Evaluation of Management Factors Affecting Volatile Loss and Dislodgeable Foliar Residues

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Goals:

- *The role of vapor pressure and temperature will be evaluated in terms of developing a screening system for turfgrass pesticides*
- *Pesticides with possible safety concerns will be further evaluated in the context of best management practices, including the role of spray volume and adjuvants.*
- *The role of thatch accumulation on the dissipation of volatile and dislodgeable residues will be assessed.*

Cooperators:

R. Cooper, NC State University
D. Haith, Cornell University

Volatilization can be a major route of pesticide loss following application to turfgrass. Consequently, a significant portion of applied pesticide may be available for human exposure via volatile and dislodgeable residues. In previous USGA-funded research carried out by this laboratory, volatile and dislodgeable residues were determined following application of triadimefon, MCPP, trichlorfon and isazofos to an established plot of PENNCROSS creeping bentgrass. For each application, a 10-meter radius plot was sprayed and the Theoretical Profile Shape (TPS) method was used to estimate volatile flux. Dislodgeable residues were concurrently determined by wiping treated turfgrass with a water-dampened piece of cheesecloth.

Less than 8% of the total applied triadimefon was measured as volatile residues with nearly all volatilization loss occurring within 5 to 7 days of application. Diurnal patterns of triadimefon volatilization were evident. Mid-day (11-1500 h) triadimefon volatile flux on Days 2 (4.6 g ha^{-2} h^{-1}) and 3 (2.4 g ha^{-2} h^{-1}) was 2 and 1.4 times, respectively, greater than the average of morning and late afternoon volatile flux on these respective days.

Less than 1% of the total applied MCPP was measured as volatile residue. Volatile MCPP residues decreased over time to non-detectable levels by Day 5. Both triadimefon and MCPP dislodgeable residues were greatest on Day 1 following application and dissipated over time. By

Day 5, triadimefon dislodgeable residues decreased to 0.04% of the initial residue level immediately following application and MCPP dislodgeable residues were non-detectable.

For trichlorfon and isazofos applications, less than 12% of applied insecticides were lost as measured volatile resides during the experimental sampling periods. Volatile loss declined in a diphasic pattern with most loss occurring within 5 to 7 days of application. Irrigation greatly reduced initial volatile and dislodgeable residues. Subsequent volatile and dislodgeable residues, however, increased substantially on Days 2 and 3 compared with residues levels in the absence of irrigation.

Trichlorfon dislodgeable residues never exceeded 1% of applied compound in the absence of irrigation, whereas with irrigation, trichlorfon and isazofos dislodgeable residues were never greater than 0.5% of applied compound. Irrigation increased the transformation of trichlorfon to DDVP, a more toxic insecticide.

Inhalation and dermal exposures were estimated using measured air concentrations and dislodgeable residues, respectively, and hazard quotients (HQs) were calculated for both volatile and dislodgeable residues of each pesticide. Exposures (i.e., doses) divided by reference doses (RfDs) resulted in hazard quotients (HQs). A HQ less than 1 indicated that the residue level is below a concentration that might reasonably be expected to cause adverse effects in humans.

Triadimefon and MCPP volatile and dislodgeable residues resulted in HQs below 1.0 throughout the entire 15-day experimental period, indicating that exposures were below any level expected to cause adverse health effects.

Calculated inhalation HQs for volatile residues were equal to or less than 1 for all sampling periods except Days 1 (HQ = 5.0), 2 (HQ =4.5) and 3 (HQ=1.5) following isazofos application. Calculated dermal HQs from dislodgeable residues were equal to or less than 1 for each sampling period except for DDVP on Day 2 (HQ = 4.6) when trichlorfon application was followed by irrigation, and on Days 2 (HQ = 14.3) and 3 (HQ = 5.7) following isazofos application.

This year, we have completed all the method development for the determination of 13 turfgrass pesticides in three separate multi-residue analyses. All experiments and field samples have been collected. A total of 13 separate experiments have been conducted and a total of 585 samples have been collected. Residue analysis of this sample set is 80% completed.

We have determined that the critical vapor pressure below which no turfgrass pesticide will volatilize to the extent that it results in an inhalation HQ greater than 1.0 to be between 3.3×10^{-6} to 5.6×10^{-5} mm Hg. We have determined the critical US EPA Office of Pesticide Programs RfD above which no turfgrass pesticide will result in a dermal HQ greater than 1.0 to be between 0.005 to 0.013.

We have collected appropriate weather data with this residue data set and have met with Dr. D. Haith, Department Agriculture Engineering, Cornell University, who has agreed to cooperate with us by modeling this data into a temperature-dependent algorithm that will determine the critical surface temperature below which no volatile turfgrass pesticide will result in an inhalation HQ greater than 1.0. This model will be available Spring/Summer 1997.

Two applications of the spreader/stricker adjuvant, Exhalt 800, have been made to determine if such ammedments can attenuate the exposure levels determined previously for the organophosphate insecticides. These data are currently being analyzed (residue data set 50% completed).

In summary, we have shown that organophosphate insecticides that possess high toxicity and volatility may result in exposure situations that cannot be deemed completely safe as judged by the US EPA Hazard Quotient determination. This assessment, however, must be viewed in terms of the assumptions that were used in making these estimations.

In all instances, maximum pesticide concentrations were used for the entire 4 hour exposure period, maximum rates for pesticide applications were used, and dermal transfer coefficients and dermal permeability factors were taken from non-turfgrass situations that are likely to exceed those that would take place on a golf course. Because of this, we view such estimates as worst case scenarios.

In order to more accurately predict the health implications of pesticide exposure to golfers, a relevant dosimetry evaluation of golfers, playing golf on a golf course, needs to be carried out. With more accurate exposure estimates, it is our belief that the exposure levels reported in this report will be found to be in excess of the true exposure to pesticides on a golf course.

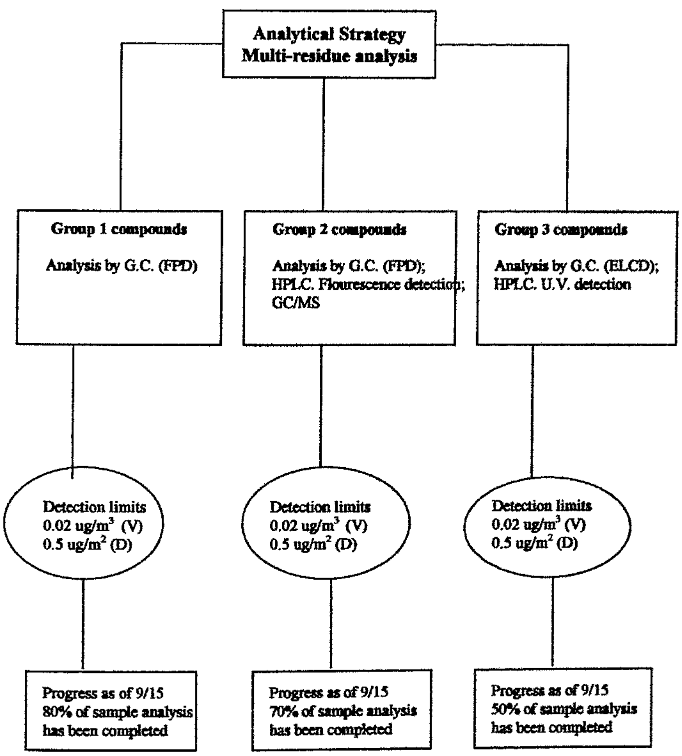

Figure 13. Analytical Strategy for multi-residue analysis. Group 1 includes ethoprop, diazinon, isazofos, chlorpyrifos and isofenphos. In Group 2 there are trichlorfon/DDVP, bendiocarb, carbaryl and cyfluthrin. Group 3 contains chlorothalonil, propiconizol, iprodione and thiophanate-methyl.

Table 9. Inhalation hazard quotients (IHQs) for turfgrass pesticides in the high, intermediate and low vapor pressure group.

Group	Pesticide	Day 1	Day 2	Day 3
		------------	IHQ[1]	------------
Group 1: high vapor pressure (i.e., vapor pressures > 1.0 x 10^{-5} mm Hg)	DDVP	0.06	0.04	0.02
	ethoprop	50.0	26	1.2
	diazinon	3.3	2.4	1.2
	isazofos	8.6	6.7	3.4
	chlorpyrifos	0.09	0.1	0.04
Group 2: intermediate vapor pressure (i.e., 10^{-5} mm Hg > vapor pressures > 10^{-7} mm Hg)	trichlorfon	0.02	0.004	0.004
	bendiocarb	0.02	0.002	0.002
	isofenphos	n/d[2]	0.02	n/d
	chlorothalonil	0.001	0.001	0.0003
	propiconazole	n/d	n/d	n/d
	carbaryl	0.0005	0.0001	0.00004
Group 3: low vapor pressure (i.e., vapor pressure < 10^{-7} mm Hg)	thiophanate-methyl	n/d	n/d	n/d
	iprodione	n/d	n/d	n/d
	cyfluthrin	n/d	n/d	n/d

[1]The IHQs reported are the maximum daily IHQ's measured, all of which occurred during the 11:00 a.m. to 3:00 p.m. sampling period.

[2] n/d = non-detect

Table 10. Dermal hazard quotients (DHQs) over a three-day post-application period for turfgrass pesticides listed by increasing RfD.

		Day 1			Day 2	Day 3
Pesticide	RfD	15 min.	5 hours	8 hours	12:00 p.m.	12:00 p.m.
ethoprop	0.000015	160	16.4	13.5	2.3	3.4
isazofos	0.00002	105	11.7	9.7	1.6	2.1
diazinon	0.00009	30	2.8	2.2	0.4	0.5
isofenphos	0.0005	3.2	0.5	0.5	n/d[2]	0.1
DDVP	0.0005	0.6	0.03	0.03	0.08	n/d
trichlorfon	0.002	6.4	0.07	0.09	0.03	0.05
chlorpyrifos	0.003	1.7	0.2	0.16	0.06	0.04
bendiocarb	0.005	3.1	0.06	0.1	0.005	0.008
propiconazole	0.0125	0.002	0.03	0.002	0.006	0.002
carbaryl	0.14	0.3	0.008	0.01	---	0.0002
cyfluthrin	0.25	---	---	---	0.004	---
iprodione	0.61	0.004	0.003	0.003	---	0.003
thiophanate-methyl	0.08	---	---	---	---	---

[1]--- = no data available at the time of this report.

n/d = not detected.