ENVIRONMENTAL PERSISTENCE AND HUMAN EXPOSURE STUDIES WITH TURFGRASS PESTICIDES

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INTRODUCTION

Pesticide use can be an important component in well designed programs to maintain turfgrass in high use areas. However it is important to examine the persistence of any pesticides used if we are to understand and to minimize the chance for human exposure to these pesticides, particularly in public areas such as parks, school yards or sports turf situations.

HEALTH CONCERNS HAVE BEEN RAISED BY THE 2,4,5-T/2,4-D DEBATE

During the 1970's and 1980's, 2,4,5-T was one of the most controversial pesticides in wide use. Its use as a military defoliant in combination with laboratory studies which documented the teratogenicity of its dioxin contaminant (2,3,7,8-tetrachloro-di-benzo-p-dioxin) led to extensive debates on the safety of its use for brush control in North America and other parts of the world. Although regulatory agencies were steadfastly maintaining that proper use of 2,4,5-T (with non-detectable levels of dioxin) posed no unacceptable risk, industrial producers ceased production of 2,4,5-T in the mid-1980's. 2,4-D was not implicated in the original studies on the teratogenicity of phenoxy herbicides conducted in the early 1970's. Nevertheless, many of the concerns about 2,4,5-T and its dioxin contaminant were also raised about 2,4-D. This was particularly true in 1980, when chemists at Agriculture Canada found that some types of dioxins (but not the teratogenic 2,3,7,8-TCDD associated with 2,4,5-T) could be present as contaminants in some 2,4-D formulations. There was never any evidence that the less toxic dioxins in 2,4-D could cause health problems. However, federal regulations now prohibit the presence of detectable levels of any dioxins in 2,4-D products approved for sale in Canada.

It is often suggested that 2,4-D may be a potential carcinogen in animals or humans. However, such suggestions are not supported by animal-toxicology studies or by the balance of epidemiology studies of exposed human populations.

Despite all of the facts, the general public continues to be fearful of 2,4-D. The logical and correct reaction is that most people prefer to avoid exposure to 2,4-D or to any pesticide. Some municipal and school jurisdictions have banned the use of 2,4-D in public areas. Several provincial and state governments now require that some areas be posted with signs when treated with pesticides so that people can choose to avoid using the area and thereby minimize their own chances for exposure.

These concerns and questions led to a series of studies at the University of Guelph on the environmental persistence of 2,4-D and other pesticides used in turfgrass. Many of these studies were designed to aid in decisions on the type of action that would be most appropriate for minimizing human exposure in treated areas. Greater emphasis has been on studies of the persistence of dislodgeable 2,4-D and insecticide residues after applications to turfgrass. However, relevant studies have also been conduced on the persistence of 2,4-D or various insecticides in thatch, soil or water. The following is a summary of the main results from these studies.

ENVIRONMENTAL PERSISTENCE OF 2,4-D AND DICHLORPROP

Persistence of 2,4-D and Dichlorprop in Soil

The persistence of 2,4-D and dichlorprop under actual field conditions was determined in agricultural soils of northern Ontario (New Liskeard) and southern Ontario (Elora) by gas liquid chromatographic methods. Persistence of 2,4-D applied later in the season to a clay and a sandy forestry soil in northern Ontario (Englehart) was also examined. 2,4-D and dichlorprop were applied at typical field rates of 0.560 kg/ha (agricultural) and 2.24 kg/ha (forestry). Dissipation (degradation and/or disappearance) of 50% of the two herbicides took place in less than 7 days in all except the northern sandy forestry soil. In all cases, residues of 2,4-D or dichlorprop were below biologically active levels by the end of the season.

Persistence of 2,4-D in Water

In possibly a worst case scenario, the aquatic persistence of 2,4-D was examined in a naturally acid, bog lake (pH 4.5) in northern Ontario (Matheson). 2,4-D was applied as the isooctyl ester formulation at rates of 1.0 and 2.5 kg/ha to the water surface in replicated limno corral enclosures. The dissipation was relatively rapid and followed similar trends at both concentrations. Within 15 days, less than 5% of the applied amount was recovered in the water. Up to 25% of the applied 2,4-D became adsorbed (bound) to the polyethylene walls of the limno corral and lesser amounts were adsorbed to bottom sediments. After release to the water, these residues were subsequently degraded.

Persistence of 2,4-D on or in Turfgrass Foliage

In field studies with 2,4-D applied at 1 kg/ha, to turfgrass, only 5-6% of the applied amount could be dislodged at "0 time" by vigorous scuffling onto cheesecloth "booties" attached over rubber boots. Disappearance of dislodgeable residues was very rapid. Less than 0.1% of applied amounts could be dislodged by scuffling after 5 to 7 days. Mowing caused only a small reduction in dislodgeable residues. However, rainfall, even on the day of spraying, immediately reduced dislodgeable residues to less than 0.01% of the applied amounts. Granular formulations of 2,4-D (with fertilizer) were less dislodgeable than the same quantity of 2,4-D applied as a spray, particularly on the day of treatment. However when compared at recommended rates, which are higher for granular formulations of 2,4-D than for 2,4-D sprays, dislodgeable residues were quite similar. As application rates were increased, there was a more than proportional increase in the amount of 2,4-D that could be dislodged by physical scuffling, but this was true only on the day of treatment. From one day on, dislodgeable residues were similar on a percentage basis and in rates of disappearance for application rates of 1.0, 2,0 and 4.0 kg/ha. Dislodgeable residues of 2,4-D were higher and disappeared more slowly in indoor studies with plots of turf than in studies in outdoor field plots. Higher rates of degradation due to photolysis was a suspected explanation for the faster disappearance of 2,4-D on turf out of doors in the absence of rainfall. However, this could not be confirmed in outdoor studies with shaded versus unshaded turf.

Persistence of other herbicides used in turfgrass

Generally, very similar rates of disappearance were observed for other herbicides, such as mecoprop, or dicamba, when they were included with 2,4-D in studies of dislodgeable residues in turfgrass.

PERSISTENCE OF INSECTICIDES IN TURFGRASS

In field studies, diazinon was applied at 4.5 kg/ha to turfgrass. Immediately after application, 20 times more diazinon (1.2% vs 0.06%) was dislodgeable by physical scuffling from sprayed turfgrass than from turfgrass treated with diazinon as a granular formulation. However dislodgeable residues declined to less than 0.1% of that applied by 1 day after treatment, for sprays or granular treatments. Similar studies were conducted with chlorpyrifos and isofenphos. For these latter two insecticides, dislodgeable residues declined from 2.5% of applied at time of application to less than 0.25% of applied after one day. Residues in the thatch remained sufficiently high for control of insects for up to 7 days after application for diazinon and for up to 14 days after application of chlorpyrifos or isofenphos.

HUMAN EXPOSURE STUDIES

Numerous volunteers participated as commercial applicators, homeowner applicators, or bystanders in studies to estimate the levels of human exposure to 2,4-D as used for broadleaved weed control in turfgrass for residential or public areas. Commercial applicators supplied total urine samples for 14 days and other volunteers supplied total urine samples for the 4 day period following their single chance for 2,4-D exposure. All samples were analyzed for 2,4-D by gas liquid chromatography.

As expected, the commercial applicators who treated numerous residential lawns each day, had the highest average daily levels of 2,4-D in their urine. Their total body dose averaged 0.003 mg/kg (body weight)/day but the highest observed exposure was only 1/50 of the ADI (acceptable daily intake) for 2,4-D (0.3 mg/kg/day) as established by the World Health Organization. Unprotected (normal-clothing) homeowner applicators who had significant exposure to the liquid concentrate on their bare hands or to the diluted spray on their hands or forearms also had quantifiable levels of 2,4-D in their urine (the highest was approximately 1/100 of the ADI). However, only 2 of 10 homeowner applicators of the spray who wore protective clothing (coveralls, boots, gloves) had detectable levels of 2,4-D in their urine compared to 6 of 10 in the unprotected group. With normal or with protective clothing, only 1 in 10 homeowner applicators of granular 2,4-D/fertilizer formulations had detectable levels of 2,4-D in their 4-day total urine samples. At one hour after spraying 2,4-D in a park-like setting, 3 of 5 volunteers who were barefoot and wearing shorts had detectable levels of 2,4-D in their urine. (0.0003 to 0.001 mg/kg/day) as a result of alternately walking and sitting on the grass for one full hour. At this same time, there was no detectable exposure to 2,4-D for volunteers who were wearing shoes, socks and long pants. When "using the park for 1 hr", at 24 hrs after spraying, neither group had detectable levels of 2,4-D in their urine. In a total of 38 volunteers who were passive bystanders (residents in homes with treated lawns) for commercial or homeowner applications, there were none with detectable levels of 2,4-D in their urine.

SUMMARY

When turfgrass is treated with pesticides for weed or insect control, only very low percentages (1-6%) can be physically dislodged by vigorous scuffling with cloth covered boots immediately after treatment. Dislodgeable residues decline rapidly to well below 1% of applied within 1 day for the insecticides diazinon, chlorpyrifos or isofenphos and within 4 or 5 days for 2,4-D or related herbicides. Mowing the turfgrass does not markedly influence the disappearance of dislodgeable residues. At equivalent rates of active ingredient, granular herbicides or insecticides are less dislodgeable than liquid formulations of the same chemicals applied as sprays. However at the high rates usually recommended for 2,4-D applied as a fertilizer formulation, the dislodgeable residues were not lower. Irrigation or rainfall immediately reduced dislodgeable pesticide residues to negligible levels (less than 0.01%) even on the day of application. A light irrigation may even enhance the effectiveness of insecticides, particularly when they are applied as granular formulations. More research is needed to define the influence of irrigation at various times on the efficacy of granular or liquid herbicide applications in turfgrass. However it may be possible to recommend irrigation after 1 or more days to minimize the chance for exposure to pesticides in treated turfgrass areas.

In studies with 2,4-D, the highest observed exposures for homeowners and commercial applicators ranged from 1/100 (0.003 mg/kg body weight/day) to 1/50 (0.006 mg/kg body weight/day), respectively, of the ADI for 2,4-D as established by the World Health Organization. There were no detectable exposures for passive bystanders who resided in homes of homeowner or commercially treated lawns or for barefoot, barelegged bystanders who actively walked or sat on turfgrass for 1 hr on the day after spraying.

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