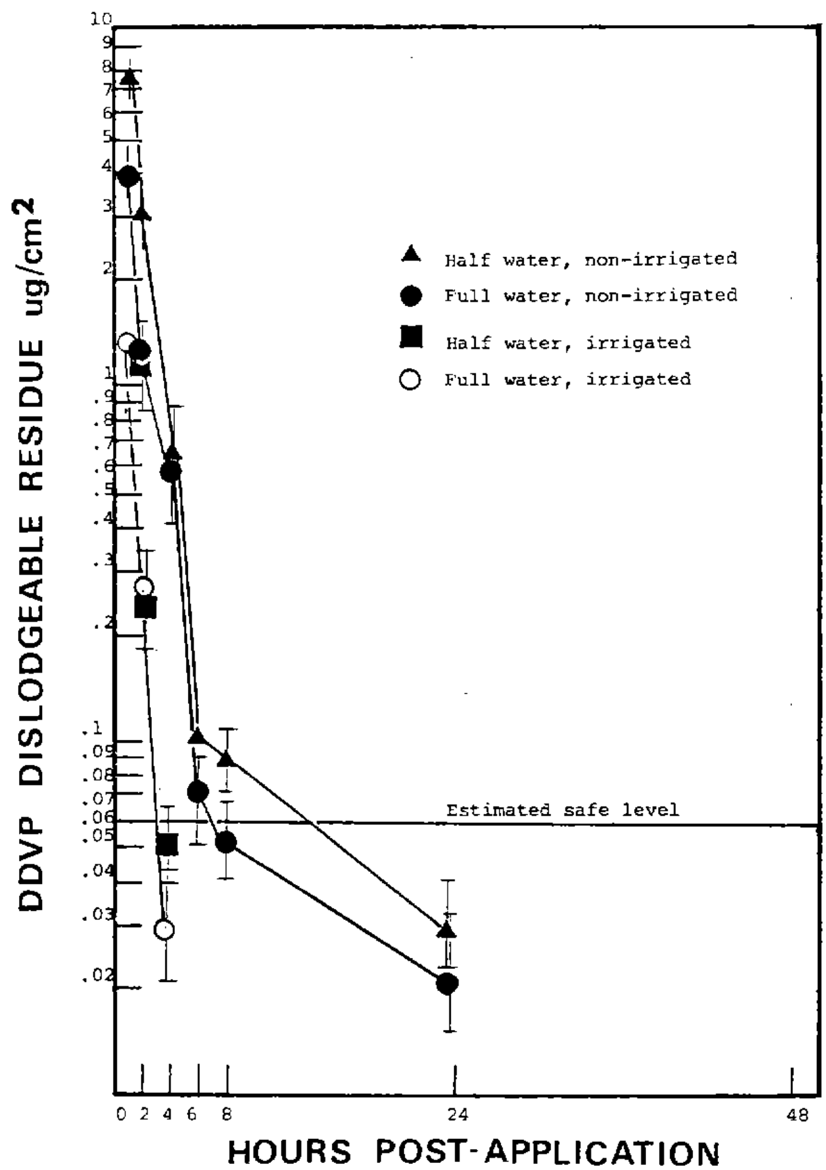

Figure 2. Dissipation of DDVP Foliar Dislodgeable Residue (± S.E.) from 100 sq. cm. of Lawn Area of Clover and Fescue. Sacramento, California, November 1984

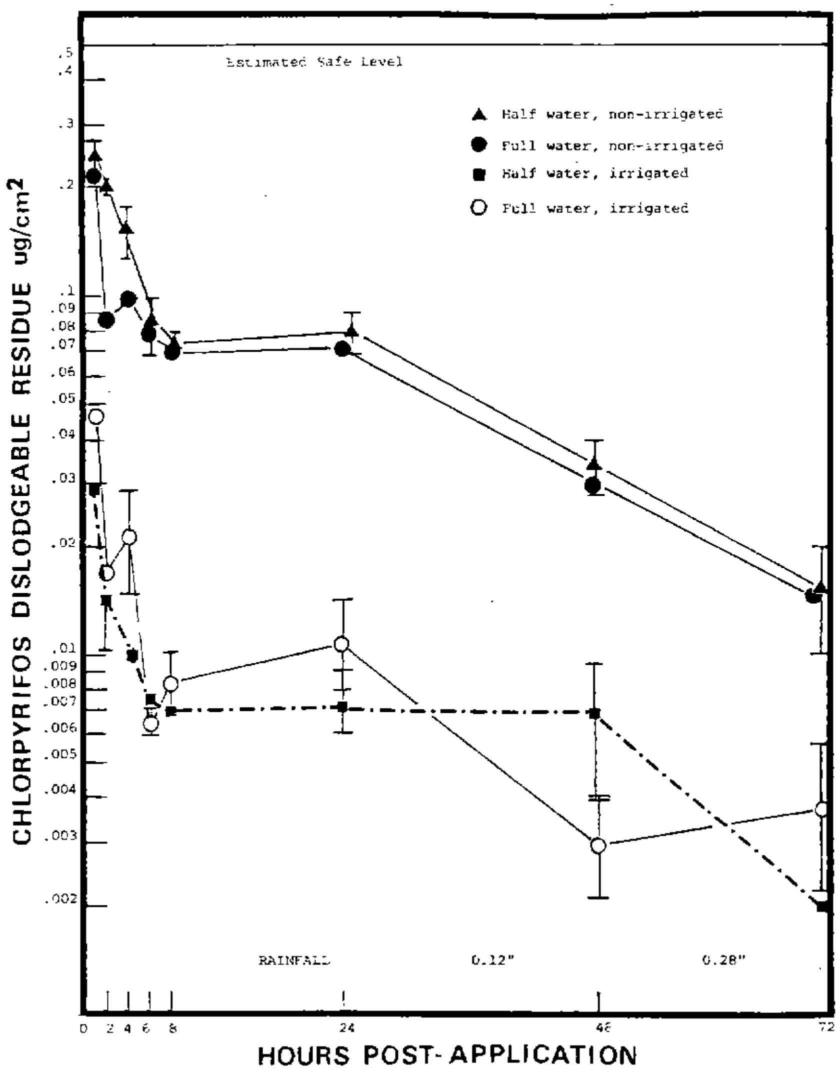

Figure 3. Dissipation of Chlorpyrifos (+ S.E.) as Measured from Total Leaf Surface Area of Clover and Fescue Lawn. Sacramento, California, November 1984

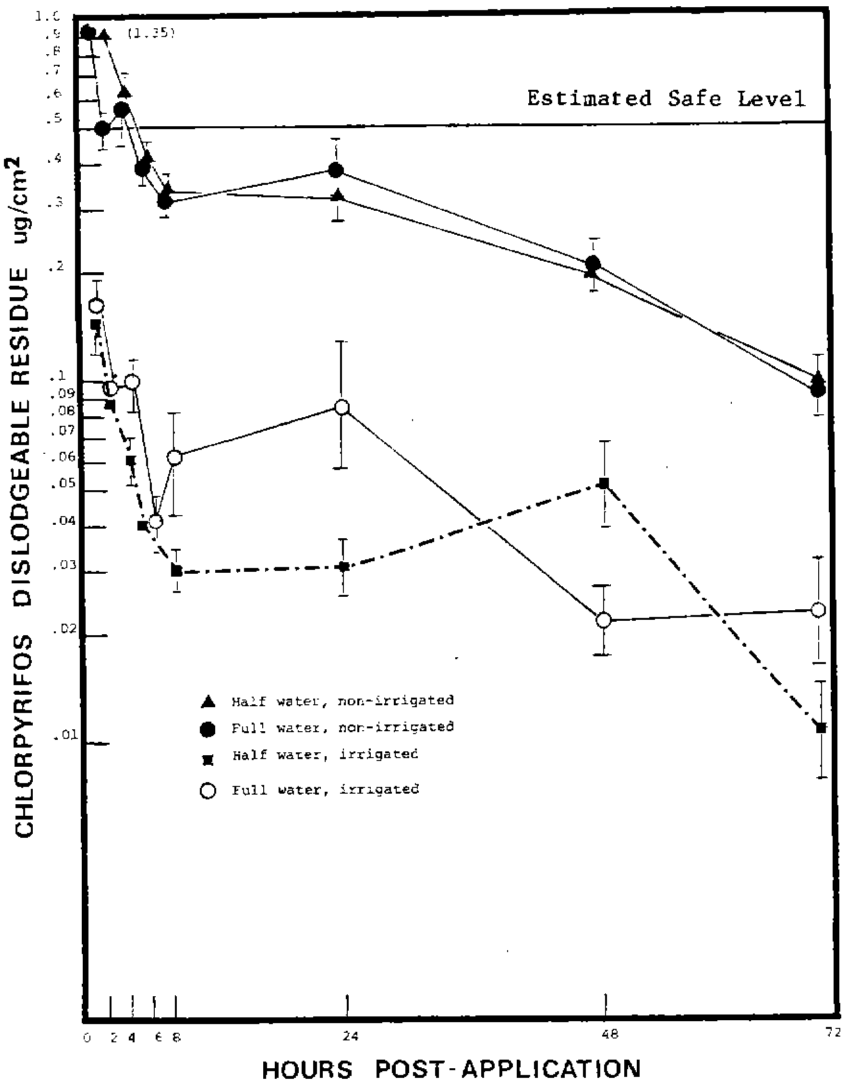

Figure 4. Dissipation of Chlorpyrifos (± S.E.) as Measured from 100 sq. cm. of Lawn Area of Clover and Fescue. Sacramento, California, November 1984

Dichloron (TM) needs to be investigated. There is also a need to adjust the safe level for repeated exposure to children from toxicants while playing or crawling on treated lawn.

Acknowledgments. The authors thank G.R. Tichelaar and D. Conrad for providing the lawn and facilitating residue analyses; D. Barbe for identification of grass species; W.G. Smith and D. Specker for review; and G. Wilson for word processing.

REFERENCES

Gaines TB (1960) The acute toxicity of pesticides to rats. Toxicol Appl Pharmacol 2:88-99.

Gaines TB (1969) Acute toxicity of pesticides. ibid. 14:515-534.

Goh KS, Edmiston S, Maddy KT, Meinders DD, Margetich S (1985) Dissipation of dislodgeable foliar residue of chlorpyrifos and dichlorvos on turf. Bull Environ Contam Toxicol (In press).

Iwata Y, Knaak JB, Spear RC, Foster RJ (1977) Worker reentry into pesticide-treated crops.. I. Procedure for the determination of dislodgeable pesticide residues on foliage. Bull Environ Contam Toxicol 18:649-654.

Knaak JB, Schlocker P, Ackerman CR, Seiber JN (1980) Reentry research: establishment of safe pesticide levels on foliage. Bull Environ Contam Toxicol 24:796-804.

Maddy, KT, Cusick WG, Edmiston S (1984) Degradation of dislodge able residues of chlorpyrifos and diazinon on turf - a preliminary survey. Cal Dept Food and Agric HS-1196.

Received August 9, 1985; accepted September 8, 1985.