

ESTIMATION OF EXPOSURE OF PERSONS IN  
CALIFORNIA TO PESTICIDE PRODUCTS THAT  
CONTAIN ABAMECTIN

By

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ABSTRACT

Abamectin, an acaricide and insecticide, is a mixture of abamectin B<sub>1a</sub> (80 percent) and abamectin B<sub>1b</sub> (20 percent). It was registered for use in California on ornamentals for the first time in 1987. A registration petition has been made for use of this chemical on cotton. There was one reported injury classified as a possible skin effect in 1988. A formulated product, AVID<sup>®</sup>, is neither a skin irritant nor a sensitizer. One percent dermal absorption was used in the estimation of absorbed dose. Rats orally administered avermectin B<sub>1a</sub> or its delta-8,9-isomer excreted two major metabolites, 3"-desmethyl- and 24-hydroxymethyl-avermectin B<sub>1a</sub> or its delta-8,9-isomer. The major portion of the dose was excreted unchanged in the feces. Due to teratogenic effects primarily observed in mice, evaluation of safety for handlers and field workers of crops treated with abamectin is essential. Absorbed daily dosage ( $\mu\text{g}/\text{kg}/\text{day}$ ) for handlers with moderate protection ranges from 0.025 to 0.112 and for a greenhouse worker is 0.005.

This report was prepared as Appendix B to the Department's risk characterization document for abamectin.

## APPENDIX B

California Department of Food and Agriculture  
Worker Health and Safety Branch

Human Exposure Assessment

Abamectin

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### INTRODUCTION

Human exposure assessment provides essential information for the risk assessment of chemicals in the pesticide registration process. This document will be incorporated as Appendix B in the risk characterization document of the California Department of Food and Agriculture. It will also be used as a basis for mitigation proposals if normal exposures to abamectin are found to cause an excessive risk.

Mixer/loader/applicator exposure estimates were derived from patch or other passive dosimeters. Exposure of harvesters who come in contact with foliage was estimated from dislodgeable foliar residues with an appropriate transfer factor. Inhalation exposure for workers was added to dermal exposure estimates to determine absorbed daily dosage.

In addition to human exposure estimates, presentation of properties of the chemical under review are necessary for a better understanding of its nature, usage, and effects. These additional categories are: physical and chemical properties, EPA status, formulations/precautions, usage, worker illness/injury, dislodgeable foliar residues, dermal toxicity/absorption, and animal metabolism.

### PHYSICAL AND CHEMICAL PROPERTIES

Abamectin or avermectin B<sub>1</sub> (AVID<sup>®</sup>, MK-936) is a mixture of avermectin B<sub>1a</sub> and avermectin B<sub>1b</sub> in an 80:20 ratio. Avermectin B<sub>1a</sub> has a chemical formula of C<sub>48</sub>H<sub>72</sub>O<sub>14</sub> and a weight of 873.11 daltons; avermectin B<sub>1b</sub> has a formula of C<sub>47</sub>H<sub>70</sub>O<sub>14</sub> and weighs 859.08 daltons. Both are macrocyclic lactone disaccharides. The avermectin class of chemicals was isolated from Streptomyces avermitilis. Abamectin (technical) has a melting point of 155-157 °C. It is a white to yellowish-white crystalline powder with no appreciable vapor pressure. Abamectin is soluble in acetone and methanol; slightly soluble in toluene and sparingly soluble in water. The AVID<sup>®</sup> formulation is stable under normal storage conditions; however, 30 percent reduction in parent compound was observed after 52 days' storage in an exposed environment of humid air at 50 °C<sup>(1,2,3,4,5)</sup>.

Abamectin is a slow-acting stomach insecticide. Its mechanism of action appears to be agonistic activity against gamma-aminobutyric acid (GABA) receptors. It is not a known acetylcholinesterase inhibitor.

## **EPA STATUS**

An abamectin-containing product (AVID<sup>®</sup> 0.15 EC) was originally registered by the Environmental Protection Agency (EPA) for commercial use in May, 1986. Prior to this date, only Experimental Use Permits were issued by the EPA for abamectin. The EPA also granted several emergency exemption uses of abamectin under the EPA Section 18 Specific Exemption.

## **FORMULATIONS/LABEL PRECAUTIONS**

Currently, there is only one product that contains abamectin (AVID<sup>®</sup> 0.15 EC) registered in California. AVID<sup>®</sup> 0.15 EC is a 2 percent formulation of abamectin. It is an emulsifiable concentrate with 0.15 pounds (lb) of abamectin per gallon. It is sold in one-quart containers. AVID<sup>®</sup> 0.15 EC is a toxicity category II product carrying the signal word "Warning". The hazards of ingestion, dermal and inhalation exposure have been indicated on the label. It can cause substantial but temporary eye injury. Mixers, loaders and applicators are required to wear a full body pesticide applicator suit, rubber gloves, boots and mask or respirator when handling this product. The reentry interval for AVID<sup>®</sup> 0.15 EC on pears and strawberries is spray residues have dried.

## **USAGE**

AVID<sup>®</sup> 0.15 EC was registered in California for the first time in 1987 for control of spider mites and leafminers on ornamental plants. However, statewide uses on agricultural crops such as pears and strawberries to control two-spotted spider mite and European mite have been authorized in California under the EPA Section 18 Specific Exemption for the last few years. The total amount of abamectin sold in California during 1988 was 402 lb<sup>(6)</sup>. AVID<sup>®</sup> 0.15 EC is recommended at a rate of 8 to 16 ounces of product (0.009-0.018 lb active ingredient (a.i.)) per acre in 100 to 400 gallons of water as a foliar spray on ornamentals. Repeated applications can be performed at seven-day intervals or more frequent as necessary. The preharvest interval (PHI) for strawberries is three days, and for pears the PHI is seven days. The product label prohibits aerial application or application through any type of irrigation system. There is no abamectin product registered in California for home use. Ivermectin (dihydroavermectin B1), a closely related chemical structure to that of avermectin B1, has been used for nearly a decade as a broad-spectrum antiparasitic agent in domestic animals; it has also been tested as a drug for human filariasis<sup>(7)</sup>.

## WORKER ILLNESS

There was one reported injury associated with abamectin exposure. It occurred in 1988 and has been classified as a possible skin effect<sup>(8)</sup>. A greenhouse worker harvesting carnations treated two days previously developed a rash on his hands, forearms and face which persisted at least 10 days. Though the number of illness/injury is small, the product only has a use history extending from 1987.

## DERMAL TOXICITY AND ABSORPTION

The rabbit dermal LD<sub>50</sub> for the AVID<sup>®</sup> formulation has been reported as 1,500 mg/kg. For the technical material, the dermal LD<sub>50</sub> for both rabbits and rats was reported as >330 mg/kg. AVID<sup>®</sup> is not considered either a skin irritant or a sensitizing agent<sup>(1,4)</sup>.

One study on dermal absorption was done using rhesus monkeys<sup>(9)</sup>. Avermectin B<sub>1a</sub> was used and was assumed by the registrant to have the same dermal absorption properties as avermectin B<sub>1b</sub>. The radiolabel was located on hydrogen (<sup>3</sup>H) instead of carbon (<sup>14</sup>C) since the <sup>3</sup>H-labeled material can be synthesized at a higher specific activity than the <sup>14</sup>C-labeled material. The higher activity was required to reach a higher sensitivity thought necessary for this study.

The same four monkeys were used throughout all phases of the study. Three to four weeks separated each dosing. An initial intravenous (i.v.) exposure was performed to identify the major route of excretion. Ninety-six percent of the i.v. dosage was recovered in the feces. The dermal dosing was done using three different solutions/rates of avermectin over a shaved forearm area of 6 cm<sup>2</sup>. One dose was 6 µg/animal (1 µg/cm<sup>2</sup>) of avermectin derived from the formulated emulsifiable concentrate (AVID<sup>®</sup> 0.15 EC). This represented potential exposure to applicators. The second dose was 300 µg/animal (50 µg/cm<sup>2</sup>) of avermectin, once again derived from formulated product, representing mixer/loader exposure. The third dose rate was 300 µg/animal (50 µg/cm<sup>2</sup>) of avermectin, derived from technical product (no formulation inerts), representing fieldworker exposure. Two exposure time intervals were used in the study: 1 hour and 10 hours. After the expiration of the exposure time, the application site was washed to remove unabsorbed material. Animals were sedated, restrained in metabolic chairs for 24 hours and excreta and blood were collected at specific intervals. After 24 hours, samples were collected at 24-hour intervals until the tenth day after exposure.

After analysis utilizing sample combustion and scintillation counting, the sample data were transformed via the following equation:

$$\text{percent dermal absorption} = \frac{\text{total radioactivity excreted (topical dose)}}{\text{total radioactivity excreted (i.v. dose)}} \times 100$$

The results of these various dermal absorption conditions are given in Table 1. Total mean dose recovery was 87.6 percent of applied dermal dose.

Table 1. Percent of dermal absorption from selected applied doses of <sup>3</sup>H-avermectin B<sub>1a</sub> to 6 cm<sup>2</sup> of rhesus monkey forearm skin. All values given as percent dermal absorption (determined over 10 days excretion).

<u>Dose</u> <u>μg/animal</u>	<u>Dose</u> <u>μg/cm<sup>2</sup></u>	<u>1-Hour</u> <u>Exposure</u>	<u>10-Hour</u> <u>Exposure</u>
6 (EC) <sup>a</sup>	1	0.21	0.49
300 (EC)	50	0.23	0.52
300 (tech) <sup>b</sup>	50	0.15	0.26

<sup>a</sup> EC - emulsifiable concentrate

<sup>b</sup> tech - technical material

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The mean 10-hour application percent absorption for the 50 μg/cm<sup>2</sup> rates is 0.39 percent. For regulatory purposes, a conservative absorption value of 1 percent will be used.

## ANIMAL METABOLISM

Animal metabolism studies of avermectin B<sub>1a</sub> and its isomer, delta-8,9-avermectin B<sub>1a</sub> were conducted to determine the distribution, excretion, and formation of the metabolites. Radiolabeled chemicals were orally administered in the rats and the goats. The results showed the majority of avermectin B<sub>1a</sub> was excreted unchanged in feces. Two metabolites were identified in rat and one in goat studies. The half-life of avermectin B<sub>1a</sub> in rat tissues is 1.2 ± 0.3 days. The metabolism of <sup>3</sup>H- and <sup>14</sup>C-avermectin B<sub>1a</sub> by rats appeared identical.

Male and female rats (CRCD-strain, nulliparous, and non-pregnant) were orally administered <sup>14</sup>C- and <sup>3</sup>H-labeled avermectin B<sub>1a</sub> in 0.5 mL sesame oil. Dosages used were: a single 1.4 mg/kg dose of <sup>3</sup>H-avermectin B<sub>1a</sub>, a single 0.14 mg/kg dose of <sup>14</sup>C-avermectin B<sub>1a</sub>, 14 daily doses of 0.14 mg/kg unlabeled followed by a single 0.14 mg/kg dose of <sup>14</sup>C-avermectin B<sub>1a</sub>, a single 1.4 mg/kg dose of <sup>3</sup>H- + <sup>14</sup>C-avermectin B<sub>1a</sub> and sesame oil for controls<sup>(10)</sup>. Urine and feces samples were collected daily. Three rats from each group were sacrificed 1, 2, 4, and 7 days after dosing. Edible tissue (liver, kidney, fat and muscle) and other tissues were collected for analysis. The results showed that a major portion of the dose (69-82 percent) was eliminated in feces, whereas urine accounted for 0.3-1.1 percent. Residue in the GI tract was 7-11 percent and in edible tissue 1.7-3.2 percent. Low residues were observed in the brain (0.002-0.006 percent) and bone (0.006-0.014 percent). Average half-life of avermectin B<sub>1a</sub> in tissues of male and female rats is 1.2 ± 0.3 days. Identification of the metabolites was achieved by comparison of metabolite spectra to those of standard compounds and by co-chromatography with standard compounds prepared from in vitro incubation of avermectin B<sub>1a</sub> with rat liver microsome<sup>(11)</sup>.

Two major metabolites identified in edible tissues were 24-hydroxymethyl avermectin B<sub>1a</sub> (0.5 percent of total dose recovered) and 3"-desmethyl avermectin B<sub>1a</sub> (0.9 percent of total dose recovered). Non-polar conjugates of these two major metabolites were also identified in the nonpolar fraction of fat. Acid hydrolysis of conjugates could release monosaccharide or 3"-desmethyl B<sub>1a</sub>.

Lactating goats that received orally-administered avermectin B<sub>1a</sub> a (0.005, 0.05 and 1.0 mg/day for 10 days) produced one major metabolite, 24-hydroxymethyl avermectin B<sub>1a</sub><sup>(12)</sup>. Unchanged avermectin B<sub>1a</sub> accounted for 37-99 percent and 24-hydroxymethyl avermectin B<sub>1a</sub> ranged 1-54 percent of the recovered dose. Dose recovery averaged 89.3 percent and the majority was in the feces. Less than one percent of the dose was excreted in urine. A minor amount of a non-polar conjugate of 24-hydroxymethyl avermectin B<sub>1a</sub> was observed in fat tissue.

Metabolism of the <sup>3</sup>H-delta-8,9-isomer of avermectin B<sub>1a</sub> was conducted using rats<sup>(13)</sup>. A dose of 1.4 mg/kg was orally administered to female rats. Three rats were used for each test period of 0, 1, 2, 4, and 7 days. Daily urine and feces samples were collected and 12 different tissue samples were also collected at the end of the testing periods. Seven days after dosing, 94 percent and 0.42 percent of the dose was recovered in the feces and urine, respectively. Total recovery of the dose was 95.4 percent. Half-life of residues in edible tissues averaged 1.5 ± 0.1 days. Two metabolites identified were 3"-desmethyl-delta-8,9-isomer (approximately 3 percent of dose) and 24-hydroxymethyl-delta-8,9-isomer (less than 1 percent of dose).

## WORKER EXPOSURE

Estimates of worker exposure to abamectin were for mixer/loader (M/L), applicator (A), mixer/loader/applicator (M/L/A), greenhouse worker and field worker in two crop groups. These two crop groups are cotton and greenhouse/shadehouse ornamentals. Exposure estimates for abamectin handlers were derived from field studies during application to particular crops or from surrogate data. Exposure of field workers and greenhouse workers to abamectin was determined using dislodgeable foliar residues and appropriate transfer factors.

### A. Cotton

#### 1. Mixer/Loaders and Applicators

There were no mixer/loader and applicator exposure data available for cotton. Exposure data from studies conducted on citrus using an airblast sprayer were submitted by the registrant as surrogate data<sup>(14)</sup>. The study of mixer/loader and applicator exposure to abamectin applied in a citrus orchard was divided into two sampling periods. Each sampling period consisted of three mixing/loading operations and three applications. The application rate per acre was 0.025 lb a.i. mixed in 500 gallons of water.

Multi-layer patches composed of an external layer of fabrics used for warm weather or 100 percent cotton coveralls, an inner layer of chromatography paper, backed with glassine, and a waterproof vinyl backing and frame were used. The exposed surface area of the

outer layer was 40 cm<sup>2</sup>. These patches were placed on the chest, back, shoulders/upper arm, forearms, thighs, and ankles/lower legs.

Exposure estimates of the face were accomplished by swabbing the surface with gauze dampened with 10 percent isopropyl alcohol. Face exposure was included in the total exposure because faces are normally unprotected and are not washed during the work period. Hand exposure was measured by vigorously shaking 25 times in a 1-gallon Ziploc<sup>®</sup> plastic bag with 750 mL deionized water (dH<sub>2</sub>O) and then rinsing in 3x250 mL isopropyl alcohol. Inhalation exposure was monitored using MSA Fixt-Flo<sup>®</sup> personal air pumps set at 1 L/minute. Charcoal sampling tubes were used to intercept abamectin airborne residues.

Dermal exposure estimates for M/L and A were derived to represent the types of clothing worn by the workers during the studies, which included long-sleeved shirts, long pants, and chemical resistant gloves. There were no detectable residues in charcoal air monitoring media. Inhalation exposure was assumed negligible.

According to the results of these studies, time used in the application per tank load was 12 minutes, whereas, the mixing/loading operation for one tank load was 6.4 minutes. If a single worker performs all three tasks continuously, the times used for mixing/loading and applying in a typical eight-hour workday are three and five hours, respectively.

Results of the exposure study are shown in Table 2. All data were adjusted for the recovery of field fortified samples averaging 75 percent.

Table 2. Exposure of mixer/loaders and applicators to abamectin during citrus airblast application<sup>a</sup>.

Work Task	Dermal Exposure(ug/person/day)				ADD <sup>b</sup> (ug/kg/day)
	Hands	Face	Body	Total	
M/L <sup>c</sup>	7.9	75.1	92.9	176	0.025
A <sup>d</sup>	6.7	75.8	175.2	258	0.037
M/L/A <sup>e</sup>	12.0	122.4	202.6	337	0.048

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<sup>a</sup> Application rate = 0.025 lbs. a.i. per acre. Workers wore long-sleeved shirts, long pants, and chemical resistant gloves.

<sup>b</sup> Absorbed daily dosage (ADD) was calculated based on dermal absorption of one percent and worker weight at 70 kg. A body weight of 70 kg was used because M/L and A are predominantly male workers. ADD = (dermal exposure x dermal absorption/body weight).

<sup>c</sup> Work period for mixer/loader was three hours per day.

<sup>d</sup> Work period for applicator was eight hours per day.

<sup>e</sup> Averaged from the exposure ratio of three hours to five hours for M/L and A, respectively.

2. Field workers (including cotton scouts)

Dislodgeable foliar residues (DFRs) of field-grown chrysanthemums<sup>(15)</sup> and an appropriate transfer factor<sup>(16)</sup> were used to calculate potential dermal exposure of cotton field workers. DFRs of field-grown chrysanthemums were used because of the similarity of leaf surface texture to that of cotton. Ornamental or citrus DFRs were not used as surrogates because they were not the closest approximation to cropping practice and size.

Field-grown chrysanthemums were treated with AVID<sup>®</sup> 0.15 EC at 0.02 lb a.i. and 0.04 lb a.i. in 133 gallons of water per acre. DFRs were determined prior to the application and after the application at two and six hours, and one, three, and seven days. Each leaf sample taken consisted of 40 1-inch diameter leaf discs. DFRs from the application rate of 0.02 lb a.i. per acre were selected for the exposure estimates since it is close to the maximum allowable application rate for cotton. Results of DFRs as shown in Table 3 were adjusted for the average recovery of 75 percent for field fortified samples.

Table 3. Dislodgeable foliar residues of field-grown chrysanthemums treated with abamectin at 0.02 lb a.i. per acre.

Time after Application	Mean DFRs (ng/cm <sup>2</sup> )	Adjusted mean DFRs <sup>a</sup> (ng/cm <sup>2</sup> )	
2 hours	5.34±1.46	7.12±1.95	(n=4)
6 hours	2.02±0.82	2.69±1.09	(n=4)
1 day	0.48±0.13	0.64±0.17	(n=4)
3 days	0.27±0.37	0.36±0.49	(n=4)
7 days	0.05±0 <sup>b</sup>	0.05±0 <sup>b</sup>	(n=4)

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<sup>a</sup> Adjusted mean DFRs - Mean DFRs x 75 percent field-fortified recovery.

<sup>b</sup> value represents MDL (0.05 ng/cm<sup>2</sup>).

A dislodgeable residue of 7.12, 2.69, 0.64 and 0.36 ng/cm<sup>2</sup> at 2, 6, 24 hours and 3 days after the application respectively were used to estimate the potential dermal exposure of field workers including cotton scouts. Exposure estimates for field workers are shown in Table 4. Field operations for workers, particularly for cotton scouts, are expected to last approximately six hours in a normal workday.

Table 4. Field worker exposure to abamectin residues in cotton field.

DFR (ng/cm <sup>2</sup> )	Transfer Factor (cm <sup>2</sup> /h) <sup>a</sup>	Potential Dermal Exposure (ng/person/6h-D)	Dermal Exposure <sup>b</sup> (ng/person/6h-D)	ADD <sup>c</sup> (ng/kg/day)
0.36 (3 days) <sup>d</sup>	15,000	32,400	3,240	0.59
0.64 (1 day) <sup>d</sup>	15,000	57,600	5,760	1.05
2.69 (6 hrs) <sup>d</sup>	15,000	242,100	24,210	4.42
7.12 (2 hrs) <sup>d</sup>	15,000	640,800	64,080	11.69

Tian, WH&S, 1990

<sup>a</sup> Potential dermal transfer factor was derived from the study of Ware et al.<sup>(16)</sup>.

<sup>b</sup> Assumed field worker wore long-sleeved shirt, long pants, shoes, and gloves. Clothing penetration of the potential dermal exposure was assumed to be 10 percent.

<sup>c</sup> Dermal absorption of abamectin is one percent. Worker weight is 54.8 kg.

<sup>d</sup> Time after application.

## B. Greenhouse/Shadehouse Ornamentals

### 1. Applicator exposure

In a greenhouse exposure study, seven applicators participated in the application of abamectin to roses and chrysanthemums using AVID<sup>®</sup> 0.15 EC at the rate of 4.1 gm a.i. (0.009 lb a.i.)/100 gallon water<sup>(17)</sup>. Residues from multi-layered patches were used to estimate total exposure and the amount that penetrated cloth layers; patches were attached outside rainsuits worn by the applicators. Gauze patches were also placed underneath rainsuits to estimate the amount of chemical penetration.

The patch consisted of an outer cloth layer (7-ounce twill: 65 percent dacron polyester and 35 percent cotton) and an inner layer of 12-ply gauze backed with food-grade aluminum foil. The exposed area of the patch was 23.75 cm<sup>2</sup>. Patches were attached to clothing corresponding to the following body parts: front and rear of thighs, lower legs, forearms, each bicep, left and right sides of the chest and upper and lower back. Patches were also attached to the front and rear of the outermost head covering. Residues found in the cloth layer represented residue intercepted by coveralls and residue found on gauze of bi-layer patches represented the amount of chemical that penetrated through cloth coveralls. Penetration of abamectin through rainsuits was determined from residue found on patches (12-ply gauze) attached to clothing worn under the rainsuit.

Inhalation exposure of applicators was determined by using a personal air sampler (Fixt-Flo<sup>®</sup>, Model 1, Mine Safety Appliance) equipped with a media sampling train composed of a glass fiber filter (Type AE, SKC #225-7) in a closed cassette followed by a

sorbent tube packed with XAD-4 resin (SKC # Special, 220 mg/400 mg). The cassette opening was attached near the applicator breathing zone. The flow rate was set at 1 L/min during the abamectin application. Hand exposure was measured by washing hands for one minute in 400-mL surfactant solution (0.1 percent sodium dioctyl sulfosuccinate).

Dermal exposures to each applicator (Table 5) were separated into three different categories: no protection, protection with coveralls, and protection with rainsuits. There were wide ranges of exposure in each category and thus the geometric means of exposures were calculated to represent the exposure in terms of  $\mu\text{g}$  abamectin per gram a.i. applied. Inhalation exposure of seven applicators ranged from 0.1 to 0.5  $\mu\text{g}/\text{m}^3$ . The geometric mean of inhalation exposure in an eight-hour workday calculated based on the ventilation rate of 36.75 L/min<sup>(17)</sup> was 3.3  $\mu\text{g}/\text{person}/\text{day}$ .

Table 5. Dermal and inhalation exposure of each applicator to abamectina.

Worker No.	22	23	24	25	26	27	29	Geometric mean
A. Dermal exposure								
(μg/gm a.i. applied)								
No protection (Body+head+hands)	27.07	540.00	20.29	15.41	85.51	6988.76	157.90	123.03
With coveralls (Body+head+hands)	2.96	60.25	1.04	1.02	5.25	2032.26	30.05	13.12
With rainsuit (Body+head+hands)	1.22	2.46	0.78	0.86	1.60	8.00	3.00	1.86
B. Inhalation exposure <sup>b</sup>								
(μg/m <sup>3</sup> )								
	0.2 <sup>c</sup>	0.1 <sup>c</sup>	0.2	0.1	0.2	0.5	0.2 <sup>c</sup>	0.2

Tian, WH&S, 1990

<sup>a</sup> Grams a.i. applied averaged 9.02 gm (0.02 lb) in 2.1 hours application time.

<sup>b</sup> Ventilation rate at high work activity is 36.75 L/min.

<sup>c</sup> Minimum detection level was used.

Applicator exposure estimates (Table 6) combined dermal and inhalation exposure in three different clothing categories. According to the abamectin use pattern in this study, the average amount of abamectin a.i. applied was 9.02 gm in the average time of 2.1 hours. The exposure estimates to these applicators were calculated to represent the exposure to 9.02 gm a.i. in 2.1 hours.

Table 6. Exposure of applicators to abamectin during greenhouse applications.

Protective Clothing		Daily Dermal Exposure ( $\mu\text{g}/\text{person}/8\text{h-D}$ )	Inhalation exposure ( $\mu\text{g}/\text{person}/8\text{h-D}$ )	Absorbed Daily Dosage <sup>a</sup> ( $\mu\text{g}/\text{kg}/8\text{h-D}$ )
No protection <sup>b</sup>	(n=7)	4227	3.3	0.802
With coveralls <sup>c</sup>	(n=7)	451	3.3	0.112
With rainsuit <sup>d</sup>	(n=7)	64	3.3	0.042

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<sup>a</sup> Dermal absorption is 1 percent (9) and inhalation uptake is 50 percent (18) A female worker weight of 54.8 kg was used because greenhouse workers are predominantly female workers and calculation of exposure was based on a surface area of 17,860 cm<sup>2</sup>.

<sup>b</sup> Assume workers wear minimal work clothing.

<sup>c</sup> Assume workers wear coveralls, rubber gloves, boots, and mask. This exposure protection is equivalent to the minimum requirements of the product label. Mask according to the product label provides no protection, unless it is specifically the type of mask approved by NIOSH and/or MSHA.

<sup>d</sup> Assume workers wear full body chemical resistant protective suits (rainsuits), work clothing, chemical-resistant gloves, boots, and mask.

## 2. Dislodgeable foliar residues and greenhouse worker exposure

Dislodgeable foliar residues of greenhouse-grown roses and chrysanthemums were determined 1, 2, and 3 hours post-application<sup>(17)</sup>. The crops were sprayed with AVID<sup>®</sup> 0.15 EC at a rate of 4.1 gm a.i. (0.009 lb a.i.) in 100 gallons of water. The applicator used a spray wand with a nozzle cluster comprised of three projections approximately three inches in length, each terminating in a single nozzle.

Rose and chrysanthemum foliage samples were collected using a Birkestrand<sup>™</sup> leaf punch with an opening of 2.54 cm diameter and fitted with a four-ounce glass jar. Each sample consisted of 40 leaf discs. Samples were collected immediately prior to the application and 1, 2, and 3 hours post application. Triplicate samples were collected from each sampling interval. All samples were stored on ice and extraction was performed within 26 hours after collection. Mean DFRs of abamectin (Table 7) represent residue from upper and lower leaf surfaces. The results showed relatively similar DFR levels of 9 ng/cm<sup>2</sup> within three hours post-application.

Table 7. Mean dislodgeable foliar residue levels of abamectin following greenhouse applications<sup>a</sup>.

Post-application (hours)	DFR ( $\mu\text{g}/\text{cm}^2$ )
1	0.009±0.005 (n=3)
2	0.010±0.006 (n=3)
3	0.009±0.007 (n=3)

Tian, WH&S, 1990

<sup>a</sup> Minimum detectable limit 0.05-0.09  $\text{ng}/\text{cm}^2$

Greenhouse worker exposure (Table 8) was estimated from the dislodgeable foliar residue of  $0.01 \text{ ug}/\text{cm}^2$  and a dermal transfer factor of  $350 \text{ cm}^2/\text{h}$  (or equivalent to potential dermal transfer factor of  $3,500 \text{ cm}^2/\text{h}$ ) which derived from workers harvesting and packing lilies<sup>(19)</sup>. The estimated dermal exposure was  $28 \text{ }\mu\text{g}/\text{person}$  in a 8-hour workday.

Table 8. Exposure of greenhouse workers to abamectin.

Dermal Exposure <sup>a</sup> ( $\mu\text{g}/\text{person}/\text{day}$ )	ADD <sup>b</sup> ( $\text{ng}/\text{kg}/\text{day}$ )
28	5.1

Tian, WH&S, 1990

<sup>a</sup> Assumed workers wore long-sleeved shirts, long pants, latex gloves, and shoes.

<sup>b</sup> Absorbed daily dosage (ADD) was calculated based on one percent dermal absorption and  $54.8 \text{ kg}$  female worker weight.

Table 9. Summary of worker exposure to abamectin.

Crops	Work Task	Dermal Exposure (ug/person/8h-D)	Inhalation Exposure (ug/person/8h-D)	ADD (ug/kg/day)
<u>Cotton</u>				
	M/L	176	NG	0.025
	A	258	NG	0.037
	M/L/A	337	NG	0.048
	Field worker (including cotton scout) (3 days PA)	3.24	N/A	0.0006
	(1 day PA)	5.76	N/A	0.001
	(6 hrs PA)	24.21	N/A	0.004
	(2 hrs PA)	64.08	N/A	0.012
<u>Greenhouse/Shadehouse</u>				
	A (no protection)	4227	3.3	0.802
	A (with coveralls)	451	3.3	0.112
	A (with rainsuit)	71	3.3	0.042
	greenhouse worker	28	N/A	0.005

NG - Negligible exposure

PA = Post application

N/A = Not available

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