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Measurement of ATV Applicator Exposure to Atrazine Using an ELISA Method

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Recent public concern about pesticide use has focused on all phases of pesticide application. The majority of pesticides applied by the homeowner do not require certification for their purchase and inevitable use. However, the agricultural user may apply restricted use pesticides, perhaps with an all terrain vehicle (ATV) towed sprayer. Information concerning operator exposure is non-existent for ATV-towed sprayers, recently introduced for agricultural use and also available to the homeowner.

Atrazine is a triazine herbicide. Laboratory experimentation estimated the acute oral LD_{50} in rats at 5100 mg/kg. Dermal LD_{50} of rabbits is 9300 mg/kg. Acute inhalation LC_{50} for rats was >2.0 mg/L in 1 hr (WSSA, 1983). Atrazine is not classified as a highly toxic pesticide.

The objectives of this study were to determine 1) the level of dermal and respiratory exposure for a given sprayer operation using an ATV-type sprayer to apply atrazine; and 2) determine the feasibility of an ELISA method for detection atrazine exposure in the field.

MATERIALS AND METHODS

The personnel selected for this study were chosen based upon their willingness to participate and expertise in the operation of spray application equipment. All four subjects were males. Age, heights, and weights are summarized in Table 1. Note the subjects are all fairly uniform in age, height, and weight; all subjects were right handed.

The study was performed at the Ohio Agricultural Research and Development Center, specifically at a pesticide handling facility for proper handling and disposal of pesticides. Protective clothing worn by each subject consisted of coveralls made of DuPont Tyvec (Abanda coveralls, style 1412). Coveralls were changed after each operation. The order of operations that each

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subject performed was : 1) mixing-loading, 2) boom application and 3) spray gun operation. Gloves which extended to the mid-forearm and mid-calf boots made of butyl rubber were worn by each subject. Respirators were worn in which filter paper discs (#2 Whatman) were placed in the filter canister behind the insertion of filters (Willson Style R683).

Table 1. Subject personal data

Pertinent Data	Subject 1	2	3	4
Age	29	26	27	31
Height (cm)	175	190	190	172
Weight (kg)	61	68	70	72

The four subjects applied atrazine (4L) at 4.5 kg a.i./ha using a Ryan Manufacturing[1] ATV-Towed sprayer. The sprayer was equipped with a 3.65 m spray boom using 8003 XR[2] nozzles with 38 cm spacing and operated at 262 kPa. A 23L-7676 spray gun[2] with a 50cm wand was also operated at 262 kPa using an 8003 XR spray tip.

Sampling for residues consisted of cutting the suit off each individual and storing the respective sample at 0^{0} C in a plastic bag. The individual sampling areas were the chest, thighs, and forearms. Square patches (112 cm^2) were cut from predetermined areas of the spray suit (Popendorf, 1976). Since all subjects were right handed, only the right side of the spray suit was sampled to simulate a worst case scenario. Timed exposure period for each operation performed by a subject was 20 minutes.

Residue analyses entailed the use of Resi-Immune atrazine test kits[3]. Extraction of atrazine residues consisted of washing the filter paper discs and samples with 20% ethanol solution (Ferguson, personal communication[3]). A standard curve for the ELISA technique was used to determine the quantity (ug/cm^2) of atrazine residue. Dermal exposure was calculated by multiplying the residues of a given sample area by an area constant (Poppendorf, 1976). Inhalatory and dermal exposure are presented as ug/kg a.i. (Mull and M^{c}Carthy, 1986).

RESULTS AND DISCUSSION

Dermal exposure during mixing-loading operations was significantly greater than during booom operation of the ATV-sprayer (Table 2). However, spray gun was not significantly different to either boom operation or mixing-loading operations. No significant differences were observed among various operations (Table 2).

[1] Ryan Manufacturing, Box 239, Newark, IL.
[2] Spraying Systems Co., North Ave. at Schmale Rd., Wheaton, IL.
[3] ImmunoSytems, Inc., 8 Lincoln St. P.O. Box AY Biddeford, ME.

Table 2. Dermal and respiratory exposure (ug/kg a.i.) associated with mixing-loading, spray gun and boom operation

Operation	Dermal[1]	Respiratory
Mixing-Loading	272 a	12 a
Spray Gun	54 ab	4 a
Boom	3 b	11 a

[1] Means following the same letter within a column do not differ significantly at the p = 0.05 level using Duncan's New Multiple Range Test.

Exposure of thighs, chest and arms during mixing-loading, boom and spray gun operation are presented in Table 3. The specific area of greatest exposure risk was the forearm during the mixing-loading, which had significantly greater concentrations than all other sampling areas and operations (Table 3). Although significantly different from forearm exposure during

Table 3. Dermal exposure (ug/kg a.i.) of thighs, chest and arms during mixing-loading, spray gun and boom operation

Sampling Area/Operation	Dermal Exposure[1]
Thigh Mixing-loading	108 a
Chest Mixing-loading	33 a
Forearm Mixing-loading	686 b
Thigh Boom spraying	1 a
Chest Boom spraying	5 a
Forearm Boom spraying	4 a
Thigh Spray gun	0 a
Chest Spray gun	1 a
Forearm Spray gun	161 b

[1]Means following the same letter within a column do not differ significantly at the p = 0.05 level using Duncan's New Multiple Range Test.

mixing-loading, exposure of the forearm exposure during operation of the spray gun had the next highest risk of exposure. This agrees with other studies, that the greatest exposure risks occur during mixing-loading (Abbott et al. 1987; Wolfe et al. 1967).

The hazards that may result from dermal and respiratory exposure were compared to LC_{50} and LD_{50} studies in rats and rabbits respectively. The amount of atrazine required to obtain the inhalatory LC_{50} in rats, >2 mg/kg would be approximately 222 times greater than the mean of the respiratory values in Table 2.

The atrazine (4L) concentration equivalent to the LD_{50} dermal of 9300 mg/kg in rabbits would need to be approximately 34,000 times greater than was present during the mixing-loading operation (Table 2).

The use of ELISA based sampling kits for pesticide residue analysis is not new (Bushway et al. 1988). However, as costs increase and time becomes an increasingly important factor, ELISA based residue analyses will become more attractive. For example, in Table 4 we compared the efficiency of the ELISA based technique to other analytical methods such as GLC and HPLC. Note the greatest savings were sue to elimination of cleanup steps and lower capital costs for instrumentation (HPLC and GLC vs Spectrophotometer). Other workers have reported similiar findings (Wie and Hammock, 1982; Newsome and Shields, 1981) that ELISA based assays are very cost effective. Further, savings in sample storage costs could be realized since ELISA techniques are more adaptable to field use. Such a system is adaptable to a variety of situations, particularly those that might be encountered when obtaining data for an exposure study.

Table 4. Comparison of HPLC, GLC and immunoassay operation costs

Method	Clean up Steps	Assays per man-day	Instrument Cost Outlay	Sensitivity Limit	Sample Size
GLC	6	8	>$20,000	100 ppb	50 ml
HPLC	4	12	>$20,000	50 ppb	250 ml
Immunoassay	0	>50	<$20,000	1 ppb	10 ml

In conclusion, the results of this study indicate applicator personnel are exposed to very low concentrations of atrazine when applied with an ATV-towed sprayer. Although exposure time was 20 minutes and assuming an operator applied atrazine for eight hours,even the 24x fold increase in dermal and respiratory exposure would be low. However, unless operators exercise extreme caution when working with a pesticide, some degree of pesticide exposure is inevitable. The potential use of ELISA based, pesticide detection kits is plausible for in field detection of pesticide residues, especially for rapid detection of potential exposure hazards.

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