Illness Among Grape Girdlers
Associated with Dermal Exposure to Methomyl

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Abstract

An illness outbreak on May 24 and May 25, 1988 characterized by nausea, vomiting, dizziness, headache, and abdominal pain occurred among 12 members of a crew of 16 workers, employed "girdling" grapes near Delano, California. Depressed or low normal levels of both red blood cell (RBC) and plasma cholinesterase were found in 12 of 13 workers tested. Four workers hospitalized for observation were asymptomatic on May 26 and were discharged. RBC cholinesterase activity measured taken on the evening of May 25 or the early morning of May 26 revealed a 20% increase relative to the initial tests taken 8 to 12 hours earlier in the emergency room. Followup interviews conducted May 26 and 27 with 9 non-hospitalized workers indicated that symptoms in this group were also transient. Repeat cholinesterase tests taken May 30 for 7 of these 9 workers demonstrated complete recovery of cholinesterase activity. For this group, mean depression at the time of illness relative to the follow-up tests was 34% for RBC and 35% for plasma cholinesterase. The transient nature of both symptoms and cholinesterase inhibition indicated the agent responsible for the illnesses was a carbamate insecticide. Methomyl, applied May 19 and 20, was identified as the only cholinesterase inhibitor used on the field during the 1988 growing season prior to May 24. This compound was found on clothing samples of four workers hospitalized for overnight observation, and samples of dislodgeable foliar residue (DFR) from the involved field demonstrated a mean methomyl level of 0.27 µg/cm 2 on May 25. A compatible illness pattern was also observed in 18 workers from five other crews working on the same ranch either May 24 or May 25. A cholinesterase monitoring study performed May 30 demonstrated no significant cholinesterase depression, relative to control subjects, in a crew of workers girdling grapes in a field with a mean methomyl DFR level of 0.065 µg/cm 2 and a peak level of 0.125 $\mu g/cm^2$. Slower than expected dissipation of methomyl in the field associated with the illness was felt to be an important underlying factor in the outbreak as well as cholinesterase depression associated with levels of methomyl DFR below the previously estimated safe-residue level of 1.5 $\mu g/cm^2$.

Introduction

Episodes of methomyl poisoning in agricultural field workers have previously been described in situations of premature worker reentry into treated fields by Hayes[1] and Knaak.[2] Hayes stated that delaying reentry beyond 24 hours probably eliminated the possibility of fieldworker poisoning, citing the rapid environmental dissipation of methomyl ($t_{1/2}$ << 24 hours) reported by Cahill for Arizona cotton.[3] However, a somewhat longer $t_{1/2}$, approximately 42 hours, can be calculated from the work of Gibbons and Richmond, who evaluated the dissipation of methomyl residues on sweet corn grown in the Southern California Coast Region.[4] Despite the longer $t_{1/2}$, all of the residues reported by Gibbons and Richmond study were below the 1.5 $\mu g/cm^2$ estimated as a safe level for entry into methomyl treated fields.[5] Thus, with adherence to a 48 hour reentry period, methomyl has not been felt to present a risk to California field workers.

During mid to late spring in the Southern San Joaquin Valley hand labor activities begin in the table grape vineyards. "Girdling" is performed during this portion of the growing season in order to prevent sugars and other products of photosynthesis from being transported to the vine roots. Piece-rate workers kneel or squat beneath the canopy of each vine trunk and interrupt the phloem layer of the vine trunk by cutting a 2-4 mm deep and 3 mm wide band around its circumference using a special curved, double-bladed knife designed for the task (Figure 1). The opportunity for dermal contact with leaf residues is potentially quite high in comparison with harvesting tree fruit, the work activity originally used for estimation of the 1.5 µg/cm 2 "safe-residue level" for methomyl and numerous other compounds (Knaak JB, Ackerman CR, Yee K, and Lee P, 1982: Reentry research: dermal dose red cell cholinesterase-response curves for methomyl. California Department of Food and Agriculture, Unpublished Data).[6,7]

This report describes a May, 1988, illness outbreak in a group of workers girdling grapes near Delano, California. Evaluation of the cause of this outbreak, the validity of the 1.5 µg/cm 2 estimate of the safe-residue level, and two day reentry interval for girdling vine trunks in methomyl treated vineyards were prime concerns in the investigation.

Methods

On May 25, 1988 the Worker Health and Safety Branch (WHSB) of the California Department of Food and Agriculture (CDFA) received a report regarding illness among members of a grape girdling crew employed by a Kern County grower, designated as "Grower A". Members of the index crew were interviewed and relevant medical records reviewed for those who sought medical treatment. Available members of six additional grape girdling crews employed by Grower A were also interviewed, on either May 26 or May 27, to determine the incidence on May 24 and May 25 of common symptoms related to cholinesterase inhibition from either organophosphates or carbamates.[8] Pesticide Illness Reports (PIRs), Doctors' First Reports (DFReps), and related medical records for these crews and for one additional crew, whose members were not available for interview, were also reviewed. Work history records and pesticide application records were reviewed in order to ascertain pesticide exposures for all seven crews.

For any worker who had a cholinesterase test, the percent depression was estimated as the difference between the measured value and the mid-point of the normal range, following the method of Namba (estimated % depression={[Mdpt-CHE_{ill}]/Mdpt} x 100), where Mdpt=midpoint of normal test range and CHE_{ill}=cholinesterase level at the time of illness).[9] For workers with both initial and followup tests the per cent depression was also estimated in comparison to the appropriate followup tests following the method of Midtling (estimated % depression={[CHE_{foll} -CHE_{ill}]/CHE_{foll}} x 100), where CHE_{foll} =followup test value and CHE_{ill} =cholinesterase level at the time of illness).[10] For the latter group, significance of the change between baseline and followup values was evaluated by a paired, one-tailed t-test using the SPSS statistical software.[11]

Field residue samples were also collected, in accordance with the dislodgeable foliar residue (DFRs) leaf-punch technique described by Gunther.[12] Methomyl was dislodged from samples consisting of 40 2.52 cm diameter leaf punches in a jar by adding 50 ml of distilled water and three to four drops of 2% Sur-Ten® surfactant solution and rotating the jar for 20 minutes. The liquid was decanted into a 500 ml separatory funnel. This process was repeated twice yielding 150 ml of aqueous solution; 50 ml of dichloromethane were added to the separatory funnel, which was then shaken for one minute. The dichloromethane layer was drained through anhydrous sodium sulfate into a 250 ml boiling flask. The dichloromethane extraction was repeated twice, the extracts combined, and subsequently evaporated to near dryness in a rotary evaporator. Five ml of methanol was added to the flask, and re-evaporated to remove traces of dichloromethane. The concentrated extract was transferred to a volumetric flask and made to the desired volume with methanol for analysis by liquid chromatography. This procedure was performed using a Perkin-Elmer Series 4 liquid chromatograph, a 4.6 by 150 mm Altrex Ultrasphere ODS 5 mu column at 30 degrees centigrade, and a fluorescence detector.

Multiresidue screens for organophosphates and carbamates were performed using the following method. Leaf punches were first extracted in 100 cc of acetonitrile, filtered into a glass container containing 10 g of NaCl. The filtered mixture was separated into two phases and the top phase separated into 3 different aliquots, which were each evaporated to dryness. One was re-suspended in benzene for analysis of chlorinated hydrocarbons, one in acetone for organophosphate analysis, and one in methanol for analysis of carbamates. Six separate carbamates and thirty-five separate organophosphate compounds could be detected by this procedure.

In conjunction with investigation of the illness, a residue dissipation study was conducted, evaluating the rate of pesticide decay in six vineyards near Ranch 1 that were treated with methomyl between May 23 and May 27, 1988. A worker monitoring study was also conducted to evaluate quantitative exposures and ascertain whether any detectable cholinesterase depression occurred following a seven day reentry interval. This consisted of pre- and post-shift red blood cell and plasma cholinesterase monitoring conducted on a single crew girdling grapes on May 30, and simultaneous blood measurements performed on a comparison group of non-exposed volunteer subjects. The difference between pre- and post-shift cholinesterase determinations was evaluated statistically in both the control and exposed populations using the paired t-test procedure in the SPSS statistical package.[11] The monitoring study, in conjunction with the field interviews, allowed qualitative assessment of the work task and the nature of the contact between workers and methomyl-treated plant foliage.

Results

Initial Presentation of Illness

At eight A.M. on May 25, 1988 the pest control advisor (PCA) for a large Kern County grape grower notified the Kern County Agricultural Commissioner's (CAC) office that four members of a 16 man grape girdling crew (crew 1) had been ill on the previous day. Upon visiting the field where the crew was working (Ranch 1), the CAC staff determined that several of the workers were nauseated and had been vomiting earlier in the morning. Two workers were found lying beneath the vines and appeared very ill to the CAC inspector. All crew members were taken to a nearby community hospital by the crew foreman and the remaining crews cleared from the field.

Risk Factors for Gastrointestinal Illness

Apart from the index crew, four of the five crews interviewed worked on either May 24 or May 25 on Ranch 1. In these four crews (2-5), the incidence of illness compatible with that reported by Crew 1 ranged from 44 to 100% of the sample of workers interviewed (27 workers total). PIRs were also received for five workers in Crew 7, whose members also worked on Ranch 1 on both May 24 and May 25. No cases were reported from Crew 6, whose members worked on those dates on a different ranch (Table 1).

For all six crews interviewed, the water consumed on the job was brought to the work site by the foreman of each crew and was obtained from the tap in his home, so that the source of water consumed on the job depended upon the location of the crew foreman's residence. Each crew member provided his own food. Eighteen separate firms were reported as previous employers during the 1988 agricultural season prior to the beginning of work for Grower A on May 17, so that there appeared to be little likelihood of a prior pesticide exposure common to all of the ill workers prior to employment by Grower A. A review of Grower A's work records indicated that all seven crews had been working for approximately 5 to 10 days prior to May 24 in fields that had not been treated with cholinesterase inhibiting pesticides. Of the five crews interviewed whose members reported illness on May 24 and May 25, the common factor appeared to be work on Ranch 1; the seventh crew, whose members were not interviewed, also worked on Ranch 1 on the May 24 and 25.

The pesticide application records obtained from Grower A demonstrated that Ranch 1 had been treated several times during the 1988 growing season. The most recent application prior to the worker entry took place on May 19 and 20, 1988. This treatment included (by amount of active ingredient) 0.9 pounds of methomyl/acre, 2.7 ounces/acre of the fungicide triadimefon, three pounds/acre of sulfur, 3.5 ounces/acre of Bacillus thuringiensis, and an emulsifier known as Triton® B. Earlier applications were made on April 8 and 25 treated with triadimefon, sulfur, and Triton® B; on the latter date the ranch also received an application of nutrient zinc. On April 26 the middle of the vineyard rows were treated with the herbicide glyphosate and Triton® B; on May 1 and May 12 applications were made of triadimefon and sulfur, with the latter application also including Bacillus thuringiensis and Triton® B. May 19 was thus the only application of methomyl or any other cholinesterase inhibiting chemical to the vineyard. Residue from this application was suspected as the cause of the worker illnesses and reported as such to the hospital emergency room staff.

Medical Evaluation in the Index Crew

Upon arrival at the community hospital emergency room, four members of crew 1 (workers 4, 6, 12, and 15), including the two noted to be very ill by the commissioner's staff (workers 6 and 15), were administered intravenous fluid (5% dextrose in water), and hospitalized for observation. Nine additional workers were seen in the emergency room and discharged following examination. The symptoms reported by all 13 workers seeking treatment are shown in Table 2. Two additional members of the crew refused medical attention.

Worker 15 had a syncopal episode in the emergency room that was attributed by the attending physician to hyperventilation. The other three hospitalized workers were also noted by the emergency room staff to be hyperventilating. Hyperventilation was thus a prominent clinical sign distinguishing the four hospitalized workers from the remaining members of the crew.

Of 13 workers seen in the emergency room, 12 had below normal or borderline normal cholinesterase values. A significant negative correlation was found between the level of plasma cholinesterase for these 13 workers and the total number of symptoms reported on interview ($R=-0.55$, $p=0.026$). A similar negative, but non-significant correlation was found for RBC cholinesterase ($r=-.36$, $p=0.116$).

The four crew members hospitalized for observation had followup cholinesterase blood tests late on the evening of May 25 or early in the morning of May 26 (Table 2), revealing an approximately 20% increase in RBC cholinesterase relative to the tests taken 8 to 12 hours earlier in the emergency room. In parallel with the rapid recovery of cholinesterase, all four workers were asymptomatic on the morning of May 26, and were discharged without requiring atropine during their hospital stay.

Interviews with 9 non-hospitalized workers conducted May 26 and May 27 indicated that all were asymptomatic. Worker 16 was re-interviewed on May 27 and reported that he had persistent symptoms of dizziness. Seven of the 9 non-hospitalized workers, who had been released back to work, participated in a cholinesterase monitoring study on May 30. These workers thus had two followup tests available for calculation of percent inhibition. For these seven workers the May 25 RBC cholinesterase values were inhibited 33.9% relative to the morning sample on May 30 and 31.5% relative to May 30 afternoon sample. When the mean of morning and afternoon samples was used as the comparison, the May 25 samples were inhibited by 32.7%. These differences were all statistically significant by paired t-test ($p<0.001$). For plasma cholinesterase values the May 25 samples were inhibited 41% relative to the morning samples from May 30, and 25% relative to the afternoon samples. When the mean of morning of afternoon and morning samples was used as a comparison, the May 25 samples were inhibited by 35%. As with the RBC cholinesterase values, these differences were statistically significant by paired t-test ($p<0.001$) (Table 2).

Other Girdling Crews

Eighteen workers from crews 2 through 6 were identified as being ill May 24 or May 25, from direct interview May 26 or May 27, from PIRs or DFReps filed by Kern County physicians, or both (Table 1). For the eight workers who sought medical advice, dates of treatment ranged from May 24 to May 30. Six of the eight had cholinesterase tests performed at the time of medical evaluation, all within the normal laboratory range. Two were tested on the afternoon of May 25, following evaluation of the index crew, and four were tested between May 26 and May 30, a day or more after their last exposures to methomyl. As with the index crew, the symptoms in the other girdling crews were transient. However, the second worker in crew number 2, whose initial symptoms on May 24 were identical to those of other ill workers, developed fever and chills three days later and was subsequently shown to have a right lower lobe pneumonia (Table 3). It could not be ascertained whether this was a complication of the initial illness, or occurred independently.

Six workers from crews 2-6 were interviewed and found to be asymptomatic. However, it was not possible to estimate the true incidence of illness in crews 2-6 because the workers interviewed on May 26 or May 27 and the 9 workers identified as ill only from the PIRs/DFReps were not necessarily representative of the remaining 52 workers. Members of crew 7, who did not work on Ranch 1 on either of the relevant dates, did not report being ill on either May 24 or May 25.

Exposure Evaluation and Dislodgeable Residue Data

Dislodgeable residue samples taken from the involved field on May 25 showed methomyl levels ranging from 0.33 to 0.19 $\mu g/cm^2$ (mean=0.27 $\mu g/cm^2$). Dermal exposure to the workers was confirmed by the presence of methomyl and triadimefon in clothing samples obtained from the four hospitalized workers (Table 4).

Residue Dissipation Studies

A series of dislodgeable residue decay studies was conducted following the episode, sampling a total of six Kern County vineyards (Ranches 4-9) previously treated with methomyl at 0.9 pounds/acre. The results shown in Figure 2 indicate that initial deposition of methomyl was uniformly below 1 $\mu g/cm^2$. Dissipation rates varied among the fields monitored, but on Ranch 4, the field with the slowest rate of dissipation, DFR levels decayed to approximately 0.1 $\mu g/cm^2$ by day 6 following application. The estimated residue half-life for the six ranches combined was 1.1 days.

Cholinesterase Monitoring Study

A cholinesterase monitoring study was performed on May 30 in a field on Ranch 4 treated May 24 with 0.9 pounds of methomyl/acre. Three DFR samples taken in the field May 30 showed levels of 0.013, 0.056, and 0.125 $\mu g/cm^2$ respectively, with a mean value of 0.0646 $\mu g/cm^2$. No significant change was noted in RBC cholinesterase of 16 workers monitored pre and post work. Plasma cholinesterase decreased 11% ($p <0.001$ by paired t-test). A comparison group of 9 unexposed individuals showed a decrease in RBC cholinesterase of 13% and 18% in plasma cholinesterase over the same time period (Table 6).

Methomyl Exposure Estimate

The mean exposure during the monitoring study, as estimated by methomyl extracted from long-sleeved cotton t-shirts worn by the workers throughout the day, was 2.0 mg of methomyl on the torso and upper arms. The 6 workers who wore the cotton t-shirts underneath their regular cotton work shirt had a mean exposure of 1.7 mg of methomyl, in comparison to the 9 who wore the t-shirts exterior to their regular work shirts who had a mean dermal exposure of

2.4 mg ($p < 0.001$ by t-test). Two workers who wore the t-shirt underneath short-sleeved shirts had a total exposure of 1.9 mg.

Discussion

Symptoms resulting from exposure to cholinesterase inhibitors are non-specific and resemble those of many common infectious gastrointestinal illnesses.[13] The outbreak reported here involved members of six crews who had no common residence, no common source of food and water, no history of common employment prior to May 17, 1988, and no exposure to a cholinesterase inhibiting agent prior to May 24. All of these factors diminished the likelihood that the outbreak had an infectious etiology or could possibly have been related to a pesticide exposure during employment earlier in the 1988 agricultural season.

In the index crew, the illness was associated with demonstrable cholinesterase depression (approximately 33% for RBC and 35% for plasma relative to followup tests done on a sample of seven workers five days later). Both the transient nature of the illness and the rapid reversal of cholinesterase depression indicate that the illness was caused by a carbamate, rather than an organophosphate, insecticide. Methomyl was identified as the responsible compound from the field application history, foliar residue samples, and the presence of methomyl residue on ill workers clothing.

The high incidence of reversible cholinesterase depression documented in the index crew suggests that the similar illnesses (Table 3) in members of five other crews working on the same ranch were probably also related to methomyl exposure. Of the 24 workers for whom some information was available from either DFReps, PIRs, or direct interview, illness was reported in approximately two/thirds. Because no information was available on 52 workers from these crews and many ill workers did not seek medical treatment, it was not possible to ascertain the true incidence of illness in these five crews.

The findings in this investigation contradict the supposition,[5] based upon the work of Knaak,[6,7] that 1.5 $\mu g/cm^2$ DFR safely allows entry without special protective equipment into all treated fields treated with methomyl regardless of the crop and work activity. The residue levels associated with cholinesterase depression and illness in this episode (three samples taken May 25, averaging 0.27 $\mu g/cm^2$ methomyl DFR) were in fact far below 1 $\mu g/cm^2$.

The mean methomyl levels at Ranch 4 during the cholinesterase monitoring study performed on May 30 at Ranch 4 was 0.065 $\mu g/cm^2$, with a range of 0.01 to 0.125 $\mu g/cm^2$. A six hour workday girdling grapes produced <3 mg of methomyl exposure to the torso and upper arms at these residue levels and produced no significant change in either RBC or plasma cholinesterase relative to the control subjects. However, the sensitivity of the study in detecting depression of cholinesterase in the exposed subjects was limited by the observed depression in the control subjects of 18% in plasma and 13% in RBC cholinesterase.

Study Limitations

The apparent systematic laboratory error observed in the cholinesterase monitoring study does suggest the possibility that the cholinesterase depression observed in ill workers was artifactual. However, this seems unlikely since there was a significant negative correlation between the plasma cholinesterase levels and the number of symptoms reported by ill workers on interview ($r=-0.55$, $p=0.026$) and a similar negative, albeit non-significant correlation for RBC cholinesterase. It is further noteworthy that the cholinesterase depression in the ill workers was approximately twice the magnitude of the artifact observed among the control population in the monitoring study. Because of spontaneous regeneration of carbamate inhibited enzyme, it is probable that the true magnitude of cholinesterase depression was in fact underestimated.

Evaluation of the outbreak is also complicated by the observation by emergency room personnel of hyperventilation in the four hospitalized workers. This observation might suggest that a portion of the symptoms in these workers were produced by anxiety. Given the cholinesterase depression in the four hospitalized workers and their symptomatic recovery coincident with recovery of cholinesterase activity, it seems probable that the anxiety in these four workers was secondary to their underlying illness rather than its primary cause. There was no sign of hyperventilation in other members of the index crew and no indication that illness outbreak, *per s*e, was secondary to anxiety.

Estimation of a Safe DFR Level (SDL)

Using data from the monitoring study one can estimate a Safe DFR Level (SDL) for cholinesterase inhibition, following the method of Knaak,[14] equal to the highest residue value encountered, 0.125 µg/cm^2. This procedure, however, has the defect of being somewhat arbitrary. An alternative estimate of the SDL might reasonably be made based upon the mean, rather than the peak residue found on Ranch 4, producing a lower estimate of the NOEL by approximately a factor of two (0.0625 vs. 0.125 µg/cm^2). Either procedure would appear to be acceptable as long as applied consistently (i.e. comparing a standard based upon peak residue levels to peak residues found in a given field; or conversely, comparing a standard based upon mean residue levels to mean residue levels found in a field).

In using an estimated SDL to set a reentry time, one must adequately take into account variations in residue dissipation. Although the six ranches monitored in the dissipation studies uniformly reached levels below the estimated SDL (taken as approximately 0.1 µg/cm^2 - Figure 2) by seven days post application, methomyl DFR levels on Ranch 1 appeared to be slightly above this level at the same time interval (Figure 2 and Table 5). Subsequent CDFA monitoring of methomyl residues in the San Joaquin Valley during September 1988 unexpectedly demonstrated even greater persistence of methomyl residue, with a half-life as long as 5.3 days, in comparison to the half-life of 1.1 days shown in the six ranches shown in Figure 2. This data led to the hypothesis that the variation in residue dissipation was primarily seasonal and that hypothesis was largely supported by residue dissipation studies conducted during 1989.[15] Variations in environmental humidity, day lengths, concentration of ozone or other environmental oxidants, and differences in early and late season irrigation practices, have all been suggested as the explanation for the slower late-season dissipation,[15] but none of these possibilities have been systematically evaluated from in either experimental or observational studies.

A complete model of residue dissipation should explain the difference between statistical outliers and "mean" or "median" behavior exemplified by other fields studied. As indicated in Figure 2, significant local variations in dissipation rates may occur that cannot be attributed to seasonal or geographical factors. Monitoring of methomyl applications in the San Joaquin Valley during August and September of 1988 demonstrated similar outliers that showed aberration relative to the "late season" pattern of decay (CDFA, Worker Health and Safety Branch, Unpublished data, September 1988). Given the current 0.1 µg/cm^2 estimate of the SDL for exposure to methomyl during grape girdling, it is obvious that understanding variations in residue dissipation are extremely critical. The present methomyl vineyard reentry intervals of 7 days for early season applications (prior to August 15 of each growing season) and 21 days for late season applications should be evaluated in terms of "outliers" as well as "median" or typical residue decay patterns.

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Table 1

Illnesses and Work History
in Seven Grape Girdling Crews 5/24/88- 5/25/88

Crew Number	Number Interviewed	DFRep/ PIR* Only	Number Ill	Asymptomatic	No DFRep/ PIR* or Interview	Total	Ranch Worked: 24th	Ranch Worked: 25th	Crew Place of Residence
1	11	4	12	3	1	16	1	1	Arvin
2	4	0	4	0	12	16	1	3	Arvin
3	3	0	3	0	13	16	None	3,1	McFarland, Earlimart
4	3	0	3	0	11	14	1	3,1	Arvin, Delano, Lamont
5	9	0	4	5	8	17	1	1	Arvin, Lamont Weedpatch
6	0	5	4	1	8	13	1	1	Earlimart
7	7	0	0	7	5	12	2	3	Delano
Total	37	9	30	16	58	104			

DFRep (Doctor's First Report)/PIR (Pesticide Illness Report)

Table 2

Cholinesterase Data

Crew member	***RBC*:** 5/25	5/26	Morning 5/30	Afternoon 5/30	% Inhibition* Observed	***Plasma*:** 5/25	5/26	Morning 5/30	Afternoon 5/30	% Inhibition* Observed	Symptoms
1	3.4	-	4.5	4.7	26	1.3	-	3.6	3.0	61	V, Dz, A
2	3.7	-	5.7	5.9	36	2.9	-	4.1	3.4	23	N, V, Dz
3	**										N, Dz, BV***
4	3.5	4.2	-	-	-	1.8	2.7	-	-		N,V,Dz
5	4.0	-	5.6	5.0	25	2.8	-	4.0	3.1	21	None
6	3.9	4.5	-	-	-	1.7	2.2	-	-		N,V,Dz,A
7	3.6	-	5.6	4.9	31	2.3	-	4.2	3.2	38	N,V
8	3.5	-	-	-	-	1.8	-	-	-	-	N,Dz,A
9	3.9	-	6.6	6.0	38	2.7	-	4.8	3.3	33	V,Dz,HA,BV
10	3.9	-	6.8	6.4	41	2.6	-	3.8	2.8	21	HA
11	4.9	-	-	-	-	3.7	-	-	-	-	None
12	3.7	4.8	-	-	-	2.9	3.2	-	-		N,V,Dz
13	**										
14	3.3	-	4.4	4.7	27	2.1	-	4.3	3.4	45	HA
15	3.9	4.5	-	-	-	1.9	2.9	-	-		Fa,Dz,V
16	**										
Mean	3.7	4.5	5.6	5.4	34	2.5	2.7	4.1	3.2	35	
Number tested	13		7	7	7	13		7	7	7	

*Estimated degree of Inhibition, assuming baseline cholinesterase approximately equal to midpoint of normal range.

RBC Cholinesterase Range Plasma Cholinesterase Range
3.9-7.1 u/ml; Midpt=5.5   2.3-4.9 u/ml; Midpt=3.6

** Cholinesterase data not drawn 5/25
*** Symptoms determined at interview May 27
++ Symptoms code: A=abdominal pain or cramping, BV=blurry vision, Dr=diarrhea, Dz=dizziness, Fa=fainting, HA=headache, N=nausea, None=asymptomatic, V=vomiting

+++ hospitalized 5/25 for observation

Table 3

Cholinesterase Data

Crew Number	Worker	Ill Date	First Treatment Date	Test Date	RBC	PLAS	Symptoms/Signs++
2	32	24	-	-	-	-	N,A
2	33	24	26	27	-	12.6*	N,V,Dz,HA,BV,F,P
2	39	24	24	-	-	-	N,V,Dz,HA,BV
2	40	24	-	-	-	-	N,V,Dz,A
4	50	24	30	30	6.2	4.6	V,Dz,HA,BV
4	57	24	26	-	-	-	N,Dz,HA,Dr,A
4	62	26	-	-	-	-	N
5	68	24	-	-	-	-	N
5	70	24	-	-	-	-	V,BV,A
5	71	24	-	-	-	-	N,V
5	79	24	-	-	-	-	V
3	88	24	-	-	-	-	V,Dz
3	93	24	-	-	-	-	V,Dz,BV
3	96	24	-	-	-	-	V,Dz
6	100	25	25	4.6	2.7	-	V
6	105	24	25	25	6.0	3.4	N,V,HA
6	106	25	26	26	5.9	3.8	N,HA
6	107	24	26	26	5.3	4.3	N,HA,BV

* Nl range at lab=7-19 IU/ml San Joaquin Community Hospital;
all other tests performed at Delano Regional Medical Center:

RBC Cholinesterase Range	Plasma Cholinesterase Range
3.9-7.1 u/ml; Midpt=5.5	2.3-4.9 u/ml;Midput=3.6

++ Symptoms code: A=abdominal pain or cramping, BV=blurry vision, Dr=diarrhea, Dz=dizziness, HA=headache, N=nausea, None=asymptomatic, V=vomiting, F=fever, P=pneumonia

Table 4

Clothing Samples from Hospitalized Workers

Worker Number	Article	Date Collected*	µg Methomyl	µg Bayleton
4	Pants	5/26/88	2,920	NA
4	T-shirt	5/25/88	500	4,020
4	Sweat-shirt	5/25/88	1,900	989
6	Pants	5/26/88	1,760	NA
12	T-shirt	5/26/88	6,350	NA
16	T-shirt	5/26/88	15,000	6,250
16	Pants	5/26/88	7,690	NA

* Samples were collected from hospitalized workers 5/26/88
NA = not analyzed

Table 5

Dislodgeable Foliar Residue Samples from Ranch 1

Sample Date	Methomyl DFR µg/cm^2	Mean DFR µg/cm^2
5/25/88	0.19	0.27
5/25/88	0.33	
5/25/88	0.29	
5/25/88	0.28	
5/26/88	0.032	0.083
5/26/88	0.125	
5/26/88	0.024	
5/26/88	0.136	
5/26/88	0.053	
5/26/88	0.057	
5/26/88	0.061	
5/26/88	0.067	
5/26/88	0.24	
5/27/88	0.11	0.15
	0.19	

Table 6

Results of 5/30/88 Monitoring Study

ID	Rbc1	Rbc2	Pla1	Pla2	µg of Methomyl Extracted	T-shirt*
1	6.8	6.4	3.8	2.8	2,948	1
2	5.8	6.7	4.0	3.2	1,874	2
3	5.7	5.9	4.1	3.4	1,517	1
4	5.8	5.6	3.7	3.2	1,247	3
5	6.6	6.0	4.8	3.3	1,558	3
6	5.3	6.1	3.6	3.3	1,317	3
7	6.5	6.2	5.2	4.3	5,046	3
8	5.6	4.9	3.8	2.9	1,023	1
9	4.7	5.6	4.2	3.4	1,536	1
10	4.8	5.0	3.7	3.2	1,969	1
11	5.5	3.7	3.5	3.2	1,910	2
12	5.1	5.0	4.0	3.1	736	1
13	5.6	4.9	4.2	3.2	4,603	3
14	4.5	4.7	3.6	3.0	3,341	3
16	4.4	4.7	4.3	3.4	1,104	3
18	3.4	3.8	3.7	3.3	1,218	3
17	5.1	4.7	2.4	2.0		
19	6.0	5.0	5.4	4.8		
20	5.8	4.8	3.7	2.8		
21	6.1	4.9	5.8	4.3		
22	4.6	4.3	3.2	2.5		
23	5.4	5.2	4.6	3.9		
24	5.2	5.3	4.6	3.8		
25	6.0	4.4	3.8	3.1		

1=wore t-shirt underneath long sleeved work shirt; 2=wore t-shirt underneath short sleeved work shirt; 3=wore t-shirt exterior to work clothing.

Figure 1 - worker underneath canopy of grape foliage "girdling" the vine trunk