Bull. Environ. Contam. Toxicol. (1987) 38:277–282

Environmental Contamination and Toxicology

Insecticide Residues on Clothing Worn by Crop Consultants in Soybean Fields Treated with Non-Conventional Application Technology

Rinn M. Cloud,[1] Mary L. Zimpfer,[1] Jaime Yanes, Jr.,[2] David J. Boethel,[3] Steven M. Buco,[4] and Claire W. Harmon[5]

[1]School of Home Economics, [3]Department of Entomology, [4]Department of Experimental Statistics, and [5]Feed and Fertilizer Laboratory, Louisiana Agricultural Experiment Station, Louisiana State University Agricultural Center, Baton Rouge, Louisiana 70803 and [2]Cooperative Extension Service, University of Tennessee, Nashville, Tennessee 37222

Previous research has established that the principal means of pesticide exposure is dermal (Wolfe et al. 1966) and that clothing serves with varying degrees of success as a barrier to dermal exposure (Davies et al. 1982a, Lillie et al. 1981). Various research methods and research designs have been used in attempts to quantify the degree of dermal exposure and clothing contamination of individuals in various situations but much remains to be done (Nigg and Stamper 1985). Numerous variables must be considered in exposure studies including type of pesticide and pesticide formulation, method of application and type of exposure, and type of clothing worn.

Type of pesticide used is dependent upon crop and field conditions. Exposure research in various areas of the country focuses on pesticides commonly used on the important crops in the area (Easter and DeJonge 1985, Kim et al. 1982). In Louisiana, greater than 800 thousand hectares a year are planted in soybeans. In recent years, the synthetic pyrethroids, permethrin and fenvalerate, have been used on this crop. And, interest in non-conventional aerial application methods such as ultra-low-volume (ULV) oil sprays using vegetable oil carriers and water-oil mixtures as pesticide carriers has increased.

Pesticide formulation has been shown by Easley et al. (1981) to affect ease of removal of pesticide residues by laundering. Their research indicated that emulsifiable concentrates were more difficult to remove from contaminated denim work clothing than wettable powder or enscapsulated formulations. The researchers suggested the results were related to the emulsifiable concentrate being an oil-based product. The use of ULV-oil spray techniques where pesticide is mixed with vegetable oil rather than water for aerial application may also affect levels of contamination of clothing.

Studies of pesticide contamination of clothing have considered three situations in which exposure may occur. Mixer/loaders may

Send reprint requests to R. Cloud at the above address.

encounter direct spills of undiluted pesticide on their clothing (Easley et al. 1982). Applicators may be exposed to the pesticide in spray form as it comes from some type of spray mechanism (DeJonge et al. 1985). In the third situation, harvesters and other field workers encounter pesticides as they work in treated fields or orchards (Finley and Rogillio 1969). It is the third type of exposure which is most difficult to simulate in a laboratory. Transfer of pesticide from plant foliage or soil to the clothing of a field worker will vary with the type of activity in which the worker is engaged. The expense and time involved in conducting field studies have limited the amount of information available regarding contamination of clothing worn into fields after pesticide treatment.

Davies et al. (1982b) found that cotton twill work clothing provided measurable protection for workers applying ethion in citrus groves. Orlando et al. (1981) found that a spun bonded olefin fabric gave better protection against penetration of pesticide than denim or chambray fabrics. The fabrics were tested in a laboratory spray chamber designed to simulate exposure to an air blast sprayer. Little is known about the comparative performance of standard work clothing and nonwoven protective clothing when worn into treated fields. The purpose of this study was to determine the effects of non-conventional application technology (ULV-oil, water + oil), soybean insect sampling methods (sweep net, ground cloth), and the type of work clothing (twill weave, nonwoven) on the levels of pesticide residues absorbed by clothing worn into soybean fields treated with permethrin.

MATERIALS AND METHODS

Experimental soybean fields were aerially sprayed with one of three treatments: (1) permethrin 0.084 kg AI/ha applied ULV in soybean oil at 0.95 l/ha finished spray rate; (2) permethrin 0.084 kg AI/ha applied in water (approximately 2.84 l) plus soybean oil surfactant (approximately 0.95 l) at 9.35 l/ha finished spray rate, and (3) permethrin 0.084 kg AI/ha applied in water at 18.70 l/ha finished spray rate. Equal-sized plots were sprayed using the three treatments in a randomized block design with four replications.

Two types of protective coveralls were used: (1) a standard work coverall sold by a major department store chain, made of a 35% cotton/65% polyester twill weave fabric; and (2) a nonwoven disposable garment produced by Dupont from Tyvek®, a spunbonded olefin. Under the suits, jersey knit white T-shirts of 100% cotton were worn.

Four individuals entered plots 48 hours after spraying and conducted insect counts using either a sweep net method or a ground cloth method. A sweep net sample consisted of 50 sweeps with a 38 cm diameter sweep net so that the opening of the net passed through the foliage with each step (Kogan and Pitre 1980).

The ground cloth sample consisted of placing a 91 cm length sheet between two adjacent soybean rows and forcefully displacing the insects by shaking the plants over the sheet (Boyer and Dumas 1963). Immediately after sampling, the plots were vacated and the suits and T-shirts removed. They were wrapped in aluminum foil, placed on ice and transported to the laboratory where they were held in a freezer until residue analysis was performed.

Specimens measuring 130.6 cm^2 were taken from the thigh, arm, and chest of each suit and from the arm and chest of each T-shirt for residue analysis. All specimens were taken from the right side. Cis and trans permethrin were extracted from the fabric specimens using hexane and were analyzed on Perkin Elmer 3920 and Hewlett Packard 5880A gas chromatographs equipped with Nickel 63 electron capture detectors. Quantification of permethrin residues was conducted on a 180 x .4cm glass column packed with 15% QFI/10% DC200 on Gas ChromQ 80/100 mesh held isothermally at 230°C oven temperature, 230°C injection temperature, and 300°C detector temperature with 80ml/min flow rate of 5% methane in argon carrier flow. Confirmation of residues were done on 120 x .2 cm glass column packed with 5% OV210 on Chromosorb W(AW-DMCS) 100/120 mesh held isothermally at 210°C oven temperature, 210°C injection temperature, and 350°C detector temperature with a flow rate of 60ml/min of pre-purified nitrogen. Concentrated samples were calculated using the peak height measurements of standard and samples. Data were analyzed using analysis of variance.

RESULTS AND DISCUSSION

No permethrin was detected by gas chromatography in extracts from T-shirt specimens or from arm and chest specimens of suits. Measurable residue was detected only on leg specimens. These results support earlier studies indicating that the transfer of insecticide from foliage to clothing worn by field workers occurs to the greatest degree on the lower torso and leg areas (Finley et al. 1979). It was expected that the ground cloth method of insect collection would give measurable residue on the arms and chests of garments since these areas would come in direct contact with foliage. However, each suit was exposed only about 10 minutes, and it is unknown whether wearing a suit for longer periods of time while repeating field procedures might have produced measurable residue. The barrier effects of frequently replacing articles of clothing while conducting field work has not been studied.

Residue data for all leg specimens were analyzed to determine effects of field treatment, suit type, and method of insect collection. Total permethrin (cis and trans) levels ranged from less than 10 ng/cm^2 to almost 200 ng/cm^2. Recovery rates of 83% or better were obtained by the extraction procedure. The actual amounts of residue obtained were not of as much interest to researchers as were the factors affecting the amount of residue. Since permethrin has a relatively low toxicity level for mammals,

the actual amount extracted from any given specimen represents very little hazard.

Table 1 gives mean permethrin levels for the two types of suits by method of insect collection and by field treatment. No variable was found to be significant ($P<0.05$), although field treatment was approaching significance.

Table 1. Mean Permethrin Residues in Leg Specimens of Suits By Method of Insect Collection and Field Treatment.

		Mean Residue (ng/cm^2)		
Suit	Method	Water	Mix	Oil
Twill	Sweep	46.8	60.9	38.3
Twill	Ground cloth	14.3	15.3	55.4
Nonwoven	Sweep	30.8	23.8	81.6
Nonwoven	Ground cloth	64.1	29.2	92.0

As shown in Table 2, mean residues of all specimens by field treatment indicate a tendency toward higher absorption of permethrin from ULV-oil sprayed fields than from water or mixture (oil + water) sprayed fields. This tendency is not unexpected since polyester and olefin fibers are oleophillic and hydrophobic by nature.

Table 2. Mean Permethrin Residues in Leg Specimens by Field Treatment.

	Mean Residue (ng/cm^2)		
Field Treatment	Cis	Trans	Total
Water	17.8	21.3	39.0
Mix	16.4	15.8	32.3
Oil	32.7	34.8	66.8

Statistical analysis showed no significant difference in residue by type of suit. However mean permethrin residue in the twill suit specimens was 38.5 ng/cm^2 as compared to a mean of 53.6 ng/cm^2 in the nonwoven. While level of residue in the fabric does not indicate degree of penetration, it does have implications for

the degree of hazard associated with continued contact with the pesticide by wearing the fabric.

Method of insect collection was not a significant variable and mean permethrin residues for specimens exposed to each method were very similar (sweep--47.0 ng/cm^2, ground cloth--45.0 ng/cm^2). It was not expected that method of insect collection would affect residue on leg specimens since much of the transfer of residue to the leg areas of clothing occurred while individuals were walking into and out of fields.

These results suggest that crop consultants' activities in aerially-sprayed permethrin-treated fields lead to measurable levels of insecticide on the leg portions of garments. Further studies are needed to determine if longer exposure times would result in measurable residue on the upper torso garment areas.

Further research is also needed to determine the effects of ULV oil spray techniques on fabrics of other fiber contents and fabric construction.

Acknowledgements. This research was funded by the Southern Region Pesticide Impact Assessment Program and the American Soybean Association. We wish to acknowledge the assistance of Jose Motz and Blake Layton. Soybean oil was supplied by LouAna Foods, Opelousas, LA, soybean oil surfactant by Stoller Chemical Co., Inc., Houston, TX, and Tyvek® coveralls by Dupont.

REFERENCES

Boyer WP, Dumas WA (1963) Soybean insect survey as used in Arkansas. Coop Econ Insect Rep. 13:91-92

Davies JE, Freed VH, Enos HF, Duncan RC, Barquet A, Morgade C, Peters LJ, Danauskas JX (1982a) Reduction of pesticide exposure with protective clothing for applicators and mixers. J Occ Med 24(6):464-468

Davies JE, Enos HF, Barquet A, Morgade C, Peter LJ, Danauskas JX, Freed VH (1982b) Protective clothing studies in the field: an alternative to reentry. In: Plimmer JR (ed) Pesticide residues and exposure. American Chemical Society, p.169

Easley CB, Laughlin JM, Gold RE, Tupy DR (1981) Methyl parathion removal from denim fabrics by selected laundry procedures. Bull Environ Contam Toxicol 27:101-108

Easley CB, Laughlin JM, Gold RE, Hill RM (1982) Laundry factors influencing methyl parathion removal from contaminated denim fabric. Bull Environ Contam Toxicol 29:461-468

Easter EP, DeJonge JO (1985) The efficacy of laundering captan and Guthion® contaminated fabrics. Arch Environ Contam Toxicol 14:281-287

Finley EL, Rogillio JRB (1969) DDT and methyl parathion residues found in cotton and cotton-polyester fabrics worn in cotton fields. Bull Environ Contam Toxicol 4:343-351

Finley EL, Graves JB, Morris HF, Harmon C, Iddings FA, Schilling PE, Koonce KL (1979) Reduction of methyl parathion residues on clothing by re-entry and laundering. Bull Environ Contam Toxicol 22:415-422

Kim CJ, Stove JF, Sizer CE (1982) Removal of pesticide residues as affected by laundering variables. Bull Environ Contam Toxicol 29:95-100

Kogan M, Pitre, Jr. HN (1980) General sampling methods for above ground populations of soybean arthropods. In: Kogan M, Herzog DC (eds) Sampling methods in soybean entomology. Springer-Verlag, New York

Lillie TH, Livingston JM, Hamilton MA (1981) Recommendations for selecting and decontaminating pesticide applicator clothing. Bull Environ Contam Toxicol 27:716-723

Nigg HN, Stamper JH (1985) Field studies: methods overview. In: Honeycutt RC, Zweig D, Ragsdales N (eds) Dermal exposure related to pesticide use. American Chemical Society, p.95

Orlando J, Branson D, Ayers G, Leavitt R (1981) The penetration of formulated Guthion® spray through selected fabrics. J Environ Sci Health B16, 5:617-628

Wolfe HR, Armstrong JF, Durham WF (1966) Pesticide exposure from concentrate spraying. Arch Environ Health 13:340-344

Received March 18, 1986; accepted July 25, 1986.