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Turfgrass Management Practices to Minimize Potential Volatile and Dislodgeable Foliar Residues following Pesticide Application

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Executive Summary

This ongoing study seeks the best management practices that reduce the potential for golfer exposure to volatile and dislodgeable foliar residues of turfgrass pesticides. Major routes of pesticide exposure for humans are primarily through inhalation and dermal penetration. Our past research has determined that pesticides with high vapor pressures and inherent high toxicities result in Inhalation Hazard Quotients (IHQs) and Dermal Hazard Quotients (DHQs) greater than 1.0, an action level for concern. Two approaches, the use of spray tank adjuvants and managing post-application irrigation levels, have been examined. During the 1998 growing season, the adjuvant, Silwet L-77, was applied to tank mixtures with the expectations of improving thatch penetration, suppressing volatilization and reducing dermal exposures. Three pesticides with high to intermediate vapor pressures (isofenphos, chlorpyrifos, and bendiocarb) were applied to small circular plots with or without the adjuvant. Two irrigation levels of 1.3 and 0.63-cm were applied to plots post-pesticide application. In 1999, the effect of irrigation levels was further examined at 0.63 and 0.32-cm following pesticide application at 1/2 and 1/4 the maximum label rates. Volatilization was measured with high volume air samplers using the Theoretical Profile Shape (TPS) method (1). Dislodgeable residues samples were collected by wiping treated turf-plots with dampened cheesecloth (2,4). The potential hazard associated with exposure to the volatile and dislodgeable foliar residues was determined by Inhalation Hazard Quotients (IHQs) and Dermal Hazard Quotient (DHQs) determination using the USEPA Hazard Quotient method (3).

For Day 1 volatile residues at 1.3-cm irrigation, the use of Silwet L-77 increased IHQ values for both chlorpyrifos and isofenphos. However at 0.63-cm irrigation, the use of adjuvant reduced IHQ values for chlorpyrifos and isofenphos. For bendiocarb, available residues were not affected by the use of the adjuvant in any of the situations examined.

For dislodgeable residues, Silwet L-77 increased DHQ values over time for all three pesticides at both 1.3 and 0.63-cm post-application irrigation. Only isofenphos exceeded DHQ values of 1.0 following the initial 15 min period post-application at both irrigation levels (value went below a DHQ of 1.0 by 5 hrs post-application at 1.3-cm, and 27 hrs post-application at 0.63-cm).

In summary, spray-tank adjuvants have not proven to be useful approaches for mitigating pesticide exposure situations following application to turfgrass. Management of post-application irrigation appears more useful particularly when used in combination with reduced rates of pesticides and in the presence of an extending use-type of adjuvant.

Specific Objective: Evaluation of selective turfgrass management practices to minimize potential volatile and dislodgeable foliar residues of turfgrass pesticides:

Objective 1: (Year 1, 1998)
Determination of volatile and dislodgeable foliar residues of organophosphorous (chlorpyrifos and isofenphos) and carbamate (bendiocarb) insecticides in the presence or absence of an organosilicone adjuvant, Silwet L-77, and at two levels of post-application irrigation (1.3 and 0.63-cm)

Objective 2: (Year 2, 1999)
Determination of volatile and dislodgeable foliar residues of organophosphorous (chlorpyrifos, isofenphos and trichlorfon) insecticides and a fungicide (triadimefon) under reduced pesticide label rates (1/2 and 1/4 full label rates) and with two levels of post-application irrigation (0.63 and 0.32-cm).

Work Completed (10/20/99):

The samples collected (310) during the summer of 98' (Objective 1) have been analyzed and results are tabulated for hazard quotient determination (see **Table 1** for Inhalation Hazard Quotients and **Table 2** for Dermal Hazard Quotients). Samples collected (180) during the summer of 99' (Objective 2) are currently being analyzed and will be completed by 1-15-00.

Results:

Volatile residues

At 1.3-cm post-application irrigation, the use of Silwet L-77 increased the Day 1 IHQ values for isofenphos and chlorpyrifos 2.1 and 1.6 fold, respectively, compared to treatments without adjuvant. At 0.63-cm irrigation, however, addition of the adjuvant reduced IHQ values for both isofenphos and chlorpyrifos by approximately 40 %. There were no appreciable differences in IHQ values from Days 2 and 3 with or without adjuvant.

The addition of Silwet L-77 has no effect on the availability of bendiocarb volatile residues at either level of irrigation or with presence or absence of adjuvant.

Nevertheless, IHQ values for these three pesticides never exceeded a value of 0.2 over the entire course of the experiment (1 week).

Dislodgeable residues

Generally, the addition of Silwet L-77 resulted in increased DHQ values over time for all pesticides tested, with a maximum increase (3.1 fold) determined for bendiocarb at 2 hrs post-application at 1.3-cm irrigation. Overall, the reduction of post-application irrigation from 1.3 to 0.63-cm resulted in increased DHQ values with and without adjuvant. Maximum DHQ values were always obtained at 15 min post-application in the presence of adjuvant and at 0.63-cm irrigation (isofenphos = 5.4, chlorpyrifos = 1.2, bendiocarb = 1.2). DHQ values exceeded 1.0 only for isofenphos application following the initial sampling period (15 min post-

application). DHQ values for isofenphos were below 1.0 by 5 hrs post-application at 1.3-cm irrigation, but did not go below 1.0 until 27 hr post-application at 0.63-cm irrigation.

In conclusion, the use of the spray-tank adjuvants has not resulted in the reduced volatile and dislodgeable foliar pesticide residues following application to turfgrass. In fact, adjuvants increase the dermal hazard by apparently holding more dislodgeable residues on the turfgrass blades over a large period of time.

Generally, reducing post-application irrigation from 1.3 to 0.63-cm reduced volatile residues as determined by IHQ values in the presence and absence of adjuvant but resulted in a substantial increase in dislodgeable residues as determined by DHQ values. The benefit of reduced levels of post-application irrigation (e.g., decreased volatilization of pesticide residues 2-3 days after application due to evapotransporation, decreased conversion of pesticides to more toxic, volatile and water soluble products, decreased potential for ground and surface water contamination, etc.) should be able to be achieved by applying reduced rates of materials (1/2 and 1/4 rates) in the presence of Silwet L-77, which should extend the effectiveness of lower applied amount of pesticides.

Table 1. Inhalation hazard quotients (IHQs) with or without adjuvant at two post-application irrigation levels of 1.3 and 0.63-cm.

Treatment		Inhalation Hazard Quotients [a]		
(Pesticide, Irrigation Level)		Day 1	Day 2	Day 3
Isofenphos, 1.3-cm	**Adj.[b]**	**0.19**	**0.02**	**0.01**
	No Adj.	0.09	0.01	0.01
Isofenphos, 0.63-cm	**Adj.**	**0.05**	**0.01**	**0.01**
	No Adj.	0.08	0.02	0.01
Chlorpyrifos, 1.3-cm	**Adj.**	**0.11**	**0.02**	**0.01**
	No Adj.	0.07	0.02	0.01
Chlorpyrifos, 0.63-cm	**Adj.**	**0.05**	**0.02**	**0.01**
	No Adj.	0.08	0.03	0.03
Bendiocarb, 1.3-cm	**Adj.**	**0.02**	**0.01**	**0.01**
	No Adj.	0.02	0.01	0.01
Bendiocarb, 0.63-cm	**Adj.**	**0.02**	**0.01**	**0.01**
	No Adj.	0.02	0.02	0.02

[a] The IHQs reported in Table 1 are the maximum IHQs measured on that sampling day.
[b] Adj. = Silwet L-77.

Table 2. Dermal hazard quotients (DHQs) over time with or without adjuvant at two post-application irrigation levels of 1.3 and 0.63-cm.

Treatment (Pesticide, Irrigation Level)		**Dermal Hazard Quotients** (Time, Post-Application)				
		15 min.	2 hrs	5 hrs	27 hrs	51 hrs
Isofenphos, 1.3-cm	**Adj.**[a]	**2.07**	**1.64**	**0.66**	**0.43**	**0.18**
	No Adj.	2.66	0.94	0.98	0.35	0.17
Isofenphos, 0.63-cm	**Adj.**	**5.42**	**2.39**	**1.65**	**0.69**	**0.25**
	No Adj.	3.29	1.71	1.37	0.27	0.20
Chlorpyrifos, 1.3-cm	**Adj.**	**0.69**	**0.32**	**0.22**	**0.10**	**0.04**
	No Adj.	0.61	0.25	0.21	0.10	0.05
Chlorpyrifos, 0.63-cm	**Adj.**	**1.23**	**0.37**	**0.28**	**0.15**	**0.06**
	No Adj.	0.95	0.30	0.28	0.07	0.10
Bendiocarb, 1.3-cm	**Adj.**	**0.79**	**0.44**	**0.32**	**0.29**	**0.43**
	No Adj.	0.40	0.14	0.30	0.16	0.05
Bendiocarb, 0.63-cm	**Adj.**	**1.23**	**0.37**	**0.28**	**0.15**	**0.06**
	No Adj.	0.95	0.30	0.28	0.07	0.10

[a] Adj. = Silwet L-77 adjuvant.

Methods and Procedure for Objective 2 (Year 2):

Formulations consisted of a total of 13.5 gallons of pesticide applied to circular, 10 m radius plots. Four applications were made and consisted of alternating between 1/2 and 1/4 the full pesticide label rates, with 0.63 or 0.32-cm post-application irrigation. The composition (1/2 and 1/4) of each tank mixture consisted of 10 fl. oz. / 5.0 fl. oz of Dursban Pro (chlorpyrifos), 5.6 fl. oz. / 2.8 fl. oz. of Oftanol (isofenphos), 0.47 lbs / 0.24 lbs of Dylox (Trichlorfon), and 0.25 lbs / 0.13 lbs of Bayleton (Triadimefon), per 15 gallons of water. A total of 180 samples were collected over the four sampling intervals.

Volatile and dislodgeable foliar residues from the treated plots were collected using high volume air samplers (Staplex) packed with XAD-4 resin (Rohm and Haas) and with dampened analytical grade cheesecloth, respectively. Both the resin and cheesecloth samples were solvent extracted and concentrated using a previous method (4), and freezer stored until analyzed.

The samples are analyzed using a Hewlett Packard 5890 gas chromatograph (GC) equipped with a mass selective ion detector. Previous research involved multiple analysis / instrumentation due to compound stability and specificity. The use of mass spectrometry has allowed the compounds to be analyzed simultaneously, making analysis cheaper and less time consuming.

Table 4. Sampling Schedule of Applications From 7/99 - 9/99

Volatile Residue Samples

Day 1		Day 2 & 3
0700-0800	Application	0700-1100
0800-0900	1st Air Sample	1100-1500
0900-1100	2nd	1500-1900
1100-1500	3rd	
1500-1900	4th	

Dermal Samples

Day 1	Day 2 & 3
0700-0800 Application	1200
0815 First Dermal Wipe	
1000 2 Hrs. Post Application	
1300 5 Hrs. Post Application	

Current Status:

Samples collected during the summer of 1999 are currently being analyzed and will be completed by 2-00. Summarization of the work over the past two years will be finished by 6-00 in a M.S thesis by S.A. Carrier.