

Industrial Hygiene Report of
Mechanical Cotton Picker Operator
Exposure to DEF

at

Valley Picking Company
1726 Oaks Street
Tulare, California 93274

SURVEY CONDUCTED BY:
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DATE OF SURVEY:
November 14-17, 1978

REPORT WRITTEN BY:
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Industrial Hygiene Section
Industry-wide Studies Branch
Division of Surveillance, Hazard Evaluations and Field Studies
National Institute for Occupational Safety and Health
Cincinnati, Ohio

PURPOSE OF SURVEY:

To conduct an in-depth survey of mechanical cotton picking operations in support of the project "Neuropathy and Pesticide Workers". In particular, to characterize mechanical cotton picker operator exposure to DEF, a cotton defoliant.

EMPLOYER REPRESENTATIVES
CONTACTED:

Gene McClure, Owner

EMPLOYEE REPRESENTATIVE
CONTACTED:

Valley Picking Company employees are not represented by a labor union.

STANDARD INDUSTRIAL
CLASSIFICATION OF PLANT:

0722

DEF is a registered trade mark of Chemagro Agricultural Division, Mobay Chemical Corporation; however, DEF will be used as an abbreviation for s,s,s-tributylphosphorotrithioate in this report.

Use of a manufacturer's name, brand, or trademark does not constitute endorsement by the National Institute for Occupational Safety and Health.

ABSTRACT

On November 14-17, 1978, NIOSH conducted an industrial hygiene survey of the mechanical cotton picking operations conducted by Valley Picking Company on the McClure Farm in Tulare, California. The purpose of this survey was to characterize mechanical cotton picker operator exposure to s,s,s-tributylphosphorotrithioate (DEF), a cotton defoliant. The respiratory samples ranged from 17.0 to 257.0 ng/m³ with a geometric mean of 34.1 ng/m³. The dermal samples ranged from 0.20 to 2.66 mg/8 hours with a geometric mean of 0.94 mg/8 hours. The unoxidized form of DEF, s,s,s-tributylphosphorotrithioite (Folex), was also detected; the Folex respiratory samples ranged from 11.4 to 76.7 ng/m³ with a geometric mean of 19.7 ng/m³. The dermal samples ranged from 0.02 to 0.09 mg/8 hours with a geometric mean of 0.04 mg/8 hours. Occupational exposure standards have not been established for DEF and Folex. Since weather conditions were abnormal, additional respiratory and dermal sampling should be conducted during more typical weather conditions which are conducive to higher exposure levels.

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is mandated under Section 20(a)(7) of the Occupational Safety and Health Act of 1970 (PL-91-596) to conduct and publish industry-wide studies of the effects of chronic or low level exposures to industrial materials, processes, and stresses on the potential for illness, disease, or loss of functional capacity in aging adults.

The purpose of the study is to characterize worker exposure to selected pesticides in support of future medical or epidemiologic studies. A cotton defoliant, s,s,s-tributylphosphorotrithioate (DEF), was selected for study because it has been associated with delayed neurological effects. For example, the neurological effects of leg weakness and paralysis were delayed at least 14 days in hens treated with 200 mg/kg of DEF.¹ Mechanical cotton picker operators were selected as a study group because the operators were exposed to DEF and were a large enough group to form a cohort for future epidemiologic studies. In particular, the industrial hygiene data collected during this survey could be used to establish a dose-response relationship between exposure and specific health effects in future epidemiologic studies.

DESCRIPTION OF FARM, WORK FORCE, AND PROCESS

The farms where cotton is picked are usually very large. These farms may consist of several thousand acres of level farm land that must be irrigated to be productive. These farms produce various crops which require many different farming techniques such as turning, disking, sowing, pesticide application, and harvesting. Over the years, production methods have improved and many changes have been implemented. Essentially, these improvements have meant the use of more mechanized techniques and the application of larger amounts of pesticides.

During this visit, only cotton picking operations performed by Valley Picking Company were surveyed. The firm used eight front-mounted, closed-cab, two-row type mechanical cotton pickers to harvest cotton. During the harvesting season, about 18 non-union workers are employed as drivers and cleaner/stompers. These workers were all men and work one shift per day which may vary from 8 to 12 hours depending on weather conditions and work schedule.

One driver operates a mechanical cotton picker. The operator will drive to the end of the field (usually $\frac{1}{2}$ section) and return, a round trip of about 1 mile in length. At the end of a round trip, the cleaner/stompers will clean the spindle guides and air intake for the blower. Also, if required, they stomp down the cotton in the basket. When the basket is full, it is emptied into a trailer for transporting to a cotton module for hydraulic pressing into a module bale, usually about 12,000 pounds. The module bale is then transported to a cotton gin for processing.

¹ Gaines, T.B.: Acute Toxicity of Pesticides. Toxicol. Appl. Pharmacol. 14:515-534 (1969).

Workers during the harvesting of cotton are exposed to many different physical and chemical agents. Physical agents include noise, vibration, UV radiation, and heat stress. Chemical exposures are usually to pesticides such as DEF, Folex, paraquat, orethene, kelthane, and toxaphene; but there are also exposures to engine combustion products, fugitive dusts, cotton fiber, and other plant particulate matter. However, during this survey only the respiratory and dermal exposures of the operator to DEF were to be evaluated.

DEF, $(CH_2CH_2CH_2CH_2S)_3P=O$, is a colorless to pale yellow liquid which is soluble in aliphatic, aromatic and chlorinated hydrocarbons, and alcohol solvents. DEF is registered by EPA as a cotton defoliant and is usually applied (2.25 lbs/acre) about 2 weeks prior to desired defoliation. The natural action of DEF accelerates the aging process of cotton leaves but in a relatively green state with adequate weight to cause them to fall to the ground. The cotton is usually picked 2-4 weeks after the application of DEF.

Several variables will affect the operator exposure to DEF. Variables that the operator controls are his position, position of the cab door, and the operation of the cab air filtering system. The highest exposure would most likely be experienced when the cab air filtering system is off, the cab door is open, and the driver is in a sitting position. Two other variables that can be controlled are re-entry time and application concentrations. Naturally, increasing the time interval between application of DEF and harvesting of the cotton and using the lowest concentration of DEF but still achieving defoliation will minimize exposure. Variables that can not be controlled are temperature, radiant heat, humidity, precipitation, soil moisture content, plant moisture content, soil type, and number of pickings. Although these conditions cannot be controlled, due to the natural parameters necessary to grow cotton, most of the conditions remain relatively constant during harvesting.

Typical conditions are temperatures of 70-80°F, high radiant heat, low humidity, very little precipitation, low soil moisture content, sandy soil, and low plant moisture content. All of these conditions tend to promote increased exposure to DEF. Most cotton crops are picked at least twice. With all other factors remaining the same, the exposure to DEF should be less for the second picking since less airborne particulate matter is generated.

DESCRIPTION OF MEDICAL, INDUSTRIAL HYGIENE AND SAFETY PROGRAMS

Non-serious medical injuries of Valley Picking Company employees are treated by a physician in Tulare, California. All serious injuries are treated at the local hospital. Employees do not receive entrance medical examinations or subsequent medical examinations.

An industrial hygiene and safety program is not in effect. Environmental and personal monitoring for pesticides is not conducted. However, worker exposure to pesticides is limited by use of re-entry times. Re-entry times give the pesticides time to oxidize, hydrolyze, or evaporate, therefore reducing worker exposure. Personnel records, which are maintained by name and social security number, include a work history and indicate any lost-time accident.

DESCRIPTION OF SAMPLING AND ANALYTICAL METHODS

Respiratory samples were collected and analyzed as described in NIOSH Sampling Data Sheet (SDS) #21 (NIOSH Manual of Sampling Data Sheets, 1977 Edition, DHEW (NIOSH) Publication No. 77-159). Basically, the sampling train consisted of a Gelman AE 37-mm glass fiber filter in a closed face cassette, with or without a cyclone, in line with a midget impinger containing ethylene glycol. The impinger was connected to a MSA Model G Pump calibrated at 1.0 liters per minute (lpm) and 1.7 lpm for total mass and respirable samples, respectively. Respiratory samples were collected inside the mechanical cotton picker cab within close proximity of the operator's breathing zone.

Dermal samples were collected to simulate deposition of pesticides on the skin. Gauze pads, 4x4 inches, bonded with 1-inch tape to a polyethylene backing, 4x4 inches, were attached to the front thigh clothing area of the operators. The gauze pads collected the pesticides that would have normally adhered to the clothing and penetrated to the skin. The air and dermal samples (2x2 inch center section) were extracted with benzene and analyzed by gas chromatography with a flame photometric detector as described in NIOSH Sampling Data Sheet (SDS) #21.

RESULTS AND DISCUSSION OF RESULTS

Results of respiratory and dermal sampling for DEF are reported in Tables I-1 and I-2, respectively, in Appendix I. Tables 1 and 2 present a statistical summary of the results in Tables I-1 and I-2, respectively. The following assumptions were made in the statistical analysis of the exposure data:

- 1) There is no significant difference in particle size distribution between respirable samples and total mass samples. Based on phase contrast microscopic examination, about 97 percent of the particles in the total mass sample were respirable (i.e. <9.5 micrometers and >1.2 micrometers in diameter).
- 2) It is valid to use for a total concentration (TC) the midpoint between "less than" and "greater than" values (e.g. $20 \leq TC \leq 30$ with the midpoint at $TC = 25$).

Table 1. Statistical Analysis of DEF Respiratory Exposure Levels of Mechanical Cotton Picker Operators Employed By Valley Picking Company (Tulare County, California)

Number of Samples	23
Highest	257.0 ng/m ³
Lowest	17.0 ng/m ³
Arithmetic Mean	47.4 ng/m ³
Standard Deviation	53.8 ng/m ³
Standard Error	11.2 ng/m ³
Geometric Mean	34.1 ng/m ³
Geometric Standard Deviation	2.07
Lower Confidence Limit	24.9 ng/m ³
Upper Confidence Limit	46.8 ng/m ³

Table 2. Statistical Analysis of DEF Dermal Exposure Levels of Mechanical Cotton Picker Operators Employed By Valley Picking Company (Tulare County, California)

Number of Samples	8
Highest	2.66 mg/8 hrs
Lowest	0.29 mg/8 hrs
Arithmetic Mean	1.14 mg/8 hrs
Standard Deviation	0.78 mg/8 hrs
Standard Error	0.27 mg/8 hrs
Geometric Mean	0.94 mg/8 hrs
Geometric Standard Deviation	1.98
Lower Confidence Limit	0.53 mg/8 hrs
Upper Confidence Limit	1.66 mg/8 hrs

3) It is valid to use for a total concentration below a "less than" value (e.g. TC < 30) the midpoint of that value and zero (i.e. TC = 15).

4) The sample data are log-normally distributed.

The 23 respiratory samples ranged from 17.0 to 257.0 nanograms of DEF per cubic meter of air sampled (ng/m^3) with a geometric mean of 34.1 ng/m^3 . In the USA, an occupational respiratory exposure standard has not been established for DEF. However, about 195 pesticides have had respiratory standards established or recommended by either ACGIH,² OSHA,³ or NIOSH. The lowest standard for a pesticide is a 1 $\mu\text{g}/\text{m}^3$ ceiling for kepone. In the USSR a Maximum Allowable Concentration of 200 $\mu\text{g}/\text{m}^3$ has been published for DEF.⁴ The respiratory levels found are two orders of magnitude less than the lowest USA pesticide standard and four orders of magnitude less than the USSR standard for DEF.

The eight dermal samples ranged from 0.29 to 2.66 mg/8 hours with a geometric mean of 0.94 mg/8 hours. An occupational dermal exposure standard has not been established for DEF although several pesticides have occupational exposure standards of 500 $\mu\text{g}/\text{m}^2$ (skin). The "skin" notation indicates a potential contribution to the overall exposure by the cutaneous route including mucous membranes and eye, either by airborne, or more particularly by direct contact with the pesticide. In the case of the mechanical cotton picker operators in this survey the potential body burden is almost all dermal, i.e. 99.9%. Therefore, a standard of 500 $\mu\text{g}/\text{m}^2$ (skin) will allow an exposure via the dermal route of 5 mg/8 hours for a man breathing 10 m^3 of air during an 8-hour shift. The dermal exposure levels found for DEF are 20% of this standard.

The unoxidized form of DEF, s,s,s-tributylphosphorotrithioite (Folex), was also detected. The Folex data are presented in Appendix II. The results are presented in Tables II-1 and II-2 and a statistical summary is presented in Tables II-3 and II-4. The Folex respiratory levels ranged from 11.4 to 76.7 ng/m^3 with a geometric mean of 19.7 ng/m^3 . The dermal levels ranged from 0.02 to 0.09 mg/8 hours with a geometric mean of 0.04 mg/8 hours. Occupational exposure standards, respiratory and dermal, have not been established for Folex.

As previously discussed, many factors such as weather conditions can affect the level of exposure to DEF that an operator will experience. Typical weather conditions for California in the areas surveyed are

² American Conference of Governmental Industrial Hygienists

³ Occupational Safety and Health Administration

⁴ Khasanov, YU.U and E.N. Davletov: Hygienic Assessment of the Helicopter Method of Defoliation. Gigiena i Sanitaryi 38:103-104 (1973) (Russian).

temperatures in the 70-80°F range, very little precipitation, clear skies, and low humidity. However, prior to the survey there were heavy rains, and during the survey weather conditions were temperatures in the 50-60°F range, heavy fogs, cloudy skies, and high humidity. Also due to the rains, the moisture content of the plant matter and soil was high. All of these abnormal conditions were conducive to reducing exposure levels. Normal weather conditions could possibly produce exposure levels that are one or two orders of magnitude higher.

CONCLUSIONS AND RECOMMENDATIONS

The mechanical cotton picker operators are exposed to DEF geometric mean respiratory and dermal DEF levels of 34.1 ng/m³ and 0.94 mg/8 hours, respectively. Also, the operators are exposed to Folex geometric mean respiratory and dermal levels of 19.7 ng/m³ and 0.04 mg/8 hours, respectively. During normal weather conditions exposure levels could be elevated by one or two orders of magnitude; therefore, additional respiratory and dermal sampling should be conducted during normal weather conditions which are conducive to higher exposure levels.

APPENDIX I

Table I-1. DEF Respiratory Exposure Levels of Mechanical Cotton Picker Operators Employed By Valley Picking Company (Tulare County, California)

Date	Sample Number	Total Concentration of DEF ng/m ³	ppt
11/14/78	TH01	<34.6	<2.7
11/14/78	TH02	8.1 ≤ TC ≤ 34.6	0.6 ≤ TC ≤ 2.7
11/14/78	TH03	<34.6	<2.7
11/14/78	TH04	<34.6	<2.7
11/15/78	TH05	70.8	5.5
11/15/78	TH06	16.8 ≤ TC ≤ 41.0	1.3 ≤ TC ≤ 3.2
11/15/78	TH07	22.4 ≤ TC ≤ 39.2	1.7 ≤ TC ≤ 3.0
11/15/78	TH08	128.6 ≤ TC ≤ 145.4	10.0 ≤ TC ≤ 11.3
11/16/78	TH09	248.4 ≤ TC ≤ 265.8	19.3 ≤ TC ≤ 20.6
11/16/78	TH10	26.9 ≤ TC ≤ 44.2	2.1 ≤ TC ≤ 3.4
11/16/78	TH11	30.7 ≤ TC ≤ 48.0	2.4 ≤ TC ≤ 3.7
11/16/78	TH12	61.5 ≤ TC ≤ 78.76	4.8 ≤ TC ≤ 6.1
11/17/78	TH13	<49.9	<3.9
11/17/78	TH14	<49.9	<3.9
11/17/78	TH15	37.1	2.9
11/17/78	TH16	53.2 ≤ TC ≤ 85.4	4.1 ≤ TC ≤ 6.6
11/14/78	RH01	<37.2	<2.9
11/15/78	RH02	<34.0	<2.6
11/16/78	RH03	13.6 ≤ TC ≤ 36.2	1.1 ≤ TC ≤ 2.8
11/15/78	RH04	<34.0	<2.6
11/16/78	RH05	17.0 ≤ TC ≤ 39.6	1.3 ≤ TC ≤ 3.1
11/17/78	RH06	<37.9	<2.9
11/17/78	RH07	62.5 ≤ TC ≤ 71.1	4.9 ≤ TC ≤ 5.5

Notes:

Rotometer and standard temperature and pressure corrections have been made.

ng/m³ = Nanograms of DEF per cubic meter of air

ppt = Parts of DEF per trillion parts of air

TC = Total Concentration of DEF which is the sum of the concentrations from the filter and impinger.

Lower limit of detection was about 10 ng/sample.

Table I-2. DEF Dermal Exposure Levels of Mechanical Cotton
Picker Operators Employed By Valley Picking Company
(Tulare County, California)

Date	Sample Number	Total Concentration of DEF	
		$\mu\text{g}/8 \text{ hrs}/\text{pad}^1$	$\text{mg}/8 \text{ hr}/\text{man}^2$
11/14/78	DH01	0.81	0.63
11/14/78	DH02	1.22	0.95
11/15/78	DH03	1.29	1.00
11/15/78	DH04	2.51	1.94
11/16/78	DH05	0.92	0.71
11/16/78	DH06	3.43	2.66
11/17/78	DH07	0.37	0.29
11/17/78	DH08	1.23	0.95

¹ Micrograms of DEF per 8 hours per 2x2 inch center section of gauze pad.

² Milligrams of DEF per 8 hours per man with skin area of 2 square meters.

APPENDIX II

Table II-1. Folex Respiratory Exposure Levels of Mechanical Cotton Picker Operators Employed by Valley Picking Company (Tulare County, California)

Date	Sample Number	Total Concentration of Folex ng/m ³	ppt
11/14/78	TH01	<32.6	<2.7
11/14/78	TH02	<32.6	<2.7
11/14/78	TH03	<32.6	<2.7
11/14/78	TH04	<32.6	<2.7
11/15/78	TH05	11.2 ≤ TC < 29.8	0.9 ≤ TC < 2.4
11/15/78	TH06	<29.8	<2.4
11/15/78	TH07	<29.8	<2.4
11/15/78	TH08	24.2 ≤ TC < 33.6	2.0 ≤ TC < 2.8
11/16/78	TH09	71.8 ≤ TC < 81.5	5.9 ≤ TC < 6.7
11/16/78	TH10	<30.7	<2.5
11/16/78	TH11	23.1 ≤ TC < 42.3	1.9 ≤ TC < 3.5
11/16/78	TH12	<46.1	<3.8
11/17/78	TH13	11.3 ≤ TC < 40.3	0.9 ≤ TC < 3.3
11/17/78	TH14	<38.7	<3.2
11/17/78	TH15	25.8 ≤ TC < 40.3	2.1 ≤ TC < 3.3
11/17/78	TH16	<38.7	<3.2
11/14/78	RH01	<28.8	<2.4
11/15/78	RH02	<26.3	<2.2
11/16/78	RH03	<27.1	<2.2
11/15/78	RH04	<26.3	<2.2
11/16/78	RH05	<27.1	<2.2
11/17/78	RH06	<22.7	<1.9
11/17/78	RH07	38.8 ≤ TC < 47.4	3.2 ≤ TC < 3.9

Notes:

Rotometer and standard temperature and pressure corrections have been made.

ng/m³ = Nanograms of Folex per cubic meter of air

ppt = Parts of Folex per trillion parts of air

TC = Total Concentration of Folex which is the sum of the concentrations from the filter and impinger.

Lower limit of detection was about 10 ng/sample.

Table II-2. Folex Dermal Exposure Levels of Mechanical Cotton
Picker Operators Employed By Valley Picking Company
(Tulare County, California)

Date	Sample Number	Total Concentration of Folex	
		$\mu\text{g}/8 \text{ hr}/\text{pad}^1$	$\text{mg}/8 \text{ hr}/\text{man}^2$
11/14/78	DH01	<0.06	<0.046
11/14/78	DH02	<0.06	<0.046
11/15/78	DH03	<0.05	<0.039
11/15/78	DH04	<0.05	<0.039
11/16/78	DH05	0.08	0.062
11/16/78	DH06	0.11	0.085
11/17/78	DH07	0.09	0.070
11/17/78	DH08	0.12	0.093

¹ Micrograms of Folex per 8 hours per 2x2 inch center section of gauze pad.

² Milligrams of Folex per 8 hours per man with skin area of 2 square meters.

Table II-3. Statistical Analysis of Folex Respiratory Exposure Levels of Mechanical Cotton Picker Operators Employed By Valley Picking Company (Tulare County, California)

Number of Samples	23	
Highest	76.7	ng/m ³
Lowest	11.4	ng/m ³
Arithmetic Mean	22.3	ng/m ³
Standard Deviation	14.3	ng/m ³
Standard Error	3.0	ng/m ³
Geometric Mean	19.7	ng/m ³
Geometric Standard Deviation	1.58	
Lower Confidence Limit	16.2	ng/m ³
Upper Confidence Limit	24.0	ng/m ³

Table II-4. Statistical Analysis of Folex Dermal Exposure
Levels of Mechanical Cotton Picker Operators
Employed by Valley Picking Company
(Tulare County, California)

Number of Samples	8	
Highest	0.09	mg/8 hrs
Lowest	0.02	mg/8 hrs
Arithmetic Mean	0.05	mg/8 hrs
Standard Deviation	0.03	mg/8 hrs
Standard Error	0.01	mg/8 hrs
Geometric Mean	0.04	mg/8 hrs
Geometric Standard Deviation	2.01	
Lower Confidence Limit	0.02	mg/8 hrs
Upper Confidence Limit	0.07	mg/8 hrs