United States
Environmental Protection
Agency

Water Engineering
Research Laboratory
Cincinnati OH 45268

Research and Development

EPA/600/S2-88/033 Sept. 1988

EPA

Project Summary

Pesticide Exposure to Florida Greenhouse Applicators

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The exposure of pesticide applicators in a commercial greenhouse facility was assessed. Data were collected primarily from five handgunners and a tractor driver. A drencher was also monitored on one occasion, as was one of the handgunners when acting as an assistant to another handgunner. The chemicals applied were fluvalinate, chlorpyrifos, ethazol, dicofol, captan, and chlorohalonil. Potential exposure was assessed with exposure pads placed outside all clothing of the applicator. Handwashes and air samples, as well as pre- and post-exposure tank mixture samples, were also collected. Pesticide penetration was measured with exposure pads placed inside protective clothing.

It was found useful in this study to normalize all exposure assessments for spray rate. This done, handgunner exposure increased with increasing fineness of the spray leaving the nozzle; the tractor driver was much less exposed than the handgunners. Ethazol penetrated Tyvek™* more than any other compound tested.

This Project Summary was developed by EPA's Water Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The exposure of greenhouse applicators is of current regulatory interest to the U.S. Environmental Protection Agency. The U.S. EPA is specifically faced with the task of (1) assessing the potential pesticide exposure of greenhouse applicators and (2) suggesting protective clothing that is both effective and comfortable. This study is a first step toward providing the data necessary for evaluations by the U.S. Environmental Protection Agency, the greenhouse industry, and pesticide manufacturers.

This study was conducted in 1985-86 at a commercial greenhouse facility in west-central Florida. The facility, devoted primarily to growing chrysanthemums and African violets, occupied three locations: at Parrish, FL, and Palma Sola, FL, where handgunners were monitored, and at Cortez, FL, where a tractor driver was monitored.

Data were collected from five handgunners who sprayed with either a fine spray, a coarse spray, or pulse fogging device; the tractor driver who pulled either a boom sprayer or a span sprayer; a drencher; and one of the handgunners when acting as an assistant to a fine spray handgunner. The chemicals applied were fluvalinate, chlorpyrifos, ethazol, dicofol, captan, and chlorothalonil.

The questions this study addressed were the following: (1) What is the potential for dermal exposure to greenhouse pesticide applicators? In other words, at what rate would pesticide accumulate on the body of an applicator, unprotected by clothing of any kind? We term this "estimated total body accumulation rate" (ETBAR) and measure it in μg/hr. Also, does the ETBAR depend upon the rate of pesticide leaving the spray nozzle, the kind of pesticide applied, the method of application (including type of nozzle), and/or the individual work habits of the applicator? (2) How is the ETBAR distributed over the anatomy of the applicator and upon what parameters does this distribution depend? (3) What is the accumulation rate of pesticide on the hands of applicators? Is there a relationship be-

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

tween worker hand preference (right or left) and exposure to the right and left hands? Does hand exposure depend upon the pesticide effluent rate, compound applied, application method, and/or individual work habits? (4) What is the atmospheric contamination of the pesticide in the breathing zone of the worker as he applies the compound? Does it depend upon the compound, its effluent rate, or the application method? (5) What is the penetration of pesticide through the various types of protective clothing worn by applicators? Does penetration depend upon the compound? (6) How do samples of the spray mixture, taken pre- and post-application, compare in pesticide concentration with that presumed to exist in the tank based on the mixture recipe and an assumption of thorough mixing?

The complete report addresses all of the questions. This summary addresses the most salient of them.

Procedure

Seven subjects were chosen for this study on the basis of their willingness to participate and the frequency with which they applied compounds our laboratory was capable of analyzing. They were instructed to change no aspect of their normal application routine and to wear only their usual protective clothing. Four subjects were male, three were female, and they ranged in age from 23 to 44 years. Their heights and weights were recorded, from which their total body surface areas were estimated. The hand preference of each was recorded.

Four of the workers normally sprayed with a Cornel™ handgun equipped with a 6-nozzle head and attached with a long hose to a Myers Du-All Spray Pump™ and an open, 60-gal, cylindrical tank. The spray mixture, sometimes containing several pesticide, fungicide, fertilizer, etc. compounds, was discharged from the nozzles as a fine, nearly misty, spray. These workers usually sprayed in completely enclosed greenhouses. They usually wore hooded coveralls, gloves, boots, goggles, an apron, and a respirator. Coveralls and hoods were made from Dupont Tyvek™ and covered all of the body surface except the face, hands, and feet. Both coveralls and hoods were disposable and changed between applications. Gloves, extending to mid-forearm; boots, extending to mid-calf; and bibbed aprons, extending from mid-chest (or waist, if the bib was not raised) to the ankle, were all made of butyl rubber. Ends of the gloves were not sealed. Goggles covered the eyes; respirators covered the nose and mouth. During pulse fogging, the respirator was replaced by a canister chin-style gas mask.

Another worker sprayed using an enclosed, 300-gal tank with a handgun, equipped with a single adjustable nozzle set to provide a coarser spray. He usually applied in an open-sided structure with a translucent roof. His usual protective clothing consisted only of an apron and boots.

The sixth subject drove a tractor that usually pulled a boom sprayer with an enclosed 300-gal tank; however, for several sampling periods he pulled a span sprayer. He applied in an open-sided structure covered on top with Siran™ a fine net-like fabric used to attenuate sunlight intensity in an otherwise completely open environment. He wore no protective clothing but did use a respirator.

One exposure was taken from the seventh subject as she drenched. Drenching was done with a nozzle that gave a low pressure, coarse spray pattern not unlike what an ordinary sprinkling can would provide. It was done in an entirely enclosed greenhouse. She wore gloves, boots, an apron, and a respirator.

Pulse fogging was occasionally practiced by the fine spray handgunners in their enclosed greenhouses. The pulse fogging device (Dramm International Inc. Pulsfog™, Style K-6005) had an enclosed, 8-gal tank and produced a misty (droplet size advertized at 0.03 mm) spray from a single nozzle.

Applicators mixed and loaded their own tanks.

Potential dermal and respiratory exposure was estimated according to the procedure described by Durham and Wolfe (Bull. Wld. Hlth. Org. 26:75-91, 1962). Exposure pads were placed on the subjects as follows: the middle of the back, the chest, the top of each shoulder, each forearm, each thigh, and each shin. These pads were entirely exposed, not covered by protective gear of any kind. If an apron or boot covered any of the above sites, pads were placed on the outside of the apron or boot at the same level as described above. Left and right pairs of outside pads (shoulders, forearms, thighs, and shins) were combined for extraction and analysis. Timed exposure periods were at the convenience of the subject but generally lasted about 30 min. The analytical results for pesticide compound, uncorrected for recovery, divided by the pad area (one or two pads) and exposure time, give the pad fluxes. The ETBAR was calculated from the outside pad fluxes as follows. Estimated fractional body surface areas were allotted to the head and neck, front torso, back torso, arms, upper legs, and lower legs using the proportions proposed by U.S. Environmental Protection Agency, which are sex-specific. Accumulation rates to the arms, for example, are the product of the estimated total body surface area, the arms fraction (14.1% male, 14.0% female), and the outside forearm pad flux. In the same way, upper leg accumulation rates were estimated from thigh pad fluxes, lower leg rates from outside shin pad fluxes, back torso rates from outside back pad fluxes, and front torso rates from outside chest pad fluxes. The head-neck accumulation rate was similarly derived, with the flux estimated from the average of the outside chest, the outside back, and twice the outside shoulder fluxes. These various accumulation rates were then summed to obtain the ETBAR. Handwash accumulation rates were included only if the subject wore no hand protection. The hands' contribution can then be regarded as truly exterior and, therefore, on the same footing as outside pads; otherwise, handwashes are omitted from the ETBAR. As a practical matter, ETBAR's were not much influenced by the inclusion or exclusion of handwashes. The atmospheric pesticide contamination is given and is based upon a 3 L/min intake of air by the personal air sampler. This air sampling device is designed to collect primarily vapor and does not discriminate among particle sizes. Tank mixture samples were taken pre- and post-application: directly from the tank for the tractor driver and the coarse spray handgunner, and from the handgun itself for the other applicators.

Inside pads were used only for those subjects who wore protective gear. Inside pads were placed immediately inside the coverall just beneath, but not overlapping, the outside pad at the following positions: chest, both forearms, both thighs, and both shins. While outside pads were without exception always exterior, inside pads were occasionally protected by more than the coverall: either by a rubber apron at the chest and thighs or by rubber boots at the shins. If no coverall was worn, inside pads were protected only by the apron or boots. Left and right pairs of inside pads (forearms, thighs, and shins) were combined for extraction and analysis.

Pads, handwashes, and air sampler plugs were extracted with hexane (or a 70% hexane-30% acetone mixture, for dicofol only) and brought from near dryness to a 10 mL volume with hexane (2,2,4-trimethylpentane, for dicofol only).

All analyses were done by gas chromatography using electron capture Ni^{63} detection.

Results and Discussion

Each exposure was an experiment unto itself—variations existed in compounds, compound spray rates, exposure times, application methods, subjects, etc. No exposure constituted a true replication of any other exposure because of these confounding variables that were not under our experimental control. Any grouping of data, therefore, is somewhat artificial. Yet, in order to draw any general conclusions, some grouping of data into classes was required. Happily, in practice, there was little variation in presumed spray rate (kg active ingredient/hr) from applicators' spray nozzles when a given subject applied a given compound by a given method. This suggested grouping all such individual exposures together into subgroups, each subgroup corresponding to a given subject/compound/application method, for which the spray rate varied little from application to application. The phrase "presumed spray rate" suggests some ambiguity and derives from our observation that thorough mixing of compound was not usually accomplished in the spray tank. Table 1 gives the pre- and post-spray tank mixture analyses for concentration, expressed as percentages of the presumed concentration. While no statistical difference existed between the pre- and post-spray samples, the data showed that for chlorpyrifos, ethazol, and captan (all formulated as wettable powders), less than half of the compound presumed to be leaving the spray nozzle, actually was. This circumstance was less pronounced for fluvalinate and dicofol (both formulated as emulsifiable concentrates) and entirely absent with chlorothalonil, a wettable powder that unaccountably appeared to be well-mixed. It is, of course, possible that losses of compound from the tank mixture samples occurred during storage prior to their being analyzed and that the discrepancy we appear to have detected between the tank mixture recipe and the tank mixture itself is spurious. With this digression as a caveat, we return to our grouping scheme, whereby all exposures of a given subject spraying a given compound by a given method are combined.

This done, it was then evident that significant differences in mean ETBAR, handwashes, and air samples existed between subjects applying the same compound by the same method. These differences were not surprising, given the fact that mean spray rates also varied among subjects. There was a general tendency, by no means without exception, that when large differences in these exposure parameters occurred, they were explainable on the basis of mean presumed spray rate differences. This effect was tested by obtaining correlation coefficients between mean spray rate and ETBAR, handwash, and air sample data for each of the five work practices (drencher and assistant excluded). Of the 15 correlation coefficients, 13 were positive and averaged 0.629. Consequently, these three exposure parameters were all normalized for (divided by) spray rate. What resulted was a measure of "mg-deposited/kg-sprayed," the time units having cancelled out. These normalized mean values then did not differ significantly among subjects within a given compound/application-method class, and subjects were, therefore, combined in Tables 2 through 4. This non-significance among subjects was confirmed with an ANOVA (analysis of variance) at $p < 0.05$. Left and right mean handwash data also showed no significant differences ($p < 0.05$) throughout and were summed to give "total mean handwash" prior to the ANOVA and their inclusion in Tables 2 through 4.

To determine whether differences exist among compounds for the various normalized parameters and application methods given in Tables 2 through 4, a Duncan's Multiple Range Test ($p < 0.05$) was applied to each of the pesticide groups. The few significant differences that were found are presented in Table 5. The analysis summarized in Table 5 shows that fine spray and pulse fog handgunners were at significantly ($p < 0.05$) more risk to normalized ETBAR (NETBAR) contamination by fluvalinate than from the other compounds tested. The coarse spray handgunner and the span spray tractor driver, both of whom also sprayed fluvalinate, were significantly more at risk to NETBAR contamination from chlorothalonil and chlorpyrifos, respectively. Regarding normalized handwash contamination, the boom spray tractor driver was significantly more at risk from chlorpyrifos than from fluvalinate or captan. For normalized air sampler contamination, fine spray handgunners were significantly more at risk from ethazol than from fluvalinate, chlorpyrifos, or dicofol; the boom spray tractor driver was more at risk from chlorpyrifos than from fluvalinate or chlorothalonil; the span spray tractor driver was more at risk from chlorpyrifos than from fluvalinate. These differences among compounds cannot be explained at this time.

Comparing the various work practices, it can be observed from Tables 2 through 4 that the NETBAR data form general classes. Largest NETBAR values came from handgunners of all types and the drencher, moderate values from the boom spray tractor driver and the assistant are an order of magnitude lower, and, finally, lowest values by another order of magnitude came from the span spray tractor driver. There is a further tendency within the handgunner group for fine spray handgunners to receive more NETBAR than coarse spray or pulse fog handgunners. These general trends are more or less pronounced depending upon the chemical applied. It should be emphasized that the separation of handgunners by fineness of spray is a qualitative separation based on visual observation only and unsupported by any measurements. For normalized handwash data, there are, once again, three obvious work practice classifications. Handgunners as a group received the most, followed by the tractor driver and the drencher with about an order of magnitude less hand contamination, and finally the assistant with a slight amount only. For normalized air sampler data, three classifications suggest themselves: highest values are found with fine spray handgunners and pulse foggers (the assistant assisted a fine spray handgunner), about one order of magnitude lower values came from the coarse spray handgunner and the tractor driver, and finally the drencher whose air sampler detected nothing. One possible explanation of this last result is that the finer the spray, the greater the atmospheric contamination, either because of the smaller droplet size or because of enhanced volatilization from surfaces. Another operating factor may be the type of greenhouse structure in which the application was carried out. Fine spray handgunners and pulse foggers applied pesticide in enclosed structures; the coarse spray handgunner applied in an open sided house; the tractor driver applied in an open setting, except for a net ceiling. Thus, fineness of spray is confounded here with openness of structure. The finer spray applications occurred in more enclosed structures. It may be that the enclosed environment rather than the finer spray is the critical factor for atmospheric contamination.

Penetration of pesticide through protective clothing was assessed by computing the ratio of inside pad flux to that of the corresponding outside pad. This value we call transmittance, a term borrowed from optics. We do note, however, that inside pads can

Table 1. *Mean Tank Mixes*, Expressed as Percents of Presumed Tank Mix*

	Fluvalinate	Chlorpyrifos	Ethazol	Dicofol	Captan	Chlorothaloni
Handgunners						
fine spray						
pre-spray	90 ± 29 (27)	16 ± 3 (22)	28 ± 4 (19)	57 ± 5 (9)		
post-spray	110 ± 28 (27)	22 ± 4 (20)	35 ± 5 (18)	69 ± 4 (8)		
coarse spray						
pre-spray	51 ± 11 (7)	47 ± 13 (8)	106 ± 25 (2)			143 ± 39 (3)
post-spray	50 ± 10 (7)	48 ± 13 (8)	112 ± 3 (2)			91 ± 8 (3)
pulse fog						
pre-spray	68 ± 28 (7)	15 ± 8 (3)	19 ± 7 (3)			
post-spray	72 ± 7 (7)	8 ± 2 (3)	21 ± 7 (3)			
Tractor driver						
boom spray						
pre-spray	57 ± 11 (7)	45 ± 6 (11)			30 ± 7 (7)	105 ± 6 (4)
post-spray	53 ± 10 (7)	50 ± 6 (11)			36 ± 8 (7)	109 ± 5 (4)
span spray						
pre-spray	94 ± 65 (3)	114 ± 23 (3)			91 ± 6 (3)	
post-spray	29 ± 5 (3)	58 ± 24 (3)			66 ± 26 (3)	
Drencher						
pre-spray		25 (1)				
post-spray		39 (1)				
All combined	81 ± 8 (102)	35 ± 4 (94)	37 ± 5 (47)	63 ± 3 (17)	47 ± 7 (20)	111 ± 10 (14)

* ± standard error (number of samples)

Table 2. *Mean* Estimated Total Body Accumulation Rate (ETBAR), Normalized for Spray Rate (mg Deposited/kg Sprayed)*

	Fluvalinate	Chlorpyrifos	Ethazol	Dicofol	Captan	Chlorothalonil
Handgunners						
fine spray +	856 ± 221 (26)	229 ± 42 (22)	39 ± 9 (17)	287 ± 81 (9)		
coarse spray †	81 ± 71 (7)	70 ± 24 (7)	26 ± 21 (2)			279 ± 93 (3)
pulse fog +	65 ± 15 (7)	6 ± 2 (3)	12 ± 4 (3)			
Tractor driver †						
boom spray	2.1 ± 0.6 (6)	4.7 ± 1.1 (10)			2.8 ± 1.0 (6)	3.8 ± 0.9 (4)
span spray	0.20 ± 0.04 (3)	0.98 ± 0.23 (3)			0.35 ± 0.13 (3)	
Drencher +		44 (1)				
Assistant +		4 (1)				

* ± standard error, with number of exposures in parentheses

\+ does not include handwash (subjects wore gloves)

† includes handwash (subjects wore no gloves)

Table 3. *Mean* Total Handwash, Normalized for Spray Rate (mg Deposited/kg Sprayed)*

	Fluvalinate	Chlorpyrifos	Ethazol	Dicofol	Captan	Chlorothalonil
Handgunners						
fine spray+	1.7 ± 0.3 (27)	1.7 ± 1.2 (23)	0.08 ± 0.02 (19)	0.91 ± 0.30 (9)		
coarse spray†	5 ± 2 (7)	7 ± 4 (8)	0.04 ± 0.02 (2)			9 ± 3 (3)
pulse fog+	5 ± 1 (7)	13 ± 10 (3)	0.08 ± 0.01 (3)			
Tractor driver†						
boom spray	0.21 ± 0.05 (7)	0.61 ± 0.10 (11)			0.23 ± 0.06 (7)	0.41 ± 0.07 (4)
span spray	0.17 ± 0.03 (3)	0.71 ± 0.28 (3)			0.13 ± 0.04 (3)	
Drencher+		0.55 (1)				
Assistant+		0.04 (1)				

* ± standard error, with number of exposures in parentheses

\+ subjects wore gloves

† subjects wore no gloves

Table 4. *Mean* Air Sampler Deposit, Normalized for Spray Rate (mg Deposited/kg Sprayed)*

	Fluvalinate	Chlorpyrifos	Ethazol	Dicofol	Captan	Chlorothalonil
Handgunners						
fine spray+	0.033 ± 0.006 (27)	0.082 ± 0.046 (23)	0.547 ± 0.232 (19)	0.020 ± 0.006 (9)		
coarse spray†	0.0088 ± 0.0074 (7)	0.0046 ± 0.0011 (8)	0.1213 ± 0.0761 (2)			0.0065 ± 0.0053 (3)
pulse fog+	0.295 ± 0.141 (7)	0.064 ± 0.031 (3)	0.344 ± 0.133 (3)			
Tractor driver						
boom spray§	0.0019 ± 0.0013 (7)	0.0051 ± 0.0011 (11)			0.0026 ± 0.0008 (7)	0.0012 ± 0.0002 (4)
span spray§	0 ± 0 (3)	0.0020 ± 0.0002 (3)			0.0015 ± 0.0008 (3)	
Drencher+		0 (1)				
Assistant+		0.0143 (1)				

* ± standard error, with number of exposures in parentheses

\+ applications made in enclosed structure

† applications made in open sided structure

§ applications made in open Siran™ structure

suffer contamination by other routes than directly through the protective clothing. For example, samplers observed in the field that when an applicator extended his arm, the sleeve of the coverall had a tendency to ride up, exposing the inside forearm pad. We intend here to include all such events in transmittance, with the latter term interpreted very loosely. Mean transmittance over all subjects and work practices is presented in Table 6. A mean transmittance of zero indicates that its mean value was less than 0.005. It is clear from Table 6 that transmittance depends both on compound and location on the subject. The data suggest that the transmittance may not, under field conditions, be a constant value for a given compound penetrating a given fabric. There is a tendency for transmittance to be smaller when outside pad contamination is larger, as is the case in this experiment with thigh and shin pads. Note, for example, the difference in mean transmittance values for chlorpyrifos penetrating only the coverall. Significant differences among compounds in Table 6 were assessed through a Duncan's Multiple Range Test ($p < 0.05$). Standard errors were large, so that the only differences confirmed were the greater penetrating ability of ethazol vis-a-vis fluvalinate and chlorpyrifos at the chest and thigh, and vis-a-vis fluvalinate at the forearm.

Conclusions and Recommendations

Differences in individual work habits of those workers applying the same pesticide by the same method resulted in little variation in the ETBAR, handwashes, or air samples. This became apparent only when these measurements were normalized for spray rate.

Statistical analyses of the pre- and post-application tank mixtures showed no signifi-

Table 5. *Significant Differences* Among Compounds+ Applied*

	Handgunners† (fine spray)	Handgunners§ (coarse spray)	Handgunners† (pulse fog)	Tractor driver§ (boom spray)	Tractor driver§ (span spray)
Normalized ETBAR	F > CS	CL > F	F > CS	none	CS > F
	F > E	CL > CS	F > E		CS > CN
	F > D	CL > E			
Normalized handwash	none	none	none	CS > F	none
				CS > CN	
Normalized air sampler	E > F	none	none	CS > F	CS > F
	E > CS			CS > CL	
	E > D				

*according to a Duncan's Multiple Range Test ($p < 0.05$)

+fluvalinate (F), chlorpyrifos (CS), ethazol (E), dicofol (D), captan (CN), chlorothalonil (CL)

†wore gloves

§wore no gloves

cant difference between the two. But, particularly for chlorpyrifos, ethazol, and dicofol (all wettable powder formulations), less than 50% of the pesticide concentration presumed to exist in the tank on the basis of the mixture recipe was actually found. Fluvalinate and dicofol (both emulsifiable concentrates) were significantly closer to expectations. Chlorothalonil, a wettable powder, was an exception to the above dichotomy, with no discrepancy from expectations.

When the ETBAR, handwashes, and air sampler data were normalized for spray rate and expressed in "mg-deposited/kg-sprayed," these normalized exposure parameters showed some compound specificity, and the specificity pattern depended upon the application method. Irrespective of compound, however, the largest normalized ETBAR values came from handgunners of all types, moderate values from the boom spray tractor driver, and lowest values from the span spray tractor driver. These groups were each separated by about one order of magnitude. Normalized handwash magnitudes followed these same lines, but with little difference between the two tractor application methods. Normalized air sampler values were largest for the fine spray handgunners and pulse foggers and about one order of magnitude less for the coarse spray handgunner and the tractor driver.

Pesticide penetrated through Tyvek™ coveralls with a transmittance (% penetration) of 0% to 23%, depending strongly upon the potential amount of pesticide to be transmitted and the compound itself. Penetration of the compounds through the coverall at the forearm location was significantly greater for ethazol than for fluvalinate. Also, signficantly more ethazol than fluvalinite or chlorpyrifos penetrated the coverall/apron barrier at the chest and thigh.

The present study has established the potential exposure to greenhouse applicators and an estimate of the protection Tyvek™ coveralls afforded. For reasons not clearly understood, Tyvek™ coveralls were observed to have much less penetration resistance against ethazol than against

Table 6. *Mean* Transmittance to Inside Pads, All Subjects*

	Fluvalinate	Chlorpyrifos	Ethazol	Dicofol	Chlorothalonil
Chest, covered by					
coverall only	0.02 ± 0.02 (11)	0.12 ± 0.08 (2)	—	0.01 ± 0.01 (9)	—
apron only	—	0.05 ± — (1)	—	—	—
coverall plus apron	0+ ± 0 (24)	0.09 ± 0.04 (24)	0.23 ± 0.04 (20)	—	—
Forearms, covered by					
coverall only	0.04 ± 0.03 (33)	0.12 ± 0.06 (26)	0.23 ± 0.04 (20)	0.12 ± 0.05 (9)	—
Thighs, covered by					
coverall only	0.01 ± 0.01 (11)	0.01 ± 0.00 (2)	—	0 ± 0 (9)	—
apron only	0.22 ± 0.13 (4)	0.11 ± 0.11 (6)	0.52 ± 0.31 (3)	—	0.01 ± 0.01 (3)
coverall plus apron	0 ± 0 (24)	0.02 ± 0.01 (24)	0.15 ± 0.03 (22)	—	—
Shins, covered by					
boots only	0 ± 0 (7)	0 ± 0 (8)	0.02 ± 0 02 (2)	—	0 ± 0 (3)
coverall plus boots	0.04 ± 0.02 (31)	0.04 ± 0.03 (26)	0.02 ± 0 01 (20)	0 ± 0 (9)	—

* ± standard error (number of exposures)

+indicated < 0.005

the other pesticide formulations. Suits should be constructed with oversized long sleeves and a closure device at the wrist; hoods should be part of the suit. Applicators should wear rubber gloves extending to mid forearm, rubber boots, and respirators.

Where necessary, pesticide mixing methods in the tank should be updated, particularly for wettable powder formulations. This way, better pest control should result and/or less pesticide could be used.

We further recommend that four additional coverall fabrics be field-tested for penetration in a commercial greenhouse setting. The materials we suggest are Duraguard™, SMS, treated twill, and untreated twill. These materials have undergone a prior battery of laboratory tests for penetration at the Department of Textiles, Merchandizing and Design (Dr. J. O. DeJonge, Head), University of Tennessee, Knoxville, TN 37996. Handgunners, who constitute the applicator group at greatest potential risk, should be employed as subjects. The compounds monitored should be fluvalinate, chlorpyrifos (the two most frequently applied compounds at our cooperating facility), and ethazol (of those tested, the most penetrating compound through Tyvek™). Field-testing these fabrics for thermal comfort could best be undertaken in a separate study conducted elsewhere.

The full report was submitted in fulfillment of grant CR-810743 by the University of Florida under the sponsorship of the U.S. Environmental Protection Agency.

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The complete report, entitled "Pesticide Exposure to Florida Greenhouse Applicators," (Order No. PB 88-219 381/AS; Cost: $19.95, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
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