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Worker Health and Safety Branch

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PESTICIDE EXPOSURE OF WORKERS IN GREENHOUSES

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Summary

We conducted a study of worker exposure to pesticide residues in greenhouses. Workers exposure was monitored while performing cultural tasks such as harvesting or disbudding of carnation flowers or roses. The study estimated exposure by taking measurements of pesticides in the workers breathing zone and using dermal dosimetry including clothing dosimeters (t-shirts, socks), hand wipes and face/neck wipes. Exposure samples and dislodgeable foliar residue (DFR) sampling was conducted for the pesticides myclobutanil, diazinon and malathion in carnations and for diazinon in roses. Foliar residues were collected and compared to the residues found on the dermal dosimetry. Mean daily dermal exposure measurements ranged from 0.9 mg to 1.8 mg for carnations treated with myclobutanil at an average DFR level of 0.31 ± 0.04 µg/cm² for five monitoring days. Diazinon dermal exposure levels ranged from 0.2 mg to 2.0 mg with an average DFR level of 0.06 ± 0.04 µg/cm² for four monitoring days in carnations. Malathion dermal exposures in carnations were measured over two days with means of 1.2 mg and 3.2 mg at DFR levels of 0.3 and 0.6 µg/cm². For the diazinon monitoring in roses, DFR results were an order of magnitude lower than in carnations at 0.005 µg/cm². Corresponding dermal exposure measurements were also lower at 0.07 mg to 0.1 mg. The highest daily potential inhalation exposure was 50 µg/day found during exposure to malathion, median levels were around 2 µg/day. Potential dermal exposure levels correlated with the amount of dislodgeable foliar residues found on the leaves. Higher dermal exposure measurements corresponded with the increase measured in DFR.

Introduction

The California Environmental Protection Agency (Cal/EPA), Department of Pesticide Regulation, Worker Health and Safety Branch (WH&S) conducted a study of human exposure to pesticide residues in greenhouses. Greenhouse floral production presents unique cultural situations with planting rows between narrow walkways to maximize growing area. This results in foliar contact to pesticide residues when workers use these walkways to perform harvesting or other tasks. The various cultural practices conducted in greenhouses may be associated with a wide range of exposure estimates. Greenhouse exposure estimates often depend upon surrogate data or data from studies conducted in different growing conditions[1,2,3]. The focus of this monitoring was on collecting representative data for worker activities and not the specific pesticide. Measurements of exposure that are task-specific yield more realistic assessments of risk potential than do those extrapolated from surrogate data. Currently, minimal research has been conducted to evaluate worker exposure in greenhouses. Zweig, et al (1985), found in 43 separate observations a correlation between dermal exposure rates and dislodgeable foliar residues for five different pesticides during strawberry and blueberry harvest. This concept can be used to estimate potential dermal exposure and the data can be used to estimate exposure to other pesticides at similar dislodgeable foliar residue levels. This study estimated pesticide exposure by measuring breathing zone concentrations and dermal exposure via clothing dosimeters (t-shirts, socks), hand wipes and face/neck wipes. Potential dermal and inhalation exposure estimates are reported for the monitoring conditions. These exposure measurements are correlated to dislodgeable foliar residue levels.

Material and Methods

There were two sites used to measure potential exposure to workers in greenhouses. One site was a carnation grower located in the Salinas Valley and the second site was a rose grower outside of Watsonville. Both sites allowed us access to their workers to obtain informed consent. The protocol detailing the study subject consent process was approved by the University of California, San Francisco, Committee on Human Research, approval number H7420-15249-01. Worker Health and Safety Staff read over the consent form titled "Pesticide Exposure to Workers in Greenhouses" and the Experimental Subjects Bill of Rights in Spanish. Staff explained the purpose, procedures and their role in the study. The workers were informed they could withdraw from the study at any time. Questions were solicited and answered prior to seeking voluntary cooperation from the workers. Workers participating in the study signed an informed consent. No attempt was made to alter the normal work clothing worn, personal protective equipment used or work habits of the workers prior to or during exposure monitoring.

Study Dates

Technical protocol approved	October 29, 1998
Ethical protocol approved	June 15, 1998 (The protocol was renewed the following two years and expired in June 2001)
Field monitoring started	June 15, 1999
Laboratory sample analysis started	June 16, 1999
Field monitoring completed	August 17, 2000
Lab sample analysis completion	December 6, 2000
Study completion	August 29, 2002

Sites

The carnation grower had twelve acres of carnations under cultivation in glass-covered greenhouses with screened sides. The sides were covered with plastic sheeting that can be rolled up for ventilation or left down for warmth. The twelve acres were divided into three blocks of four acres each called "ranches". Each four-acre block was divided into one acre of greenhouse and each one-acre greenhouse was numbered starting with one and ending at twelve. There were 72 beds per greenhouse (36 each side). There were 1200 plants per bed when growing the standard carnations and 1000 plants per bed when growing the mini carnations. Beds were either 36 or 40 inches wide and 110 feet long. Mini carnations are grown to produce multiple flowers on one stem with the central flower removed while the standard carnations are grown for one large flower. Plants are usually grown for three years before being replanted. Exposure monitoring of workers harvesting, disbudding and pinching carnations took place June 15, 17, 22, 23, 24 and July 5 through 8, 1999.

The roses were grown in a glass-covered greenhouse with corrugated plastic sheeting for the sides. The greenhouse had nine bays with a large aisle way down the middle, measuring 100 x 220 feet. The planting beds were of different sizes and styles through the greenhouse. Some roses were planted on beds that could be rolled from side to side to allow for an aisle way passage, and others were planted in small stationary beds with aisle ways between. There were numerous rose varieties being grown in the greenhouse from one to seven years old. The exposure monitoring at this site took place on the afternoon of August 16 and on the following day in two half-day increments, August 17, 2000.

The rose and carnation locations had similar temperature conditions during the monitoring with lows of 55 to 60 °F in morning and highs in the mid afternoon of 78 to 83 °F.

Application Equipment

For both sites, all pesticides were stored in a secure locked location. For the carnations, each 4-acre block had its own sprayer in a fenced and locked location with two acres of greenhouse on each side. At the rose site, the sprayer was housed in a separate building and the greenhouses were plumbed to run off the one sprayer. The sprayers used for roses and carnations were similarly equipped with 400-gallon tanks and operated at 250 to 300 psi. Applications were made using a hand wand equipped with three nozzles placed inline approximately four inches apart delivering a spray swath of 30 inches. All applications abided by label requirements and California Code of Regulations, Title 3, Food and Agriculture, Division 6.

Treatments and Rates

The pesticides monitored for the worker exposure scenarios in greenhouse grown carnations were myclobutanil, diazinon, and malathion. Myclobutanil was applied at the rate of 1.6 oz of active ingredient (AI) in 400 gallons of water per acre, using the product Systhane WSP Ornamental Fungicide (EPA# 707-253). Diazinon 50W (EPA# 51036-163) was applied at 8 oz of AI in 400 gallons of water per acre. Malathion 8 Flowable (EPA# 10163-21) was applied at the rate of 12.8 oz AI in 400 gallons of water per acre. For the rose treatment, Clean Crop Diazinon 50 W (EPA# 100-460) was applied at 8 oz AI in 300 gallons of water per acre on 8/15/00 in the early morning. The greenhouses were allowed normal ventilation during and after application. Pesticide applications for the sites are reported in Appendix 1 and include treatments that were not part of the worker exposure monitoring. Table 1 presents the pesticide application date and date of worker exposure monitoring.

Table 1. Dates of pesticide application and worker entry into treated area

Crop	Pesticide applied	Application Date	Worker Entry Date
Carnations	Myclobutanil	6/12/1999	6/15/1999
			6/17/1999
		6/19/1999	6/22/1999
			6/23/1999
		6/23/1999	6/24/1999
	Diazinon	6/19/1999	6/22/1999
			6/24/1999
		7/3/1999	7/6/1999
			7/8/1999
	Malathion	7/3/1999	7/5/1999
			7/7/1999
Roses	Diazinon	8/15/2000	8/16/2000
			8/17/2000

Worker Characteristics

At the carnation site, three women and thirteen men were monitored for pesticide exposure during their workday. The three women were assigned to work one per each four-acre block. These three women did not harvest carnations but worked at disbudding or pinching, either removing all the side shoots to produce a single carnation or in the mini carnations removing the main shoot to produce more carnations on the laterals. Usually the women would work in the same section of the greenhouse all day performing these operations. These two tasks required them to reach across the beds to complete the work. This task was different than harvesting because it wasn't necessary to reach through the plant bed to cut the long stem and remove the flower. The task was performed while standing on a stool with their body facing the plant bed and reaching over into the plants where they would either pinch off the center flower or reach down and into the plants and disbud the side shoots. These women usually wore gloves, cloth or PVC, while performing this work task. The men would harvest in the morning and part of the afternoon. To complete the workday in the afternoon they would do disbudding, pinching or caging of plants in the other sections. Caging requires the worker to walk between the beds and either push the stems growing out the side of the beds back into the bed or break off any long stems growing outside the bed that could not be pushed back into the supporting net.

For the roses, all workers were male performing cutting of roses. Even when removing roses that were not marketable the task was essentially the same as cutting for market. We monitored their exposure in a greenhouse where diazinon was applied early in the morning. The workers were monitored for a half-day on the afternoon after the pesticide treatment. On the following day, two more half-day exposure periods were monitored. The periods consisted of the morning and afternoon with exposure media being removed at the lunch break and replaced with new exposure media until removal at the end of workday. Previous research[5] has shown that exposure periods of at least three hours can be used to accurately extrapolate to a full days work. This allowed us to collect representative data in the time made available to conduct the monitoring. All workers wore similar clothing including coveralls and heavy gloves.

Inhalation Monitoring

Samples were collected using MSA Escort Elf® personal air pumps operating at a flow of two liters per minute. The collection matrix was a 37-mm glass fiber filter, type AE, 1 µm pore size, (SKC number 225-7), backed with a support pad[6]. The filter was housed in a plastic cassette and sealed with self-sealing bands. It was attached via vinyl tubing to the personal air pump clipped to a webbed belt and the cassette was secured to the worker’s collar region. Elapsed time was recorded from each pump and multiplied by the liters per minute to get total liters collected. At the end of the sampling period the cassettes were removed from the sampling train, ends capped, and placed in a track seal bag. The bag was placed in an insulated cooler on dry ice. This sampling method traps particulate matter found in the air and not vapors. This method was used because of the low vapor pressures for the compounds being sampled and the sampling would not occur until approximately 24 hours after application.

At the carnation site, inhalation monitoring was conducted for a full day on the first day of exposure monitoring but for only half a day on all subsequent days. This was because during the morning of the second day workers complained of the pump catching on the plants or plant

supports when moving down the narrow pathways between the plant beds. The half-day air sampling was reached as a compromise because the workers were ready to drop out of the study if required to wear the pump the entire workday. For the rose site all sampling was for a half-day.

Dermal Exposure

Dermal exposure sampling was conducted for the entire day at the carnation site and for three half days at the rose site. Measurements were conducted using 100% cotton long sleeved t-shirts for the torso and arms. The long sleeved t-shirts were worn as upper body dosimeters for the duration of the monitoring interval under their normal work shirt. White knee-length socks (80% cotton and 20% polyester) were use to measure residues for the lower leg including feet and for extrapolating thigh exposure. All dermal sampling media were pre-washed twice in hot water before use. At the end of the sampling period, the t-shirt and socks were placed in separate labeled track seal bags and then double bagged.

Exposure to the hands and face/neck area were measured by wiping each area with a 100% cotton cloth 6 x 8-inch in size. Two wipes for the hands and two wipes for the face neck area were collected at the end of the workday. For the hands, sampling was conducted before any break, or at any time the worker wished to clean his hands. Wipes for the hands were combined as one sample for each worker each day and the two face/neck wipes were combined as one sample for that body region. Wipe samples were placed in one-pint canning jars capped with aluminum foil and sealed with standard canning lids and rings. Dermal sample collection at the end of the study day was conducted in the following order starting with hand wipes, face/neck wipes, long sleeved t-shirt, and removal of the socks. All samples were stored in insulated coolers with dry ice.

Dislodgeable Foliar Residues (DFR)

Sampling for foliar residues was conducted each day the workers wore dermal dosimetry. For the carnation leaves, DFR samples were collected by taking whole leaves and measuring the surface area with a Licor® model LI 3100 electronic area meter or by using a 1.25 cm^2 leaf punch, Rabbit Tool U.S.A, Inc. Leaf punch samples consisted of 160 leaf punches for a surface area of 400 cm^2 when counting both sides of the leaf. For the roses, a 5.0 cm^2 leaf punch was used and 40 punches were collected. Punches were taken randomly within the four to six foot range of the plant canopy. All leaf discs were collected in labeled four-ounce glass jars attached to the punch. Each sample jar was capped with a Teflon-lined lid, bagged, and placed on ice in an insulated chest. Samples were shipped on ice to the California Department of Food and Agriculture, Center for Analytical Chemistry (CDFA) laboratory the day of collection and sample extractions were completed the following day.

Sample Analysis

Dermal samples and DFR were analyzed by the California Department of Food and Agriculture (CDFA) Center for Analytical Chemistry. Leaf disks were shaken three times with 50 mL 0.02% sodium dioctyl sulfosuccinate solution, the combined amount of water was then extracted three times using 50 mL ethyl acetate. The organic extract was then dried by anhydrous sodium sulfate. Ethyl acetate was added to the dermal and inhalation samples and agitated 30 minutes or 60 minutes for the cotton long sleeved t-shirts. At this point, the diazinon and malathion were ready for analysis. For myclobutanil, an aliquot of methanol was exchanged before the sample

was ready for analysis. Table 2 reports the analytical conditions for the pesticides. Recoveries for fortifications and storage spikes at levels from 2 µg to 500 µg were above 90 % for diazinon and malathion. For myclobutanil recoveries, fortifications and storage spikes averaged over 90 %, except for the socks where interference's precluded accurate quantifying of spikes. Table 3 reports the limit of quantification for each matrix by pesticide.

Table 2. Analytical Conditions for the Pesticides

Pesticide	Instrument	Detector	Column	Oven Temp ^{o}C	Mobile phase or gas flow	Retention min
Diazinon & Malathion	HP 5890 GC	HP 7673 FPD	HP-5 10 m x 0.53 mm x 2.65 µ	150-220 program	27.5 mL/min	4.2 5.4
Myclobutanil	HP 1050 LC	HP 1050 UV	Phenomenex Luna C18, 2.00 mm x 150 mm x 5 µ	30	20-90% ACN, 0.4 mL/minute	11.8

Table 3. Pesticide and Matrix Limit of Quantification (LOQ) reported in µg/sample.

	Diazinon	Malathion	Myclobutanil
Cotton wipes	0.25	1	2.5
Glass fiber filters	0.025	0.1	0.25
Long sleeved t-shirts	1	1	25
Socks	1	1	30
Leaves	0.15	0.15	1

Data Analysis

Sample data were entered into a relational database. Analytical results for the DFR reported in micrograms per sample were divided by the surface area of the leaves and reported as µg/cm². Measurements include both sides of the leaf surface. Potential dermal exposures in carnations were calculated by summing the residues found on the dermal dosimetry for the wipes and shirt. The sum of the shirt and wipes were added to the calculated legs and feet exposure. For exposure to the legs and feet, sock residues were doubled. The leg was assumed to receive uniform deposition of the pesticides, thus exposure to the thighs (3663 cm^2)[7] whose surface area is similar to the lower legs and feet (3711 cm²)[7] was assumed equal to the sock region. Due to the low residues found on the socks no additional protection factor was used for residues of lower legs/feet (socks being used as a skin surrogate would be under a pair of socks). Rose exposure calculations were similar, except the half day of exposure monitoring had to be accounted for so wipes, shirt results were multiplied by a factor of two and the sock results were multiplied by a factor of four to also account for the exposure to the thigh region. For sample results below the limit of quantification (LOQ), the LOQ was used in place of none detected or zero exposure. Potential inhalation exposure was calculated by using filter residues reported as µg/sample divided by the total liters collected, multiplied by a breathing rate of 14 L/min[7] times the length of the workday in minutes.

Results

Dislodgeable Foliar Residues (DFR)

Myclobutanil results averaged 0.31 ± 0.04 µg/cm² for the five days dermal monitoring was conducted in carnations. Diazinon foliar residues during the exposure monitoring at the carnation site averaged 0.06 ± 0.04µg/cm². Malathion DFR levels were 0.32 and 0.58 µg/cm² for the two days worker exposure monitoring was conducted. The DFR levels for diazinon in roses were low at 0.004 - 0.005 µg/cm² even with the treatment having occurred the previous afternoon. Mean results by site, pesticide and exposure monitoring day are reported in Table 3. The daily results for the DFR sampling are reported in Appendix 2.

Potential Dermal and Inhalation Exposure

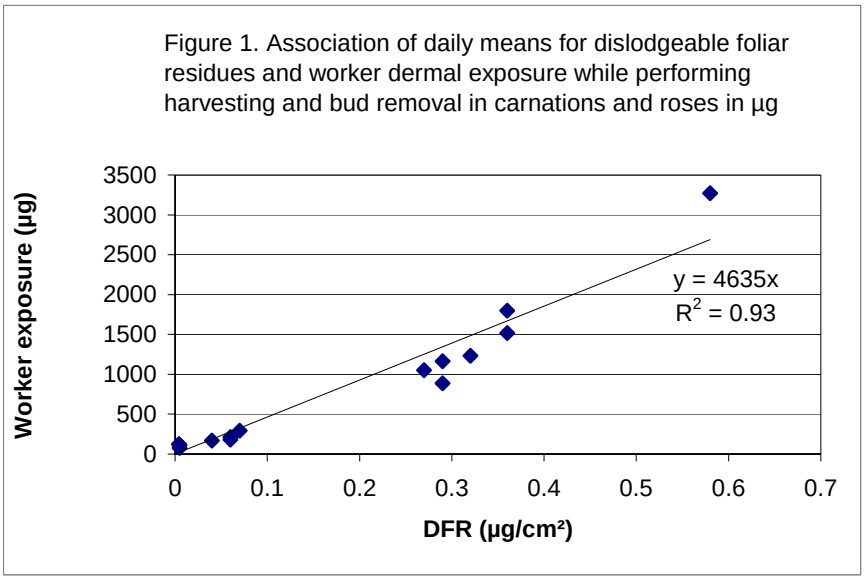
Table 4 presents mean daily potential dermal and inhalation exposure along with the corresponding DFR level for each day worker exposure-monitoring was conducted. In general, the potential dermal exposure levels fluctuated with the change in the DFR levels. As the DFR levels were higher, the corresponding dermal exposure levels also were higher. Linear regression was performed on the day means for DFR and potential exposure. Figure 1 shows the result of this regression with the regression coefficient or transfer factor. Appendices 3 though 6 present the exposure data by pesticide, site and monitoring day for each worker. Appendix 7 shows the relationship between DFR and dermal exposure figuratively for each site and pesticide. The raw data used to develop Table 4 and potential exposures for each worker are reported in Appendices 8 through 12.

Potential worker exposure in carnations averaged 1285 ± 368 µg for myclobutanil (dermal plus inhalation exposure) over the five days monitored. Worker exposure to malathion for the two exposure days averaged 2283 ± 1468 µg and were similar to those found for myclobutanil at DFR levels within the same range. Diazinon potential worker exposure was considerably lower; corresponding to the lower DFR levels, averaging 217 ± 56 µg. Average potential worker exposure in roses was estimated to be 95 ± 41 µg by doubling the half-day monitoring periods. This was lower than the levels found for myclobutanil and diazinon in carnations due to the ten to a hundred fold differences in the DFR results. Calculated potential inhalation exposures for both sites all workdays were usually below 20 µg except for one malathion exposure day on 7/5/99 where the results were 48 µg. For that day potential inhalation exposure to malathion ranged between 25 and 62 µg for the four workers monitored with the application having taken place two days earlier. These higher potential inhalation exposures were extrapolated from results of 2 µg to 4.8 µg malathion per sample, collecting 620 liters of air for five hours.

Table 4. Mean daily DFR levels, potential daily dermal and inhalation exposure levels by crop and pesticide.

Crop Pesticide	Day	DFR (µg/cm²)		Worker count	Mean PDE[a] ± sd (µg/day)	Mean PIE[b] ± sd µg/day
Carnations		N	Mean ± SD	N	Mean	Mean ± SD
Myclobutanil	6/15/99	6	0.27 ± 0.07	4	1052 ± 329	2.8 ± 5.2
	6/17/99	6	0.29 ± 0.08	6	1164 ± 861	2.3 ± 2.6
	6/22/99	3	0.36 ± 0.02	3	1798 ± 631	<LOQ[c] ± 0.0
	6/23/99	7	0.29 ± 0.20	4	887 ± 658	2.1 ± 4.2
	6/24/99	3	0.36 ± 0.04	3	1516 ± 592	1.3 ± 2.3
Diazinon	6/22/99	3	0.07 ± 0.02	3	295 ± 104	5.8 ± 2.4
	6/24/99	3	0.04 ± 0.004	3	169 ± 179	1.3 ± 1.7
	7/6/99	3	0.06 ± 0.006	3	213 ± 81	5.5 ± 3.8
	7/8/99	3	0.06 ± 0.004	3	182 ± 60	1.7 ± 0.5
Malathion	7/5/99	3	0.58 ± 0.16	4	3272 ± 2858	48.4 ± 18.5
	7/7/99	3	0.32 ± 0.22	8	1234 ± 957	11.7 ± 5.2
Roses						
Diazinon[d]	8/16/00	4	.004 ± 0.001	6	110 ± 36	NS[e]
	8/17/00	3	.005 ± 0.001	5	69 ± 35	17.9 ± 7.1
	8/17/00	3	.005 ± 0.003	6	100 ± 44	7.5 ± 5.9

a PDE = potential dermal exposure is the average daily dermal exposure from Appendices 2, 3, 4 and 5.
b PIE = potential inhalation exposure is the average daily inhalation exposure from Appendices 2, 3, 4 (calculated at a 14L/min breathing rate for a full work day.
c all results for that day were <0.25 µg per sample limit of quantification
d Potential dermal exposure was doubled because workers were monitored a half day. Inhalation exposures were calculated for an entire workday. (filter residues adjusted for liters collected a 14 L/min breathing rate and a full workday)
e NS = not sampled



Regional Exposure Distribution

Combined mean hand exposures for all days were significantly lower ($p < .05$) for the women who always wore gloves while disbudding and pinching. Their measured hand exposure residues from the wipes averaged 224, 8, and 5 µg for myclobutanil, diazinon and malathion respectively. Hand exposures for the men averaged 902, 54, and 484 µg for myclobutanil, diazinon and malathion, respectively. However, myclobutanil potential dermal exposures were the same at 1303 µg for the women and 1290 µg for the men. This was also true of diazinon where there was no significant difference ($p < .05$) between potential dermal exposures for the women and men at 297 µg and 162 µg, respectively. Malathion potential dermal exposure was significantly lower when wearing gloves, but the sample size for gloved workers was two and this was one woman monitored on two different days.

For the myclobutanil dermal exposures, the hands accounted for 70% of the exposure in men but only 17% for the women wearing gloves. For the women the shirts accounted for the majority of exposure. For women exposed to diazinon wearing gloves the hand wipes accounted for 3% and the long-sleeved shirts 92% of the potential dermal exposure. Face and neck wipes along with the sock measurements contributed only a small amount to the potential dermal exposure, as seen in Table 5. Unlike workers harvesting tree fruits or grapes, it is not necessary to get within or under the plant canopy because the middle of the beds can be reached at arms length, reducing the exposure potential to the face and neck from the plant leaves. Additionally, it is noticeably less dusty inside the greenhouse than in an orchard or vineyard. The raised beds, heavier type material worn for pants as opposed to shirt material, and no dust being kicked up from the wet ground likely explains the low residues for the socks (legs/feet).

Table 5. Regional Exposure Distribution (Percent)

Crop, Pesticide		Face/neck wipes	Hands wipes	Upper body t-shirts	Legs/feet socks
Carnations					
Myclobutanil	No glove	2	70	23	5[a]
	Gloved	1	17	77	5[a]
Diazinon	No glove	3	32	58	7
	Gloved	1	3	92	4
Malathion	No glove	1	21	77	1
	Gloved	1	2	93	4
Roses					
Diazinon	Gloved	2	2[b]	83	13

a Myclobutanil residues were below the 30 µg limit of quantification, at 30 µg the contribution would be 2%

b Workers always wore heavy gloves while working in roses.

Discussion

DFR results for the myclobutanil carnation treatments were similar to predicted mean DFR levels found on grapes[8] at a somewhat higher rate of application (grape treatments were 2 oz/acre and the carnation treatments were 1.6 oz/acre). For the grape treatments[8], the predicted limits ranged from 0.03 - 0.39 µg/cm² one-day post application to 0.023 - 0.23 µg/cm² ten days post application. For the five days, we monitored workers harvesting and performing other tasks in

carnations the DFRs ranged from 0.27 - 0.36 µg/cm². Diazinon DFR levels on carnations were similar to results previously reported by this branch[9], where average DFR's on cole crops were 0.09 and 0.02 µg/cm², one and two days post application respectively, at 8 oz of active ingredient per acre. These levels encompassed the range of DFR found during our worker exposure monitoring. Diazinon DFR levels on roses were ten fold lower. We were unable to witness this application but were told that the spray was directed at the top of the plant toward the buds. During harvest, the workers cut stems at least 30 inches below the bud. The leaf punching was performed at the height where the workers reached into the plant to cut the stem. This may account for the lower DFR levels. For the carnation treatments, the observed applications were sprayed over the entire plant.

Limited data is available post application for comparison of potential inhalation exposure, Brouwer et al (1992) reported a mean concentration of 0.07 mg/m^3 during cutting of carnations following dusting applications of zineb and thiram. Boleij et al. (1991) reported levels of 0.015 mg/m^3 three days after application of methomyl. For our study, the highest calculated potential inhalation did not exceed 0.003 mg/m^3. The American Conference of Governmental Industrial Hygienists[12] Threshold Limit Values (TLV) for diazinon and malathion inhalation exposure are 0.1 and 10 mg/m^3, respectively. This study is well under the TLV's for malathion and diazinon. Myclobutanil does not have an established TLV or permissible exposure limit. Giles et al (1994)[12] reported that 15 to 45 minutes after a full coverage application of permethrin to roses the air concentrations were below the detection limit of 0.3 µg/m^3. Rech et al (1988) also reported no detectable residues for five pesticides following venting of greenhouses. There would be no reason to believe that air concentrations in this study would behave any differently since the greenhouses in this study were allowed normal ventilation during and after pesticide treatment and reentry was at least one day after application. Therefore, the potential inhalation exposures measured particulates found in the air as the workers moved through the greenhouse and plants are shaken due to worker contact during harvest or other cultural practices.

The gloves did reduce hand exposures but appeared to have no effect on dermal exposure. This may be due to the low levels of exposure found and the way the long-sleeved t-shirts used to measure dermal exposure fit under the normal work clothing. Workers required a large or extra large t-shirt, but the arms of these shirts would be proportionally longer than the workers' arms. During the workday, the cuff/forearm portion of the long sleeve shirt would creep out from beneath the work shirt exposing the long sleeved t-shirt. Whether a worker pulled the work shirt down or left the t-shirt could easily influence exposures of less than one milligram. Additionally, when reaching across a plant bed, a worker's sleeve rode up the forearm, exposing the wrist and lower forearm area. During studies of field workers, under much dustier conditions, this has been observed when workers remove the shirts and noticeable dirt stains are seen on the forearm and wrist area of the long sleeved shirt used for the dermal exposure monitoring.

Dermal exposure has previously been measured during the cutting of carnations [1, 2], using cotton gloves that covered the hands and forearms, with reported dermal exposures averaging 15.2 mg/hr at DFR levels of 5 µg/cm^2 (surface area used one side of the leaf). The exposure period was just over one hour and the harvester was the owner/grower, unlike our study where the subjects are employed by the grower. While the use of gloves to measure hand exposure is common, this method may overestimate exposure[14, 15]. At this time, there has been no validation

for hand sampling methodology. The researchers[2] reported an overall transfer factor of 4500 cm^2/hr for workers in carnations. This is the relationship between dermal exposure and DFR. Other researchers[4, 16, 17] have reported average transfer factors of 5000 to10,000 cm^2/hr from work in strawberries and citrus. Two of these studies also used gloves to measure exposure[4,16] and one study used a solvent rinse handwash[17]. In this study, the differences in pesticide exposure relate to the variances in DFR at reentry as shown in Figure 1. The equation presented in Figure 1, $y = 4635x$, where x is the DFR, could be used as a transfer factor to estimate potential dermal exposure (y). Provided the DFR levels are within the range of results found in this study and the reentry time is one day or greater.

Quality Assurance Statement

The study "Pesticide exposure to Workers in Greenhouses", Worker Health and Safety Project Number 9801 followed the protocol "Pesticide Exposure to Workers in Greenhouses" having UCSF approval number H7420-15249-01. The resulting data and study report were sent for data/report audit on September 9, 2002 and reported to the study director and branch management on October 28, 2002.

Original signed by Kathy Orr *November 20, 2002*

Kathy Orr, Quality Assurance Officer Date
Worker Health and Safety Branch

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Appendix 1. Pesticide treatments in carnations two weeks prior to study and during study period.

Greenhouse	Section	Date	Pesticide	Pesticide[a]
3	11	6/5/1999	dimethoate	
2	6	6/5/1999	avermectin	
1	4	6/5/1999	EBDC	fluvalinate
2	5	6/9/1999	methiocarb	
3	10	6/11/1999	conserve	
1	1	6/12/1999	myclobutanil	methiocarb
3	11	6/12/1999	conserve	
2	5	6/16/1999	dienochlor	
2	6	6/16/1999	botanigard	
1	2	6/16/1999	botanigard	
2	7	6/19/1999	myclobutanil	
2	7	6/19/1999	myclobutanil	dienochlor
1	3	6/19/1999	myclobutanil	diazinon
3	12	6/19/1999	botanigard	
1	4	6/23/1999	botanigard	
2	8	6/23/1999	myclobutanil	
2	8	6/24/1999	myclobutanil	fluvalinate
3	11	6/25/1999	fluvalinate	dienochlor
3	10	6/26/1999	dimethoate	EBDC
1	1	6/26/1999	botanigard	
2	6	6/26/1999	dienochlor	
2	7	7/1/1999	dienochlor	
3	11	7/3/1999	malathion	
2	8	7/3/1999	diazinon	
1	3	7/3/1999	dienochlor	avermectin
2	8	7/7/1999	dienochlor	diazinon

Rose treatments two weeks prior to study

Bay Numbers	Date	Pesticide	
All Bays	8/15/2000	diazinon[b]	
3,5	8/14/2000	piperalin	
All Bays	8/12/2000	azadirachtin	
1,5,6,7,8,9	8/8/2000	potassium bicarbonate	
3,4	8/6/2000	potassium bicarbonate	
1 - 7	8/5/2000	azadirachtin	
1	8/1/2000	potassium bicarbonate	
All Bays	7/31/2000	propiconazole	

a = Column is blank if two pesticides were not used in the mix
b = Previous diazinon treatment was to entire greenhouse on 6/7/2000

Appendix 2: Carnation dislodgeable foliar residue data
reported by sample number, µg/sample and µg/cm²

Sample No	Greenhouse section	Date	Myclobutanil µg	Diazinon µg	Malathion µg	area cm²	Myclobutanil µg/cm²	Diazinon µg/cm²	Malathion µg/cm²
45	3	6/24/1999	126.00	17.10		400	0.32	0.04	
46	3	6/24/1999	156.00	16.30		400	0.39	0.04	
47	3	6/24/1999	154.00	14.10		400	0.39	0.04	
92	3	6/23/1999	207.00			400	0.52		
93	3	6/23/1999	175.00			400	0.44		
94	3	6/23/1999	206.00			400	0.52		
95	7	6/23/1999	73.80			400	0.18		
96	7	6/23/1999	54.10			400	0.14		
97	7	6/23/1999	54.30			400	0.14		
98	11	6/23/1999	28.70			400	0.07		
145	3	6/22/1999	143.00	22.30		400	0.36	0.06	
146	3	6/22/1999	149.00	39.50		400	0.37	0.10	
147	3	6/22/1999	136.00	23.40		400	0.34	0.06	
192	1	6/17/1999	110.00			400	0.28		
193	1	6/17/1999	149.00			400	0.37		
194	1	6/17/1999	152.00			400	0.38		
195	2	6/17/1999	78.70			400	0.20		
196	2	6/17/1999	106.00			400	0.27		
197	2	6/17/1999	91.40			400	0.23		
244	2	6/15/1999	128.00			400	0.32		
245	2	6/15/1999	135.00			400	0.34		
246	1	6/15/1999	130.00			400	0.33		
247	2	6/15/1999	103.00			400	0.26		
248	2	6/15/1999	70.00			400	0.18		
249	2	6/15/1999	74.50			400	0.19		
254	11	7/5/1999			252.00	388			0.65
255	11	7/5/1999			188.00	472			0.40
256	11	7/5/1999			315.00	462			0.68
263	11	7/7/1999			281.00	490			0.57
264	11	7/7/1999			61.40	432			0.14
265	11	7/7/1999			124.00	482			0.23
266	8	7/6/1999		27.30		400		0.07	
267	8	7/6/1999		23.50		416		0.06	
268	8	7/6/1999		27.30		426		0.06	
272	8	7/8/1999		22.10		400		0.06	
273	8	7/8/1999		25.00		400		0.06	
274	8	7/8/1999		24.70		400		0.06	

Appendix 3: Myclobutanil potential dermal and inhalation exposure by worker and day (µgs) while harvesting and performing cultural practices in greenhouses growing carnations.

Date	Worker	Face/neck	Hands	Arms/torso	Legs/feet[a]	PDE[b]	PIE[c]
6/15/1999	5[d]	22	282	736	<60	1100	3
6/15/1999	12	31	1273	147	<60	1511	<1
6/15/1999	14	12	602	457	<60	1131	5
6/15/1999	11	14	481	150	<60	705	<1
6/17/1999	5[d]	12	86	631	<60	789	<1
6/17/1999	14	7	363	111	<60	541	<1
6/17/1999	10	8	490	644	<60	1202	3
6/17/1999	11	8	498	225	<60	791	<1
6/17/1999	12	126	2604	122	<60	2912	3
6/17/1999	2	8	549	492	<60	1109	5
6/22/1999	12	40	1888	308	<60	2296	<1
6/22/1999	2	17	1502	565	<60	2144	<1
6/22/1999	16[d]	8	102	965	<60	1135	<1
6/23/1999	16[d]	7	214	1484	<60	1765	<1
6/23/1999	5[d]	9	364	449	<60	882	7.76
6/23/1999	14	4	72	25	<60	157	<1
6/23/1999	11	4	501	418	<60	983	<1
6/24/1999	16[d]	15	299	1776	<60	2150	<1
6/24/1999	2	11	498	398	<60	967	<1
6/24/1999	12	20	1304	228	<60	1612	4

a Legs/feet = Sock result was doubled to account for upper leg exposure. Limit of quantification (LOQ) was 30 µg, twice the LOQ was used because all samples were below the LOQ.

b DE = potential dermal exposure (hands + face/neck + upper body + legs/feet)

c PIE = potential inhalation exposure filter residues adjusted for liters collected a 14 L/min breathing rate and a 9½ hour workday

d Female workers wearing gloves disbudding or pinching plants

Appendix 4: Diazinon potential dermal and inhalation exposure by worker and day (µgs) while harvesting and performing cultural practices in greenhouses growing carnations.

Date	Worker	Face/neck	Hands	Arms/torso	Legs/feet[a]	PDE[b]	PIE[c]
6/22/1999	12	9	178	75	11	273	8
6/22/1999	2	7	81	93	21	201	3
6/22/1999	16[d]	5	15	377	11	408	7
6/24/1999	16[d]	2	15	337	20	375	<1
6/24/1999	2	1	14	34	6	55	<1
6/24/1999	12	1	53	18	4	76	3
7/6/1999	5[d]	1	2	250	13	265	8
7/6/1999	17	4	17	212	23	256	5
7/6/1999	11	2	46	48	24	120	1
7/8/1999	5[d]	1	2	131	6	140	1
7/8/1999	6	1	28	195	<2	224	2
7/8/1999	11	3	12	74	2	92	3

a Legs/feet = Sock result was doubled to account for upper leg exposure. Limit of quantification (LOQ) was 1 µg, twice the LOQ was used for samples that were below the LOQ.
b DE =potential dermal exposure (hands + face/neck + upper body + legs/feet)
c PIE = potential inhalation exposure filter residues adjusted for liters collected a 14 L/min breathing rate and a 9½ hour workday)
d Female workers wearing gloves disbudding or pinching plants

Appendix 5: Malathion potential dermal and inhalation exposure by worker and day (µgs) while harvesting and performing cultural practices in greenhouses growing carnations.

Date	Worker	Face/neck	Hands	Arms/torso	Legs/feet	PDE[b]	**PIE**
7/5/1999	9	5	52	1997	<2	2054	25
7/5/1999	6	9	2075	5063	4	7150	56
7/5/1999	7	11	795	2622	6	3434	62
7/5/1999	13[d]	3	4	423	20	450	38
7/7/1999	3	3	335	375	<2	713	13
7/7/1999	1	2	309	800	5	1116	16
7/7/1999	8	2	105	1244	<2	1351	21
7/7/1999	15	58	599	2290	28	2975	19
7/7/1999	6	<1	11	65	<2	76	<1
7/7/1999	7	49	511	1523	13	2096	21
7/7/1999	9	4	43	1254	<2	1302	143
7/7/1999	13[d]	2	7	219	6	234	73

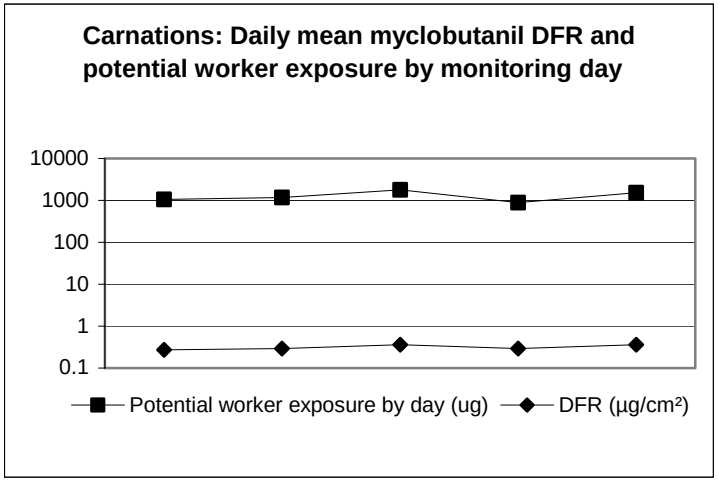
a Legs/feet = Sock result was doubled to account for upper leg exposure. Limit of quantification (LOQ) was 1 µg, twice the LOQ was used for samples that were below the LOQ.
b PDE = potential dermal exposure (hands + face/neck + upper body + legs/feet)
c PIE = potential inhalation exposure (filter residues adjusted for liters collected a 14 L/min breathing rate and a 9½ hour workday)
d Female workers wearing gloves disbudding or pinching plants

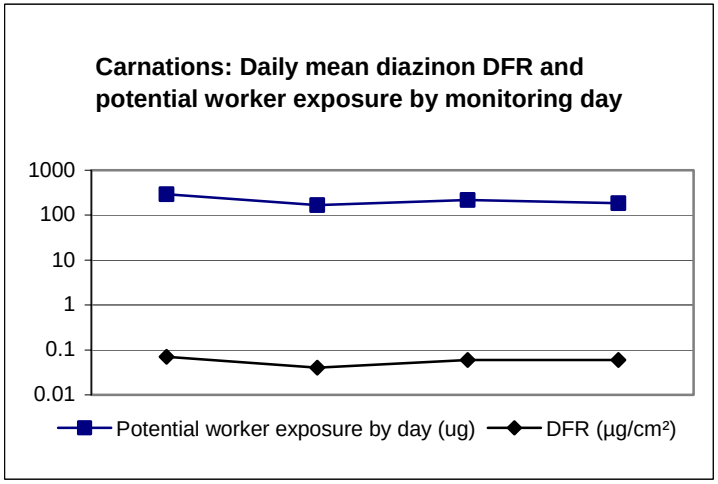
Appendix 6: Diazinon potential dermal and inhalation exposure by worker (µgs) while harvesting and performing cultural practices in greenhouses growing roses.[a]

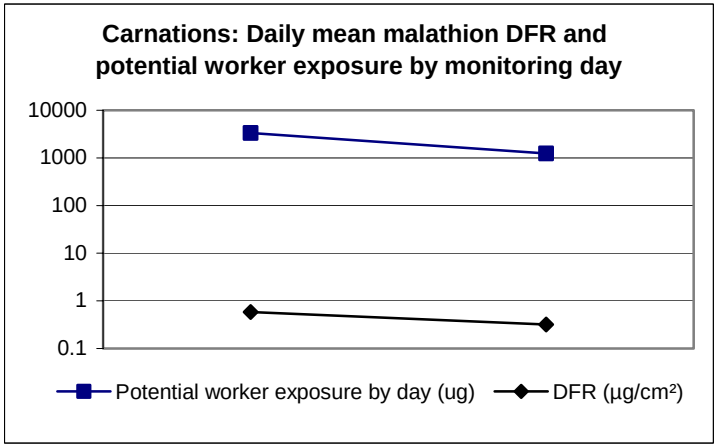
Date	Worker	Face/neck	Hands	Arms/torso	Legs/feet	PDE[c]	PIE[d]
8/16/00 pm	21	4.2	1.0	84.4	12.2	101.9	NS[e]
8/16/00 pm	22	4.5	0.7	42.8	4.0	52.1	NS
8/16/00 pm	23	2.9	1.3	110.0	13.0	127.2	NS
8/16/00 pm	24	5.5	1.1	103.2	19.5	129.4	NS
8/16/00 pm	25	2.8	1.4	141.4	12.2	157.8	NS
8/16/00 pm	27	4.0	9.7	71.4	11.7	96.8	NS
8/17/00 am	21	2.6	0.6	64.2	11.4	78.7	23.1
8/17/00 am	23	2.8	0.8	21.8	24.0	49.5	22.6
8/17/00 am	24	1.3	6.4	116.0	4.0	127.7	Lost
8/17/00 am	25	1.0	0.3	41.2	8.1	50.5	7.7
8/17/00 am	27	1.5	1.5	29.2	9.2	41.4	18.1
8/17/00 pm	21	2.0	1.1	95.8	10.5	109.4	14.9
8/17/00 pm	23	1.3	0.6	109.2	21.6	132.7	0.6
8/17/00 pm	24	0.7	0.6	104.6	22.1	128.0	5.6
8/17/00 pm	25	0.7	0.3	127.2	10.9	139.0	3.2
8/17/00 pm	26	1.4	0.3	23.2	4.0	28.8	14.7
8/17/00 pm	27	1.2	2.4	49.8	11.2	64.6	5.9

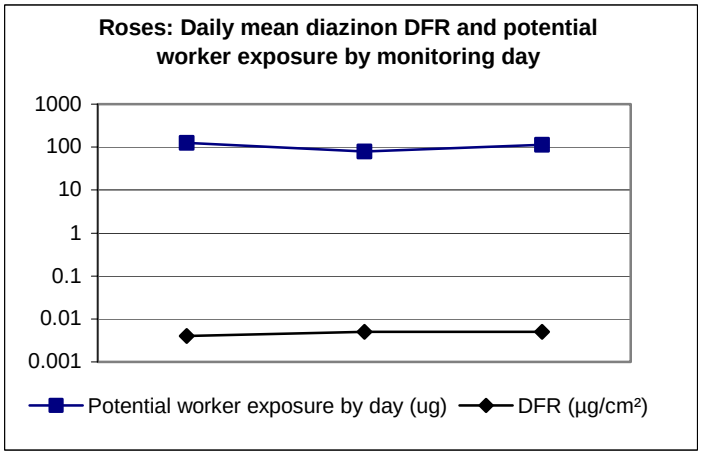
a Sampling was conducted on three half-days and results are multiplied by two for full day exposure.
b Legs/feet = Sock result were multiplied by four to account for upper leg exposure and a full day exposure.
c PDE =potential dermal exposure (hands + face/neck + upper body + legs/feet)
d PIE = potential inhalation exposure (filter residues adjusted for liters collected a 14 L/min breathing rate and a nine hour workday)
e NS = No sample

Appendix 7: DFR and potential worker exposure by site and pesticide.









Appendix 8: Myclobutanil use in carnations dermal exposure data by sample number

WHS Sample No	Matrix	Worker	Date	µg myclobutanil
1	Shirt	5	6/15/1999	736.00
2	Shirt	12	6/15/1999	147.00
3	Shirt	14	6/15/1999	457.00
4	Shirt	11	6/15/1999	150.00
8	Shirt	5	6/17/1999	631.00
9	Shirt	14	6/17/1999	111.00
10	Shirt	10	6/17/1999	644.00
11	Shirt	11	6/17/1999	225.00
12	Shirt	12	6/17/1999	122.00
13	Shirt	2	6/17/1999	492.00
14	Shirt	12	6/22/1999	308.00
15	Shirt	2	6/22/1999	565.00
16	Shirt	16	6/22/1999	965.00
18	Shirt	5	6/23/1999	449.00
19	Shirt	14	6/23/1999	25.00
20	Shirt	11	6/23/1999	418.00
21	Shirt	16	6/23/1999	1484.00
24	Shirt	16	6/24/1999	1776.00
25	Shirt	2	6/24/1999	398.00
26	Shirt	12	6/24/1999	228.00
51	Socks	5	6/15/1999	< 30
52	Socks	12	6/15/1999	< 30
53	Socks	14	6/15/1999	< 30
54	Socks	11	6/15/1999	< 30
55	Socks	10	6/15/1999	< 30
58	Socks	5	6/17/1999	< 30
59	Socks	14	6/17/1999	< 30
60	Socks	10	6/17/1999	< 30
61	Socks	11	6/17/1999	< 30
62	Socks	12	6/17/1999	< 30
63	Socks	2	6/17/1999	< 30
64	Socks	16	6/22/1999	< 30
65	Socks	12	6/22/1999	< 30
66	Socks	2	6/22/1999	< 30
69	Socks	16	6/23/1999	< 30
70	Socks	5	6/23/1999	< 30
71	Socks	14	6/23/1999	< 30
72	Socks	11	6/23/1999	< 30
74	Socks	16	6/24/1999	< 30
75	Socks	2	6/24/1999	< 30
76	Socks	12	6/24/1999	< 30
101	Face/neck wipes	5	6/15/1999	21.70
102	Face/neck wipes	12	6/15/1999	31.30
103	Face/neck wipes	14	6/15/1999	11.90
104	Face/neck wipes	11	6/15/1999	14.20

Appendix 8: Myclobutanil use in carnations dermal exposure data by sample number

WHS Sample No	Matrix	Worker	Date	µg myclobutanil
107	Face/neck wipes	5	6/17/1999	12.40
108	Face/neck wipes	14	6/17/1999	6.82
109	Face/neck wipes	10	6/17/1999	7.80
110	Face/neck wipes	11	6/17/1999	8.29
111	Face/neck wipes	12	6/17/1999	126.00
112	Face/neck wipes	2	6/17/1999	7.66
113	Face/neck wipes	12	6/22/1999	40.20
114	Face/neck wipes	2	6/22/1999	16.80
115	Face/neck wipes	16	6/22/1999	7.74
117	Face/neck wipes	5	6/23/1999	8.53
118	Face/neck wipes	14	6/23/1999	< 2.5
119	Face/neck wipes	11	6/23/1999	4.24
120	Face/neck wipes	16	6/23/1999	6.54
122	Face/neck wipes	16	6/24/1999	15.00
123	Face/neck wipes	2	6/24/1999	11.00
124	Face/neck wipes	12	6/24/1999	19.90
151	Handwipes	5	6/15/1999	282.00
152	Handwipes	12	6/15/1999	1273.00
153	Handwipes	14	6/15/1999	602.00
154	Handwipes	11	6/15/1999	481.00
157	Handwipes	5	6/17/1999	85.50
158	Handwipes	14	6/17/1999	363.00
159	Handwipes	10	6/17/1999	490.00
160	Handwipes	11	6/17/1999	498.00
161	Handwipes	12	6/17/1999	2604.00
162	Handwipes	2	6/17/1999	549.00
163	Handwipes	12	6/22/1999	1888.00
164	Handwipes	2	6/22/1999	1502.00
165	Handwipes	16	6/22/1999	102.00
166	Handwipes	16	6/23/1999	214.00
167	Handwipes	5	6/23/1999	364.00
168	Handwipes	14	6/23/1999	71.80
169	Handwipes	11	6/23/1999	501.00
170	Handwipes	16	6/24/1999	299.00
171	Handwipes	2	6/24/1999	498.00
172	Handwipes	12	6/24/1999	1304.00

Appendix 9: Diazinon use in carnations dermal exposure data by sample number

WHS Sample No	Matrix	Worker	Date	µg diazinon
14	Shirt	12	6/22/1999	75.80
15	Shirt	2	6/22/1999	93.80
16	Shirt	16	6/22/1999	377.00
24	Shirt	16	6/24/1999	337.00
25	Shirt	2	6/24/1999	34.40
26	Shirt	12	6/24/1999	18.20
34	Shirt	5	7/6/1999	250.00
35	Shirt	17	7/6/1999	212.00
36	Shirt	11	7/6/1999	47.70
64	Socks	16	6/22/1999	5.72
65	Socks	12		5.49
66	Socks	2	6/22/1999	10.60
74	Socks	16	6/24/1999	10.20
75	Socks	2	6/24/1999	2.99
76	Socks	12	6/24/1999	1.85
84	Socks	5	7/6/1999	6.26
85	Socks	17	7/6/1999	11.30
86	Socks	11	7/6/1999	12.00
113	Face/neck wipes	12	6/22/1999	8.70
114	Face/neck wipes	2	6/22/1999	6.51
115	Face/neck wipes	16	6/22/1999	4.94
122	Face/neck wipes	16	6/24/1999	2.38
123	Face/neck wipes	2	6/24/1999	0.67
124	Face/neck wipes	12	6/24/1999	1.18
132	Face/neck wipes	5	7/6/1999	1.30
133	Face/neck wipes	17	7/6/1999	4.30
134	Face/neck wipes	11	7/6/1999	1.77
163	Handwipes	12	6/22/1999	178.00
164	Handwipes	2	6/22/1999	80.50
165	Handwipes	16	6/22/1999	14.80
170	Handwipes	16	6/24/1999	15.30
171	Handwipes	2	6/24/1999	13.80
172	Handwipes	12	6/24/1999	52.70
181	Handwipes	5	7/6/1999	1.65
182	Handwipes	17	7/6/1999	16.80
183	Handwipes	11	7/6/1999	46.30
286	Shirt	5	7/8/1999	131.00
287	Shirt	6	7/8/1999	195.00
288	Shirt	11	7/8/1999	74.10
311	Socks	5	7/8/1999	2.94
312	Socks	6	7/8/1999	<1
313	Socks	11	7/8/1999	1.00
335	Face/neck wipes	5	7/8/1999	0.88
336	Face/neck wipes	6	7/8/1999	1.40
337	Face/neck wipes	11	7/8/1999	3.44
364	Handwipes	5	7/8/1999	1.79
365	Handwipes	6	7/8/1999	27.90
366	Handwipes	11	7/8/1999	12.30

Appendix 10: Malathion use in carnations, dermal exposure data by sample number

WHS Sample No	Matrix	Worker	Date	µg malathion
27	Shirt	9	7/5/1999	1997.00
28	Shirt	6	7/5/1999	5063.00
29	Shirt	7	7/5/1999	2622.00
30	Shirt	13	7/5/1999	423.00
77	Socks	9	7/5/1999	<1
78	Socks	6	7/5/1999	1.81
79	Socks	7	7/5/1999	2.85
80	Socks	13	7/5/1999	10.20
125	Face/neck wipes	9	7/5/1999	4.53
126	Face/neck wipes	6	7/5/1999	8.57
127	Face/neck wipes	7	7/5/1999	10.90
128	Face/neck wipes	13	7/5/1999	3.21
174	Handwipes	6	7/5/1999	2075.00
175	Handwipes	7	7/5/1999	795.00
176	Handwipes	13	7/5/1999	3.87
177	Handwipes	9	7/5/1999	52.00
276	Shirt	3	7/7/1999	375.00
277	Shirt	1	7/7/1999	800.00
278	Shirt	8	7/7/1999	1244.00
279	Shirt	15	7/7/1999	2290.00
280	Shirt	6	7/7/1999	64.70
281	Shirt	7	7/7/1999	1523.00
282	Shirt	9	7/7/1999	1254.00
283	Shirt	13	7/7/1999	219.00
301	Socks	3	7/7/1999	<1
302	Socks	1	7/7/1999	2.50
303	Socks	8	7/7/1999	<1
304	Socks	15	7/7/1999	14.10
305	Socks	6	7/7/1999	<1
306	Socks	7	7/7/1999	6.38
307	Socks	9	7/7/1999	<1
308	Socks	13	7/7/1999	3.17
326	Face/neck wipes	3	7/7/1999	3.47
327	Face/neck wipes	1	7/7/1999	2.46
328	Face/neck wipes	8	7/7/1999	1.99
329	Face/neck wipes	15	7/7/1999	58.30
330	Face/neck wipes	6	7/7/1999	<1
331	Face/neck wipes	7	7/7/1999	49.30
332	Face/neck wipes	9	7/7/1999	4.47
333	Face/neck wipes	13	7/7/1999	1.70
350	Handwipes	3	7/7/1999	335.00
351	Handwipes	1	7/7/1999	309.00
352	Handwipes	8	7/7/1999	105.00
353	Handwipes	15	7/7/1999	599.00
354	Handwipes	6	7/7/1999	11.20
355	Handwipes	7	7/7/1999	511.00
356	Handwipes	9	7/7/1999	43.30
357	Handwipes	13	7/7/1999	6.61

Appendix 11: Air sampling data in carnations reported by sample number, µg/sample

WHS Sample No	Worker	Date	Pump	Run time minutes	Liters collected	Myclobutanil µg/sample	Diazinon µg/sample	Malathion µg/sample
201	5	6/15/99	50699	617	1234	0.49		
202	12	6/15/99	50700	635	1270	<0.25		
203	14	6/15/99	50703	608	1216	0.76		
204	11	6/15/99	50705	625	1250	<0.25		
207	5	6/17/99	50699	314	628	<0.25		
208	14	6/17/99	50703	316	632	<0.25		
209	10	6/17/99	50709	327	654	0.28		
210	11	6/17/99	50705	313	626	<0.25		
211	12	6/17/99	50700	314	628	0.26		
212	2	6/17/99	50706	332	664	0.43		
214	12	6/22/99	50700	319	638	<0.25	0.61	
215	2	6/22/99	50706	326	652	<0.25	0.25	
216	16	6/22/99	50709	158	316	<0.25	0.27	
218	16	6/23/99	50709	308	616	<0.25		
219	5	6/23/99	50699	307	614	0.60		
220	14	6/23/99	50703	310	620	<0.25		
221	11	6/23/99	50705	309	618	<0.25		
223	16	6/24/99	50709	306	612	<0.25	0.26	
224	2	6/24/99	50706	312	624	<0.25	0.16	
225	12	6/24/99	50700	316	632	0.28	0.26	
227	9	7/5/99	50709	311	622			1.97
228	6	7/5/99	50703	310	620			4.34
229	7	7/5/99	00755	310	620			4.78
230	13	7/5/99	50705	287	574			2.74
234	5	7/6/99	50709	307	614		0.65	
235	17	7/6/99	50703	316	632		0.42	
236	11	7/6/99	50705	315	630		0.11	
376	3	7/7/99	50701	200	400			0.64
377	1	7/7/99	50702	214	428			0.91
378	8	7/7/99	50705	212	424			1.13
379	15	7/7/99	50706	208	416			0.99
380	6	7/7/99	50703	182	364			<0.1
381	7	7/7/99	50700	213	426			1.13
382	9	7/7/99	50709	210	420			0.76
383	13	7/7/99	00755	309	618			0.56
386	5	7/8/99	50699	300	600		0.08	
387	6	7/8/99	50703	218	436		0.13	
388	11	7/8/99	50705	211	422		0.15	

Appendix 12: Diazinon use in roses data reported by sample number and µg/sample

Study ID	Sample no	Project #	Type	Worker Number	Comment	Minutes	diazinon µg's
FS00	1	Project 9801	Air filter	24	lost was spraying ornazin		
FS00	3	Project 9801	Air filter	23	set 2 pump#50702	134	0.80
FS00	4	Project 9801	Air filter	21	set 2 pump#00753	133	0.81
FS00	5	Project 9801	Air filter	25	set 2 pump#00751	134	0.27
FS00	6	Project 9801	Air filter	27	set 2 pump#50705	137	0.66
FS00	7	Project 9801	Air filter	24	set 3 pump#	157	0.23
FS00	8	Project 9801	Air filter	23	set 3 pump#50702	162	0.03
FS00	9	Project 9801	Air filter	21	set 3 pump#00753	69	0.27
FS00	10	Project 9801	Air filter	25	set 3 pump#00751	159	0.14
FS00	11	Project 9801	Air filter	27	set 3 pump#50705	116	0.18
FS00	12	Project 9801	Air filter	26	set 3 pump#50700	64	0.25
FS00	81	Project 9801	Handwipes	24	set 1 Aug 16 pm		0.56
FS00	82	Project 9801	Handwipes	22	set 1 Aug 16 pm		0.36
FS00	83	Project 9801	Handwipes	23	set 1 Aug 16 pm		0.66
FS00	84	Project 9801	Handwipes	21	set 1 Aug 16 pm		0.51
FS00	85	Project 9801	Handwipes	25	set 1 Aug 16 pm		0.67
FS00	86	Project 9801	Handwipes	27	set 1 Aug 16 pm		4.87
FS00	87	Project 9801	Handwipes	21	set 2 Aug 17 am		0.29
FS00	88	Project 9801	Handwipes	24	set 2 Aug 17 am		3.21
FS00	89	Project 9801	Handwipes	23	set 2 Aug 17 am		0.41
FS00	91	Project 9801	Handwipes	25	set 2 Aug 17 am		0.13
FS00	92	Project 9801	Handwipes	27	set 2 Aug 17 am		0.73
FS00	93	Project 9801	Handwipes	24	set 3 Aug 17 pm		0.29
FS00	94	Project 9801	Handwipes	23	set 3 Aug 17 pm		0.32
FS00	95	Project 9801	Handwipes	21	set 3 Aug 17 pm		0.55
FS00	96	Project 9801	Handwipes	25	set 3 Aug 17 pm		0.13
FS00	97	Project 9801	Handwipes	27	set 3 Aug 17 pm		1.22
FS00	98	Project 9801	Handwipes	26	set 3 Aug 17 pm		0.13
FS00	161	Project 9801	Face/neck wipes	24	set 1 Aug 16 pm		2.77
FS00	162	Project 9801	Face/neck wipes	22	set 1 Aug 16 pm		2.27
FS00	163	Project 9801	Face/neck wipes	23	set 1 Aug 16 pm		1.45
FS00	164	Project 9801	Face/neck wipes	21	set 1 Aug 16 pm		2.11
FS00	165	Project 9801	Face/neck wipes	25	set 1 Aug 16 pm		1.39
FS00	166	Project 9801	Face/neck wipes	27	set 1 Aug 16 pm		1.99
FS00	168	Project 9801	Face/neck wipes	24	set 2 Aug 17 am		0.65
FS00	169	Project 9801	Face/neck wipes	23	set 2 Aug 17 am		1.42
FS00	170	Project 9801	Face/neck wipes	21	set 2 Aug 17 am		1.28
FS00	171	Project 9801	Face/neck wipes	25	set 2 Aug 17 am		0.48
FS00	172	Project 9801	Face/neck wipes	27	set 2 Aug 17 am		0.73
FS00	173	Project 9801	Face/neck wipes	24	set 3 Aug 17 pm		0.35
FS00	174	Project 9801	Face/neck wipes	23	set 3 Aug 17 pm		0.63
FS00	175	Project 9801	Face/neck wipes	21	set 3 Aug 17 pm		1.01
FS00	176	Project 9801	Face/neck wipes	25	set 3 Aug 17 pm		0.34
FS00	177	Project 9801	Face/neck wipes	27	set 3 Aug 17 pm		0.60
FS00	178	Project 9801	Face/neck wipes	26	set 3 Aug 17 pm		0.69
FS00	241	Project 9801	Socks	24	set 1 Aug 16 pm		4.88
FS00	242	Project 9801	Socks	22	set 1 Aug 16 pm		1.00
FS00	243	Project 9801	Socks	23	set 1 Aug 16 pm		3.24

Appendix 12: Diazinon use in roses data reported by sample number and µg/sample

Study ID	Sample no	Project #	Type	Worker Number	Comment	Minutes	diazinon µg's
FS00	244	Project 9801	Socks	21	set 1 Aug 16 pm		3.06
FS00	245	Project 9801	Socks	25	set 1 Aug 16 pm		3.06
FS00	246	Project 9801	Socks	27	set 1 Aug 16 pm		2.93
FS00	248	Project 9801	Socks	24	set 2 Aug 17 am		1.00
FS00	249	Project 9801	Socks	23	set 2 Aug 17 am		6.00
FS00	250	Project 9801	Socks	21	set 2 Aug 17 am		2.84
FS00	251	Project 9801	Socks	25	set 2 Aug 17 am		2.02
FS00	252	Project 9801	Socks	27	set 2 Aug 17 am		2.31
FS00	254	Project 9801	Socks	24	set 3 Aug 17 pm		5.53
FS00	255	Project 9801	Socks	23	set 3 Aug 17 pm		5.39
FS00	256	Project 9801	Socks	21	set 3 Aug 17 pm		2.62
FS00	257	Project 9801	Socks	25	set 3 Aug 17 pm		2.73
FS00	258	Project 9801	Socks	27	set 3 Aug 17 pm		2.79
FS00	259	Project 9801	Socks	26	set 3 Aug 17 pm		1.00
FS00	321	Project 9801	Shirt	24	set 1 Aug 16 pm		51.60
FS00	322	Project 9801	Shirt	22	set 1 Aug 16 pm		21.40
FS00	323	Project 9801	Shirt	23	set 1 Aug 16 pm		55.00
FS00	324	Project 9801	Shirt	21	set 1 Aug 16 pm		42.20
FS00	325	Project 9801	Shirt	25	set 1 Aug 16 pm		70.70
FS00	326	Project 9801	Shirt	27	set 1 Aug 16 pm		35.70
FS00	328	Project 9801	Shirt	24	set 2 Aug 17 am		58.00
FS00	329	Project 9801	Shirt	23	set 2 Aug 17 am		10.90
FS00	330	Project 9801	Shirt	21	set 2 Aug 17 am		32.10
FS00	331	Project 9801	Shirt	25	set 2 Aug 17 am		20.60
FS00	332	Project 9801	Shirt	27	set 2 Aug 17 am		14.60
FS00	334	Project 9801	Shirt	24	set 3 Aug 17 pm		52.30
FS00	335	Project 9801	Shirt	23	set 3 Aug 17 pm		54.60
FS00	336	Project 9801	Shirt	21	set 3 Aug 17 pm		47.90
FS00	337	Project 9801	Shirt	25	set 3 Aug 17 pm		63.60
FS00	338	Project 9801	Shirt	27	set 3 Aug 17 pm		24.90
FS00	339	Project 9801	Shirt	26	set 3 Aug 17 pm		11.60
FS00	401	Project 9802	DFR		Aug 16		1.06
FS00	402	Project 9803	DFR		Aug 16		2.00
FS00	403	Project 9804	DFR		Aug 16		0.90
FS00	404	Project 9805	DFR		Aug 16		1.71
FS00	405	Project 9806	DFR		Aug 17		2.55
FS00	406	Project 9807	DFR		Aug 17		1.91
FS00	407	Project 9808	DFR		Aug 17		1.60
FS00	408	Project 9809	DFR		Aug 17		3.31
FS00	409	Project 9810	DFR		Aug 17		1.74
FS00	410	Project 9811	DFR		Aug 17		0.86