U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
COMPOSITE REPORT ON THIRAM
75-THIRAM-352

HHE 75-188 Challenge Reforestation, Inc., Falls City, Oregon
75-136 Forestery Planting Service, Eugene, Oregon
75-137 The Hoedads, Eugene, Oregon
75-132 Industrial Forestry Association, Canby, Oregon
75-184 Klamath Reforestation, Inc., Toledo, Oregon
75-140 Webfoot Reforestation, Pleasant Hill, Oregon
75-123 Weyerhaeuser Company, Centralia, Washington

DECEMBER, 1976

I. TOXICITY DETERMINATION

Based upon a health hazard evaluation conducted by the National Institute for Occupational Safety and Health (NIOSH) between September 16, 1975 and April 7, 1976, it has been determined that Thiram (tetramethylthiuram disulfide, TMTD) poses a toxic hazard to both nursery workers and tree planters in the reforestation industry in the Pacific Northwest. This determination is based upon medical histories and review of the literature. Environmental sampling yielded non-toxic air levels of Thiram, but demonstrated a considerable variation in the amount of Thiram to be found on the trees to which the workers were exposed.

Skin irritation in a portion of the work force due to direct contact with Thiram treated trees was suggested by symptoms reported during the few days each individual group was studied, in addition to being identified in the general medical histories. Irritation of eyes, nose and throat caused by Thiram exposure was identified by general medical history. However, during the individual periods of study the incidence of these symptoms occurring during the study period failed to show significant differences between groups working with Thiram and groups not working with Thiram.

Systemic symptoms were attributed to exposure to Thiram by history, particularly when exposed to heavily sprayed trees or when the work week was extended beyond five days. These symptoms included headache, dizziness, nausea, diarrhea and other stomach complaints, fatigue and an intolerance to alcohol. Except for one worker apparently ill from Thiram exposure prior to the few days his group was studied, no systemic symptoms definitely attributable to Thiram were observed over the individual study periods. This included a lack of alcohol intolerance. It is of note that the alcohol intolerance described by history was generally fairly mild as compared to that experienced by persons taking the drug disulfiram.

II. DISTRIBUTION AND AVAILABILITY

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office at the Cincinnati address.

Copies of this report have been sent to:

(1) Challenge Reforestation, Inc., Falls City, Oregon
Forestry Planting Service, Eugene, Oregon
The Hoedads, Eugene, Oregon
Industrial Forestry Association, Canby, Oregon
Klamath Reforestation, Inc., Toledo, Oregon
Webfoot Reforestation, Pleasant Hill, Oregon
Weyerhaeuser Company, Centralia, Washington
(2) International Wood Workers of America -
Local 3-1 Centralia, Washington
Local 3-2 Aberdeen, Washington
Local 3-40 Molalla, Oregon
(3) U.S. Department of Labor, Region X
(4) Department of Labor and Industries, Olympia, Washington
Oregon State Accident Prevention Division
(5) NIOSH, Region X

For the purpose of informing the "affected employees," the employer will promptly "post" the Determination Report in a prominent place(s), near where the affected employees work, for a period of thirty (30) calendar days. In addition to this report the firms listed above are being sent supplementary data on the exposure of their own group.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following receipt of a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health received such requests from the firms listed in Section II of this report. These requests were submitted to determine if the compound "Thiram" (tetramethylthiuram disulfide, also called TMTD) is toxic as used under the following conditions: 1) spraying,

lifting, culling, and packing of Thiram-treated trees in the nursery; 2) planting the Thiram-treated trees in the forests. Thiram, as used in the preceeding occupations was suspected of producing contact dermatitis, alcohol intolerance, nausea, and fatigue in a portion of the exposed workers.

IV. HEALTH HAZARD EVALUATION

A. Description of Process

This evaluation involves the health effects of "Thiram" in the reforestation process. "Thiram" is a trade name for tetramethylthiuram disulfide. It is mixed with a latex emulsion, which acts as a sticking agent, and is applied to the seedlings in the nursery. The seedlings are treated with Thiram to prevent small animals (rabbits and snow shoe hares) from eating the trees after they have been planted in forests.

Reforestation is a long process covering several years. It begins with the collection of seed several years before an area is logged. The seeds are catalogued by area, elevation, etc. About two years before an area is to be replanted, the appropriate seeds are planted at the nursery. The seedlings are kept grouped through the growth in the nursery and planted in similar areas, elevations, etc., in the forest.

1. Nursery Operations

The nursery operations are divided into two types, the plug facilities and the bare root facilities. The spraying is done inside the plug facility and outdoors in the bare root facility. The culling, counting and packing of the seedlings is done indoors in a central facility. As the trees are handled in these facilities, the Thiram-Latex particles may: 1) flake and/or dust off, become airborne and subsequently be inhaled; 2) the trees may brush against the body causing the particles to fall off and contact the exposed skin area; and, 3) particles adhering to hands may be ingested when eating if the individual does not wash his hands. These facilities have wash rooms and separate lunch rooms available to the employees, thus the potential for ingesting Thiram is reduced if proper utilization of these facilities is employed.

The clothing worn during culling, counting and packing consists of long sleeve shirts or jackets and/or rubber slickers and gloves. In the plug facilities studied, several employees wore disposable-type single use paper respirators.

a. Plugs - The seeds are planted and the seedlings grown in small containers (size - 3 cubic inches to 8 cubic inches). These containers may be individual containers placed in a frame holding 100 to 400 trees

or the frame may be of styrofoam with 48 containers moulded in. The seedlings are grown in controlled conditions in greenhouse-type facilities.

Several days or weeks prior to culling and packing, the trees are sprayed with the Thiram-latex mixture. In the one plug facility involved in the study, the spraying was accomplished by hand using a garden hose attached to the spray tank. The sprayers used disposable coveralls and head covers, respirators, rubber gloves but no boots.

b. - Bare Root Seedlings - The seeds are planted and grown outdoors. After one or two years they may be transplanted and grown an additional year. They are designated by how old they are, such as 2-0, 2-1 (a 2-1 is 3 years old as it was two years old before transplanting and then has grown 1 year as a transplant).

The trees are sprayed with a Thiram-latex mixture while still in the field. The spraying is done, depending on the nursery, in the fall or just several days prior to lifting. The Thiram-latex mixture is mixed with water in a spray rig which is pulled by a tractor. The spray tank is equipped with a gas engine driven compressor which pumps the mixture through a series of nozzles directly behind the tank. The rate of application of the Thiram is then dependent on the speed of the tractor, the pump pressure, size of the nozzles and the Thiram concentration in the spray tank. Because of these variables, the amount of Thiram on the trees varies greatly from nursery to nursery. The sprayers wore disposable coveralls, gloves and boots.

The trees are lifted out of the ground by machine or by hand and transported to the packing area. In the packing area, the trees are culled, counted, and bagged and placed in storage. During the culling, counting, and bagging, the trees are kept moist to prevent drying out. This procedure also aids in preventing the Thiram particles from becoming airborne; however, skin contact with the Thiram can still be a potential problem.

2. Planting Operations

Planting trees is very strenuous as most of the planting is done on the sides of hills. The hills often have a slope of from 45° to 70°. The slash and undergrowth make planting and climbing difficult. As the trees are handled during the planting process, the Thiram-latex particles may: 1) flake and/or dust off, become airborne and be subsequently inhaled; 2) the trees may brush against the body, causing some of the particles to fall off and contact the exposed skin area; 3) particles adhering to the hands may be ingested when eating if the individual does not wash his hands.

The clothing worn by the planters depends on the weather. On rainy days they wear slickers, on dry days they wear jackets, and on dry warmer days they may wear a short-sleeved shirt or roll up their sleeves. The clothing worn on cold and wet days prevents skin contact on the arms with Thiram. Gloves are worn by most planters; however, all planters did not wear them. Wash water is not available. Occasionally, some men will wash their hands in a stream before eating.

The types of trees planted are plug seedlings and bare root seedlings and are discussed below.

a. Plug Planting - The plug seedlings are brought to the planting areas by the company inspector for whom the planting is being done. The plugs that were planted during the study were in moulded styrofoam containers that held 48 seedlings. The planters carried a back pack that held up to seven of these containers. One container would be placed on a rack attached to the belt from which they removed the individual trees for planting.

Prior to placing the containers in the back pack, they would shake the silica chips (which are placed on the seed beds in the nursery) off the surface of the containers. This shaking causes the Thiram to flake off and become airborne posing a potential Thiram inhalation exposure.

The planters usually work in crews consisting of from 9 to 12 persons. The trees are planted in a specified pattern. The plug planter digs a hole with a tool called a "dibble", inserts the plug in the hole and packs the dirt with his foot. Depending on the terrain, amount of slash, etc., a planter will plant from about 1000 to 3000 trees a day.

b. Bare Root Planting - The bare root trees are brought in bags to the planting area by the company inspector for whom the planting is being done. There may be from 150 to 1,000 trees packed in each bag (depending on the size of the trees). The trees are removed and placed in a planting bag (50 to 500 trees), which is then attached to the planters' waist. A planting crew usually consists of 9 to 12 persons.

The trees are planted in a specified pattern. The planter digs a hole with either a tool called a hoedag or with a shovel, inserts the roots of the tree in the ground and packs the dirt with his foot. Depending on the terrain, amount of slash, etc., a planter will plant from 500 trees a day to about 1,500 trees a day.

B. Study Progress and Design

1. General

The entire Thiram study consisted of environmental-medical evaluations at: (a) one plug nursery and two bare root nurseries which were spraying Thiram and lifting, culling, counting, and packing Thiram-treated trees; and (b) seven tree planting crews which consisted of 1) four crews planting Thiram-treated trees, 2) two crews planting trees treated with "Snow" (an inert substance with a physical appearance similar to Thiram), and 3) one control crew planting untreated trees (no Thiram or "Snow"). Additionally, one crew which was idled by inclement weather (snow) was evaluated medically.

The "Snow" trees were included in this study at the request of several of the companies involved, to determine if other products on the trees would give effects either analytically and/or medically similar to those of Thiram. The "Snow" was a white, inert substance which gave a physical appearance similar to Thiram when sprayed on the trees.

Exposure to Thiram could be expected to result from 1) inhalation of Thiram contained in the sprays during spray operations and in the dust formed when handling Thiram sprayed trees, or 2) ingestion of Thiram when eating food or smoking cigarettes with Thiram contaminated fingers. Direct skin contact could occur while handling sprayed trees. Spraying was confined to the nursery setting. Handling trees occurred during both nursery and planting operations.

2. Environmental Sampling

A total of 145 breathing zone samples were collected, most of which were from 6 to 8 hours in length. The 145 samples were as follows: (a) nurseries: controls - 8, Thiram exposed - 60; (b) Planters: controls - 7, "Snow" Exposed - 19, Thiram exposed - 51.

A total of 26 trees were collected from the various lots of trees being planted in order to determine the concentration of Thiram per gram of tree (above ground portion only). In addition, 5 cigarettes were collected from the planters after they had simulated smoking them to determine if Thiram particles were being transferred to the cigarettes during smoking.

3. Medical

The medical evaluation consisted of drawing a blood specimen for Thiram and dopamine beta-hydroxylase (DBH) levels before exposure to Thiram for the week. During the visit a questionnaire was administered and a brief physical examination performed according to Appendix A. At the end of the

exposure period a brief questionnaire (Appendix B) was given to record symptoms occurring during the period of exposure being tested. Repeat blood specimens were also obtained.

At the nurseries approximately 30 workers per nursery were included in the study group. At the plug nursery this included all workers in the packing area. In the other nurseries this represented a 50% systematic random sample to which sprayers were added. (No blood was drawn on sprayers unless they were spraying during the time of the visit.) In all 96 workers out of approximately 160 were seen and detailed questionnaires were completed on 94 (20 men and 74 women). Details on age, sex and general work area are contained in Table I. Blood specimens were drawn at the nursery. Except at the plug facility the post-exposure bloods were drawn during the last afternoon of exposure. At the plug facility all bloods were drawn following the 2 hour exposure.

Six groups of tree planters were evaluated: One group was seen planting Thiram-treated trees from plugs; one group was seen planting Thiram-treated bare root trees; two groups were seen twice, once planting "Snow" treated bare root trees and a second time planting Thiram-treated bare root trees; and two control groups were seen one while planting Thiram-free bare root trees, and the other while idled because inclement weather prevented planting. (No blood was obtained from this latter group.)

Most crews consisted of about 10 workers. The whole crew was used if willing to participate. In one case two crews were utilized to obtain about 10 workers willing to participate. In the control group which was actually planting, about half the crew was used, planters being selected who had had past experience with Thiram.

Of approximately 100 planters at the seven different locations studied, 77 were seen (71 men and 6 women). Details are included in Table I. Not all planters had complete questionnaires as work was stopped early on one occasion because of dryness.

C. Evaluation Methods

1. Environmental Sampling and Analytical Methods

The environmental sampling method consisted of collection of the Thiram-Latex particles on Millipore type AA filters (0.8 u) in the breathing zone of the workers. MSA model G pumps were used to draw the air through the filter at a flow rate of 1.7 liters per minute. The Thiram collected on each filter was eluted with a chloroform-acetone mixture. The acetone was removed, a color was developed by the addition of cuprous iodide and the absorbance read on a spectrophometer at 400 nm. A complete description of the analytical method is described in Appendix C.

The seedling trees collected were cut off at the ground line and sealed in plastic bags and sent to the NIOSH laboratory. The tree samples were weighed (as received), the Thiram was extracted with chloroform and then the samples were treated the same as the filter samples.

2. Medical Evaluation Methods

Blood specimens were analyzed at the Poisonlab, Denver, Colorado. Thiram was assayed utilizing a modification of the method for testing for antibuse.[1] The lower level of detection was 1 part per million (ppm) or 100 ug/dl. The dopamine beta-hydroxylase (DBH) determination followed their standard procedure for this enzyme.[2] Blood tests were chosen instead of tests for several different substances in the urine because: 1) None of the substances in the urine are specific for Thiram although changes might properly be used to monitor Thiram absorption; 2) the required collection techniques for the urine determinations presented considerable technical difficulty in a field setting.

Statistical analysis of the data utilized standard chi-square and t tests on raw data. The difference between pre- and post-exposure levels of Thiram and DBH were analyzed by means of the SPSS program "ANOVA". The four variables evaluated were sex, pretest exposure, exposure type and exposure length, the effect of each variable being balanced for the effects of the other three.

D. Evaluation Criteria

1. Environmental Criteria

The environmental air standard for occupational exposure to Thiram as promulgated by the U.S. Department of Labor, Code of Federal Regulations July 1975, Part 1910, Title 29, Chapter XVII, Subpart Z, Table Z-1, is 5 mg Thiram/m^3 air. The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values for Chemical Substances and Physical Agents (1976) also recommends 5 mg Thiram/m^3 air.

The report "Pesticide Residues in Food" of a joint meeting of the Food and Agriculture Organization of the United Nations (FAO) Committee on Pesticides in Agriculture and the World Health Organization (WHO) Expert Committee on Pesticide Residues - Geneva 30 September - 7 October, 1963, estimates of acceptable, non occupational, daily intake for man of 0.025 mg/Kg body weight. (This is equivalent to 2 mg/day for a 175 pound individual). At a breathing rate for hard work of 30 liters/min, the volume of air breathed in an eight-hour workday is 14.4 m^3. An environmental air concentration of Thiram of 0.14 mg/m^3 would give, if all is absorbed into the system, a total intake of 2 mg/day.

2. Medical Criteria & Toxic Substances Medical Data

Thiram has been used for some time as an accelerator in the rubber industry and as a fungicide for treating seeds and grass. Locally on contact it is irritating to the eyes, nose, throat, lower respiratory tract and skin.[3,4] It may be absorbed into the body by ingestion or by inhalation of Thiram containing dusts. Systemic symptoms include a general weakness, headache, irritability, nausea, vomiting, gastric distress and diarrhea.[3,4] Acute poisoning may also lead to low blood pressure and a drop in body temperature.[3] In addition to systemic effects due to the Thiram itself, it has an action similar to disulfiram (tetraethylthiuram disulfide, Antabuse®) of causing alcohol intolerance.[3,4,5]

Thiram can cause an allergic dermatitis and has been implicated in dermatitis caused by some rubber goods where the Thiram was used as an accelerator.[3,4,6] Moisture and sweat can leach sufficient Thiram from the rubber to cause an eczematous contact dermatitis.[6] Also alcohol ingestion can cause a marked reddening, itching and hive-like reaction at the site of skin contact with Thiram.[6]

Although the pharmacology of Thiram has not been well worked out, disulfiram, a closely related chemical, has been studied for use in helping to control alcoholism.[5]

Disulfiram is well absorbed when taken by mouth. Initial onset of action is delayed with full activity not being apparent for about 12 hours. This may be due to initial storage in the body fat. Elimination is slow, with about 1/5 of a dose still being present in the body after a week. Carbon disulfide is one of the early breakdown products within the body. Ultimately most of the disulfiram is metabolized to sulfates.

The alcohol intolerance is due to a blocking of the enzyme aldehyde dehydrogenase. Symptoms of alcohol intolerance due to disulfiram may include flushing of the face, throbbing of head and neck with a pulsating headache, respiratory distress, nausea, vomiting, sweating, chest pain, fall in blood pressure, weakness, dizziness, blurred vision, confusion and unconsciousness. Disulfiram also inactivates dopamine beta-oxidase (dopamine beta-hydroxylase) which converts dopamine to norepinephrine and may be part of the reason the blood pressure is affected.

The effects of disulfiram last for 6-12 days after stopping the drug, but serious reactions to alcohol ingestion usually only occur in the first 3-4 days after stopping the drug. The usual dose is 0.5 g per day for a prolonged period of time, although if there are unpleasant side effects the dose may be reduced to 0.25 g per day. (An equivalent dose of Thiram based on molecular weights would be 0.4 g/day for full usual dose, also expressed as 400 mg/d, however similar substances with similar effects often are not equivalent on a molecular basis.)

Several studies in animals have shown Thiram to be teratogenic in high concentrations.[7,8] Roben[7] working with hamsters looked primarily at skeletal abnormalities in the fetuses. Abnormalities of the skull and fused ribs predominated. Foll[8] using mice, found that doses up to approximately 250 mg/kg to be free of teratogenic effects. (This would be equivalent to a dose of about 12.5 g for an average 50 kg/woman.) Roben when using a non-teratogenic vehicle found effects at this level, but not at half this level. On the other hand rats fed 48 ppm Thiram in their food for three generations showed no effects.[9]

A probability of chance occurence of 0.05 or less was considered statistically significant. Normal blood levels of Thiram and of dopamine beta-hydroxylase are not established, so comparisons will be confined within this study. Nagatsu and Udenfriend[2] reported a mean DBH level of 42.6 units/liter on 54 subjects. The range was 3-100 units/liter and the 95% confidence limits of the mean were $\pm$ 7.4 units/liter.

E. Evaluation Results and Discussion

1. Environmental

The results of all the samples collected for the Thiram study are summarized in Tables II, III, IV, and V. A total of 145 personal breathing zone air samples were collected. They were as follows: 15 for control individuals (non-Thiram exposure), 19 with workers exposed to Snow-treated trees and 111 during handling of Thiram-treated trees. All the samples from the control and "Snow" groups showed less than detectable amounts (5.0 micrograms of Thiram per filter). Of the 111 samples for the Thiram exposed workers, 14 (12.6%) were positive for Thiram and 97 (87.4%) were less than the detectable amount. A further breakdown of the Thiram samples by operation is (a) nurseries: 60 total samples; 1 (1.7%) was positive for Thiram and 59 (98.3%) were not detectable. The positive sample contained 0.015 mg of Thiram/cubic meter of air. Depending on the volume of air sampled, 8 of 59 negative samples contained less than (<) 0.05 mg/m^3, 3 <0.04 mg/m^3, 16 <0.03 mg/m^3, 13 <0.02 mg/m^3 and 19 <0.01 mg/m^3. (b) Planters: 51 total samples, 13 (25.5%) were positive and 13 (74.5%) were not detectable. Thirty-six of the 51 were from persons planting bare root trees. Of these, 8 (22.2%) were positive and 28 (77.8%) were not detectable. Fifteen of the 51 were from persons planting plugs and of these 5 (33.3%) were positive and 10 (66.5%) were not detectable. The concentration in mg/m^3 of the 13 that were positive were 0.011, 0.012, 0.018, 0.019, 0.020, four at 0.021, 0.028, 0.029, 0.030 and 0.157.

In summary, 1.7% of the samples collected in the nursery were positive for Thiram compared to 25.5% of the samples collected during the planting process; thus the planters chances of inhalation of Thiram is significantly

greater than the nursery workers, although the inhalation exposure is very low as discussed in the next paragraph.

Thirteen of the 14 positive samples were 0.030 mg/m^3 or less. This is approximately 1/167th (0.5%) of the existing Federal standards of 5 mg/m^3 or about 1/5 of that amount needed to achieve through inhalation a daily intake of 2 mg/day (based on a ventilation rate of 14.4 m^3/8 hour day) which the World Health Organization considers a maximum daily exposure. The other positive sample contained 0.157 mg/m^3 which is 1/32 (3%) of the existing Federal standard or 113% (2.26 mg) of the WHO recommended maximum daily intake of 2 mg.

Results of the tree (above ground portion only) samples collected (Table IV) show that the amount of Thiram on 18 Thiram-treated trees ranged from 89 ug Thiram/gm of tree to 8400 ug/gm of tree with an average of 2269 and a median of 1800. The "Snow" treated trees ranged from 1 to 7 ug Thiram/gm tree with average of 4.5 ug/gm tree. Two untreated trees showed a level of 1 ug Thiram/gm tree and the other two showed none. The moisture content of the trees was not determined prior to analysis. This large difference is not unexpected because of the many variables in spraying processes and the lack of quality control programs for spraying in the nurseries.

Thiram was not detected on any of the five cigarettes (Table V) collected from planters after they had simulated smoking them.

One comment expressed by several planting crews was that the effects and symptoms were not as frequent or severe this year as in the past. One change in the application of Thiram in the nursery occurred this year. This year's change was the use of Thiram contained in a liquid emulsion whereas in the past the Thiram was in the form of a wettable powder. The effects of the change on the subsequent exposure of planters are unknown as there were no prior studies on this. It is interesting to note that although the nursery workers handle many more trees per day per person than a tree planter only 1 out of 39 (2.6%) of the nursery workers sampled who handled trees (sprayers are excluded as they do not handle trees) were positive while 13 out of 51 (25.5%) of the planters sampled were positive. This may be explained by the fact that at the nursery the trees are kept moist which helps prevent dusting off of Thiram particles. In addition, none of the 21 samples collected during spraying operation were positive.

Although there are caution labels with each bag of trees shipped, the safety and health measures listed on the labels were not being followed. It is obvious that the employers are not enforcing these suggestions. A copy of this label is in Appendix D.

1. Medical

Tables VI and VIII show symptoms developing over the study period among the nursery workers and tree planters respectively. Table VII and IX give the symptoms reported on detailed questioning for the two group.

a. Symptoms Developing During Study Period

Over the study period nasal irritation was the most likely symptom to develop, in a slightly greater percentage among nursery workers than among planters but not significantly so. However, the workers planting Thiram free trees reported about the same percentage of nasal irritation as the planters planting Thiram. Planting "Snow" trees caused a little less nasal irritation, but not significantly so.

The planters of both Thiram and Thiram free trees were also likely to develop eye irritation to a statistically significantly greater extent than were the nursery workers or planters planting "Snow" trees.

The planters of the "Snow" trees were most likely to develop throat irritation to a statistically significantly greater degree than either the Thiram planters or the Thiram free planters (who reported about the same amount of throat irritation). The nursery workers were intermediate between the two extremes, but were not significantly different from either.

The nursery workers gave headaches as the second most likely symptom to develop over the study period. This symptom was considerably more prominent among them than among the tree planters. However, this difference did not quite reach statistical significance.

The planters planting "Snow" trees differed from all other groups by reporting no skin problems during the study period. (The Thiram free tree planters reported only 1). Although this difference was not sufficient to reach statistical significance, it is suggestive of a clinically significant difference.

Of note among negative findings is the lack of problems associated with alcohol consumption following working with Thiram. Except for one planter who was clinically ill and really failed to work most of the study period, no one reported adverse effects with alcohol during the study period. A couple of the planting crews had adequate opportunity to test this as work was shut down for a day in the middle of the study period due to the weather. The nursery workers also failed to give a history of alcohol intolerance during the study period, but very few drank during the study period.

Other symptoms showed very similar patterns among the groups working with Thiram and not working with Thiram.

b. Symptoms as Obtained by History

On questioning about symptoms which might have been noticed while working with Thiram the nursery workers most often identified skin problems, with nasal irritation being slightly less prominent. This represents a reversal of their relative positions among symptoms developing over the study period. Headaches also dropped considerably in importance. Eye irritation was mentioned more frequently than throat irritation, and was primarily mentioned in relation to getting flakes or splashes in the eyes from the trees. Systemic symptoms, including alcohol intolerance, were mentioned only rarely.

In contrast, the planters identified eye problems most frequently, but again related it primarily to getting something into the eye. They mentioned this with about the same frequency as they did for such occurrences over the study period. Skin problems were mentioned more often than they were over the study period and considerably less often than they had been by the nursery workers. The difference however did not quite reach a level that could be considered statistically significant.

The planters reported a statistically significantly lesser amount of nasal irritation than did the nursery workers. This represented a much lesser proportion reporting this symptom by history than reported it over the study period.

On the other hand the planters reported statistically significantly more nausea, fatigue and diarrhea than did the nursery workers. Several planters did relate symptoms to working longer periods without a day off.

In all cases the workers identified that more heavily treated trees were more likely to give problems. The planters identified that the larger trees were more likely to brush the face and cause skin problems.

Most of the nursery workers had heard of someone who had had, or probably had had a reaction to alcohol after working with Thiram. The proportion reporting having had an adverse reaction themselves was about the same as those reporting other symptoms of systemic toxicity (with the exception of headaches in the case of the nursery workers). A few of the workers reported fairly severe symptoms, but not of the severity seen when drinking after being treated with disulfiram (Antabuse®). Some, among the planters in particular, said only that it seemed to make them get drunk on less, or that their hangovers tended to last longer. A few suggested that the inconvenience was transitory and that they only noted problems at the beginning of the season.

c. Physical Findings

Physical findings were not remarkable in relation to working with Thiram, although two planters were ill with a flu-like ailment. Blood pressures and pulses were taken at the time the detailed questionnaire was administered. Table X gives mean systolic and diastolic pressures and mean pulse rate for seasoned workers. Workers with less than two weeks work in the current season were excluded because of the possibility that acclimation rather than Thiram exposure has an important influence on these parameters.

In this study, as seen from the Table, the planters planting Thiram had a statistically significantly higher systolic blood pressure and pulse than the planters planting Thiram free trees. The other groups fell between these two extremes and were not statistically significantly different from either of them. There were no statistically significant differences in mean diastolic pressures. The clinical significance of this is in doubt. The study done through the Student-Originated Studies Project at the University of Oregon[10] showed a statistically significant shift in the opposite direction. Examination of their data on diastolic pressure suggests that the differences they observed in this parameter might be ascribed to an acclimation of the tree planters to the physically strenous job of planting trees on rather rugged hillsides.

d. Correlation of Symptomatology with Work Practices and Conditions

The tree planters seldom had any means available at the work site for washing their hands before eating or smoking, would work with Thiram continuously throughout the day, sometimes worked more than 5 days in a row. Also, some crews seldom worked out of their established residence and were not always able to bathe regularly or frequently (21% of the tree planters interviewed bathed less frequently than every other day while in the field).

Three major living and working arrangements were noted among various tree planting crews:

(1) Some crews did all their work from the same base. Most crew members stayed at their permanent residence and were able to enjoy their usual personal hygiene. These workers usually worked a five day week with weekends off.

(2) Some crews seldom worked out of the same base for more than a few weeks. Except when working in the vicinity of their permanent residence, the crews were put up as a group in a local motel. They were able to enjoy their usual personal hygiene, but among some crews it was the practice to work 10 days in a row and then take 4 days off.

(3) Some crews, also seldom working out of a base near their permanent residence, would camp out while working away from home base. Under these circumstances frequent bathing was impractical. Among the group in which camping out was usual work rules also permitted the individual to work as much, as long and as many days in a row as he desired. Although a few worked extended periods of time, most would work 5 or less days in a row before taking time off.

Because the crews were small and sufficient other variables were present, statistically significant differences could not be shown among the different life styles of the planters. However, the planters whose groups were inclined to work more than 5 days in a row did show a statistically significantly greater incidence of systemic symptoms and/or alcohol intolerance, by history (20 out of 28) than did planters from groups which seldom worked more than a 5 day work week (5 out of 36) or nursery workers (18 out of 94). (Chi square on a 2.2 table is 36.513, probability of being due to chance is considerably less than 0.0005).

Symptoms of headache, dizziness or lightheadedness, fatigue, nausea or upset stomach, diarrhea, loss of balance, depression, irritability when working with Thiram and a complaint that working more days in a row was more likely to bring out these symptoms seem indications of Thiram absorption. Of the 11 persons reporting what seemed definitely to be some intolerance to alcohol after working with Thiram, 8 also reported other systemic symptoms associated with work with Thiram apart from drinking. For 77 persons who drank after working with Thiram who did not notice any problems, only 21 reported other systemic symptoms. (Chi square for this difference is 7.174, probability of being due to chance is 0.008).

The planters planting Thiram-treated trees from plugs observed during this study received their trees in styrofoam blocks of 48 trees. It was their practice to turn the blocks upside down at the time of loading their racks to shake out the silica chips which were used as mulch. Dr. Thoburn had occasion to be standing near a planter loading up and noticed a bitter-sweet taste developing during this procedure.

Tree planters made the following observations about circumstances under which the Thiram seemed to cause more problems than usually or circumstances under which they noticed problems:

(1) They were much more likely to have problems with the Thiram if the trees were heavily coated, if the weather was dry and the Thiram tended to flake off, if the trees were big and tended to brush against

their face, or if they worked a longer period of time without a few days off. A breeze, on the other hand, helped. One planting group had considerable problem with both local and systemic symptoms when they received a batch of trees which had an exceptionally heavy coating of Thiram.

(2) A couple of the workers observed that when the group they were with first started working with Thiram and were having considerable trouble with systemic effects it was not uncommon for the planters to carry their lunches in their planting bag.

(3) The observation was also made that several in this same work force were new to tree planting and the group life style.

(4) At least one planter related his eye irritation while working with Thiram to the sweat running down from his forehead into his eyes. This condition was considerably helped by wearing a sweat band. Whether the irritation was due to Thiram dust washed into the eye by the sweat, or just to the sweat is not completely clear, as sweat itself can be quite irritating, particularly if one has no facilities handy for washing out his eyes.

The nursery workers had hand washing facilities available on the job, usually did not work with Thiram continuously during the day, seldom worked more than 5 days per week or 5 days in a row, had established residences, and were able to bathe regularly (83% daily, 14% at least every other day).

Some differences were noted in work practices in the nurseries as well:

(1) One of the nurseries grew their trees in plugs, mostly in greenhouse style sheds. Spraying with Thiram was done shortly before the trees to be packaged were lifted. The first step in packaging was to remove the plugs from the rack. This was done in a machine which operated at about face level of the worker running it. The plugs were loosened by vibration, with the worker removing by hand any not falling out by themselves. In packaging, the plugs were bundled together and secured with a rubber band.

(2) One of the nurseries which grew trees outdoors and packaged the seedlings with bare roots was also in the habit of spraying with Thiram only a short time before lifting the trees for packaging.

(3) The other nursery growing trees outdoors and packaging the seedlings with bare roots was in the habit of spraying the trees with Thiram early in the season over a few days time, and then lifting and packing them as needed without further Thiram spraying. This nursery also had a sprinkling system to keep a fine water mist on the packing line to prevent the trees from drying during packing.

The nursery workers working inside with trees sprayed early in the season and kept moist during packing showed statistically less nasal irritation over the study period than did inside workers at the nursery where the trees were sprayed with Thiram only shortly before lifting. (5 out of 15 inside workers as opposed to 15 out of 18 inside workers.) (Chi square is 6.6351; probability of being due to chance is 0.01.)

By history inside workers related the lowest incidence of local symptoms at the nursery where the trees were sprayed early in the season (8 out of 18), an intermediate amount where trees were grown outdoors and packed with bare roots (14 of 18), and most in the plug facility (19 out of 22). (Chi square [d.f. = 2] is 8.9065; probability of being due to chance is 0.012.) This same difference in history of local symptoms was also observed among the outside workers at the bare root facilities, 3 out of 14 reporting symptoms among the workers where trees were sprayed early in the season as opposed to 11 out of 15 where trees were sprayed shortly before lifting. (Chi square is 6.0226; probability of being due to chance is 0.016.)

No statistically significant differences were noted in the histories of systemic problems in general given by workers in the three different facilities. However, all three nursery workers reporting having personally had reactions to alcohol after working with Thiram worked at the plug facility. This is statistically significant as only 7 out of 46 workers "at risk" worked in the plug facility. (Chi square is 13.2750; probability of being due to chance is less than 0.0005.)

Nursery workers made the following observations about circumstances under which the Thiram seemed to cause more than average problems.

(1) The persons mixing the spray noted problems when they had to weigh out Thiram powder. This was eliminated by switching to a liquid suspension of Thiram.

(2) One incidence was recounted in which a number of workers weeding in a field were exposed to a cloud of Thiram spray which was being applied nearby on a windy day. Later that evening a number of the workers got sick with symptoms suggestive of alcohol intolerance when visiting the local tavern.

(3) Several of the workers in the plug nursery visited have found paper dust masks helpful in cutting down local irritation when sorting Thiram-treated trees.

(4) The inside workers at the bare root facilities felt that problems were worse if the trees were dry (as did the tree planters). On the other hand the workers at the plug facility felt that moist trees gave more problem because of an increased likelihood of splashing water from the trees into their eyes when putting on the rubber bands.

(5) In one of the nurseries packing bare root trees several workers observed that there were more symptoms during the time of our study because they were packing Thiram trees continuously for the study period rather than having batches of Thiram-treated trees intersperced with untreated trees during the course of the day.

(6) At one nursery it was mentioned that preparing bags for reuse which had contained Thiram trees caused irritative and systemic problems.

e. Correlation of Work Practices and Clinical Findings with Blood Thiram and Serum Dopamine Beta-hydroxylase Levels

No correlation could be made between serum dopamine beta-hydroxylase (DBH) level and blood Thiram level, either for the group as a whole, or when just looking at those persons showing a measurable blood Thiram level. The serum DBH levels showed a normal distribution further suggesting the lack of any significant findings. Table XI gives some detail on blood Thiram level on the initial test in relation to the pre-test exposure history. Table XII does the same for serum DBH. Eight (8) planters were seen once while planting "Snow" trees and once while planting Thiram trees. They are included once for each exposure with a note to compare their two experiences. None of the findings on pre-test DBH can be considered significant.

A statistically significantly greater number of the nursery workers (inside, inside and outside, and sprayers, but not outside only) showed a blood Thiram level above 1 ppm than did the outside only nursery workers and tree planters (Thiram or "Snow"). Both groups had greater numbers with measureable Thiram levels than persons without a history of Thiram exposure in the previous couple of weeks. The last had no levels above 1 ppm, the lower limit of detection.

The changes in level over the study period of both the blood Thiram and the serum DBH were analyzed for multiple variables using SPSS "ANOVA" program. Results are summarized in Tables XIII and XIV. (A "+" means the level dropped over the study period; a "-" means it rose.) Because of uncertainty of the amount of exposure to Thiram the planters planting "Snow" trees and one planter who because of illness worked only a part of the period the rest of the crew worked were excluded from this analysis. The sprayers were also excluded because of their small numbers. Blood Thiram levels of "less than 1 ppm" were assumed to be 0.5 ppm.

There were no significant differences between exposure groups or any other variable and changes in blood Thiram level over the study period

There was a significant difference in changes in serum DBH over the study period and the length of exposure. Table XV expands upon exposure length utilizing raw means. The interpretation of exposure length is a little difficult as some exposure types had unique exposure length as well. Both the two hour exposure and half-day exposure groups (which show a drop over shift in their adjusted means) had their post-exposure blood drawn mid-day. The other exposure lengths had their post-exposure blood drawn at the end of the day. It is quite possible that DBH levels have a normal diurnal variation. On the other hand looking at raw means in Table XV it is noted that only the nursery workers at the plug facility and the planters who actually got in 3 working days planting Thiram had drops in DBH levels which were statistically different from 0. This suggests that amount of exposure may be important. It would be well to point out that the mean drop is clinically insigifnicant in relation to the variation in DBH levels found in this study. In comparing the relative rise or fall in DBH level with systemic symptoms developing over the study period there was no overall consistency.

Two planters were clinically ill with flu-like symptoms at the time of the study. One was seen on his first day of tree planting and again two days later after planting Thiram-treated trees. Both his blood Thiram levels were below the limit of detection. His serum DBH dropped from 19 units/liter to 14. It was felt that he probably had the flu.

The other planter felt ill enough to only work about one-half day during the two day study period. Besides the flu-like symptoms he claimed an intolerance to alcohol during this time, primarily a more washed out feeling the next morning than he was used to when not working with Thiram (a symptom noted other times also). He had been planting Thiram-treated trees for some time. He pre-test blood Thiram level was 30 ppm, dropping to 23 ppm over the two day study period. DBH levels were 149 u/l and 72 u/l respectively. Considering history and laboratory findings, this planter may have been suffering from acute Thiram toxicity. Other acute systemic symptoms in relation to maximum blood Thiram levels are given in Table XVI. Thiram levels of 20 ppm may be associated with headaches, but this is not definite as there were many headaches with no demonstrable Thiram levels. There was also a level of 12 associated with headache. On the other hand the highest level without any systemic symptoms was 15.

If Thiram is inactivated at about the same rate as disulfiram (1/5 still present in a week),[5] we would expect to see a drop in Thiram level comparable to that seen in the planter who may have been suffering from Thiram toxicity. Although there is the possibility that not all people inactivate Thiram at the same rate, no distictions could be made from this study.

F. Summary

1. Although the serum dopamine beta-hydroxylase (DBH) levels did not prove helpful, blood Thiram levels at least showed that there was significant absorption into the body. This is compatible with the finding in the Oregon Study[10] that some planters excreted carbon disulfide. Similarly to that study, this study showed many workers with no measurable level of the substance tested for. This would suggest that most workers were not accumulating appreciable body burdens of Thiram at the time of this study. The fact that one planter planting "Snow" trees had a blood Thiram level suggests that all sources of exposure were not eliminated by simply reducing the Thiram on the trees to near zero.

2. Using the Poisonlab method for blood Thiram determination it would appear that anything up to 1 ppm Thiram (the lower limit of detection) can be considered a negative finding. Blood levels up to 15 ppm can apparently occur without symptoms. A blood level of 30 ppm is probably indicative of toxicity. The interval between these two figures is questionable. Because this test is expensive and so many workers showed no Thiram levels, it cannot be recommended for routine use.

3. The most frequent symptom developing during the study period was nasal irritation, but this did not statistically relate to Thiram exposure. The tree planters also were at risk of eye irritation, but again this did not seem to relate specifically to the Thiram. The nursery workers, most of whom were women, did show a greater incidence of headache than the planting groups, most of whom were men. Again it is likely that there are other factors besides Thiram exposure. On the other hand it was suggested at one nursery that there was an increase in both upper respiratory irritation and headache from running Thiram through the line continuously instead of only intermittently.

Although complaints of skin problems were not prominent and differences did not reach statistical significance, it was noted that none of the planters planting "Snow" trees had skin problems while 19% of the nursery workers and 17% of the tree planters did have some problem with their skin. This is probably significant clinically. Also of note was the lack of adverse effects on consuming alcohol. The planter with a blood Thiram level of 30 ppm did report problems. A planter with a blood Thiram level of 15 drank during the study period without ill effect. Nothing can be said concerning the workers with levels of 20 ppm as neither drank during the study period.

4. The planters planting the "Snow" trees showed a statistically significantly greater incidence of throat irritation over the study period than did the other planters.

5. By history eye irritation was most often associated with getting something containing Thiram (dust or splash) into the eye. This was most likely to occur outside or when trying to bundle wet plugs with rubber bands. This was one of the major complaints.

6. Skin irritation or dermatitis was also a major complaint affecting 45% of the nursery workers and 28% of the tree planters. This was helped by any measures which reduced the amount of exposed skin.

7. Besides eye irritation and skin problems local symptoms included irritation of the nose and throat and chest discomfort or shortness of breath. Systemic symptoms included headaches and an intolerance for alcohol, and for the tree planters in particular, nausea or upset stomach, diarrhea, fatigue, and occasionally dizziness, loss of balance, irritability and depression.

8. The alcohol intolerance usually was not severe, mainly being manifest as a lowering of the quantity of alcohol causing intoxication and prolonging of the hangover (or manifesting a hangover when not usually experienced). There was the suggestion that there was a degree of acclimation to these effects.

9. Local effects appeared to relate particularly to how heavy the immediate exposure was. Systemic effects related to how heavy the exposure was, how long it was sustained, and other factors which could relate to increased ingestion of Thiram.

10. In the nursery setting the following factors seemed to affect exposure:

a. Anything which tended to allow Thiram dust or spray to become airborne increased exposure and increased symptoms unless precautions were taken. Conversely anything which cut down on the airborne Thiram reduced problems. In the spraying operation changing from powdered Thiram to a liquid suspension of Thiram in the formulation greatly reduced the exposure of the persons responsible for mixing the spray. Carelessness in exposing workers to the spray can lead to unnecessary exposure.

The outside workers were not nearly as affected by airborne Thiram as were the inside workers. Certain jobs increased exposure, such as removing Thiram trees in plugs from their holders and salvaging used bags which had contained Thiram trees. Humidity was a decided help in preventing problems. (The one exception being in the plug facility where rubber bands were used.) A fine mist over the packing line appeared to be a definite advantage.

b. Besides variations in the amount of Thiram sprayed on the trees, the time of spraying and general method of growing the trees affected the degree of exposure and subsequent symptomatology. It would appear that the workers in the plug facility where the trees were sprayed shortly before packing and where the trees were under cover much of the time had the greatest exposure. It is of note that this was the

only nursery where any of the workers talked to had actually experienced any ill effects from drinking alcohol after working with Thiram. Intermediate in exposure was the nursery where the trees were sprayed shortly before packing, but trees were grown outside. Least exposure was in the nursery where all trees were sprayed at the beginning of the season and were grown outside.

c. One factor tending to reduce the exposure and ill effects of Thiram in the nursery setting was the practice of running Thiram trees through the packing line in batches with batches of Thiram free trees between times.

11. In the tree planting setting the following factors seemed to affect exposure:

a. Again increased exposure was related to heavily sprayed trees, and, particularly, dryness which encouraged the Thiram to flake off and become airborne. Also shaking plugs to remove the silica chips would have the same effect of producing airborne Thiram. Wind helped reduce exposure.

b. Skin protection is important to prevent skin problems. Adverse factors were warm weather encouraging shedding of clothing and 3 year old trees which were tall enough to brush the planter's face when removed from the planting bag.

c. Length of exposure was important. Major problems of systemic toxicity were found among those crews who worked or were allowed to work for more than 5 days in a row on a regular basis.

d. Although the major factor in the increased incidence of systemic symptoms among tree planters appears to be working a longer "week," ingestion undoubtably is an important route of entry. Such practices as carrying one's lunch in the planting bag in non-impervious containers would greatly increase the likelihood of ingestion. The fact that hand washing facilities are usually lacking in the field is probably a contributing factor. It is possible to eat with unwashed hands without contaminating the food, but requires conscious effort. Hand washing would be preferable.

12. 1.7% of the environmental breathing zone air samples collected in the nursery contained detectable quantities of Thiram compared with 25.5% of those collected during the planting process; thus the planters' chances of inhalation of Thiram is significantly greater than the nursery workers'. This is probably a result of the trees being kept moist in the nursery whereas in the planting operations the trees dry out and the Thiram flakes off more readily. Based on the low concentration of Thiram measured (13 of 14 positive samples were 0.030 mg of Thiram/m^3 of air or less), the

inhalation exposure is considered very low. 0.030 mg of Thiram/m^3 of air is approximately 1/167th (0.6%) of the existing Federal standards of 5 mg/m^3 or about 1/5 of that amount needed to achieve through inhalation a daily intake of 2 mg/day (based on a ventilation rate of 14.4 m^3/8 hour work day) which the World Health Organization considers a maximum daily exposure. The other positive sample contained 0.157 mg/m^3 which is 1/32 (3%) of the existing Federal standard or 113% (2.26 mg) of the WHO recommended maximum daily intake of 2 mg.

13. It was not possible to correlate the individual blood Thiram levels with the environmental air samples. In the nursery, only one of 60 samples contained detectable amounts of Thiram. Regarding the planters, it appears that ingestion is the greatest source of introducing Thiram into the body; hence correlation is difficult.

14. The concentration of Thiram per gram of tree on Thiram-treated trees varied over a very large range. This indicates quality control programs are lacking in the industry. The concentration of Thiram on the trees should be limited to that amount needed to achieve the desired antibrowsing results, and all the nurseries should apply approximately the same concentration of Thiram on the trees.

15. The analytical results of; a) environmental air samples collected during handling and planting of "Snow" treated trees or non-Thiram trees and; b) the tree samples that were treated with "Snow" or were not treated with either "Snow" or Thiram, showed that there was no material present in the air or on the trees that would give a false positive indication that Thiram was present. All positive results can therefore be attributed to Thiram.

G. Conclusions

In conclusion, except for the skin problems probably due to direct contact, exposure to Thiram at the levels seen during this study was not causing any definite illness, although some increase in irritation and headache was suggested as being caused by a more continuous packing of Thiram-treated trees at one nursery (the one planter probably sick from Thiram had his exposure before the study period).

Based on the low breathing zone sample results (out of 111 Thiram samples), 13 of the 14 positive samples contained less than 0.303 mg/m^3 and 97 samples contained less than the detectable amount, it is concluded that very little exposure occurs through inhalation. Although particle size distributions were not done on the particles that flake off, the low concentration found on the filters probably indicates that these particles are rather large (greater than 10 microns in size) and tend to fall readily, therefore they are not collected by the sampler and are not readily inhaled. It is more likely that Thiram

would enter the body through ingestion since the personal hygiene habits of many of the tree planters are poor (e.g., not washing before eating, no daily bath or shower, infrequent change of work clothing, etc.)

By history, Thiram has caused local irritative symptoms and skin problems and systemic problems including a not too severe alcohol intolerance. The most important factor in determining systemic problems is the dose,which can be either an extremely heavy dose at one time (as when workers are inadvertently sprayed with Thiram or trees are considerably oversprayed), or by a much more usual dose continued over a longer period of time without giving the body a chance to clear itself. This latter showed a sharp distinction between groups only working 5 days in a row as opposed to groups which often worked longer periods without time off.

Based on other industries where good personal hygiene practices are required and are being adhered to, the recommendations that follow can be practiced in the reforestation industry and the individual exposures reduced.

H. Recommendations

The following recommendations cover both the planters and nursery operations although some may apply to only one operation.

1. Length of work week is very important when working with Thiram. More than 5 days in a row is not recommended unless great care be taken to prevent Thiram absorption. This would involve suppressing Thiram dust and observing scrupulous personal hygiene.

2. "Tempered" wash water and hand wipe materials should be provided either by the planting firm, or preferably, by the firm for whom the planting is being done. It could be carried on the inspector's truck in an insulated container or containers heated by a small propane or gas burner.

3. Employees should wash their hands before eating or smoking and at the close of work.

4. If the hands are not washed prior to eating, the food should be handled with napkins, etc. Bad practices observed were crumbling crackers with dirty hands into soup, polishing apples on dirty clothing, handling sandwiches with dirty hands, etc.

5. Every planter or nursery employee should bathe or shower regularly, preferably daily.

6. Food should never be stored or consumed in the packing area of the nursery.

7. It would be desirable to have a "clean" area for carrying lunches in the crummy (usually a passenger van or bus). Probably it would be sufficient to have the "clean" area elevated off the floor and not used to carry anything other than lunches.

8. Food must never be carried in the planting bags.

9. If the individual is susceptible to skin irritation, long sleeve shirts should be worn even when warm to reduce skin contact. Silicone barrier creams may prove of value to other exposed skin areas (e.g., face).

10. The clothing worn by the planters and the nursery workers should be washed daily or at a minimum of every other day.

11. Rubberized gloves or latex gloves with liners could be worn by the planters. Cloth gloves become wet and the inside becomes readily contaminated. If rubber-type gloves are used, the hands must be clean before inserting them into the gloves. Planters were observed handling Thiram trees with the bare hands and then inserting the Thiram contaminated hands in the gloves.

12. The sprayers in the nurseries should wear rubber boots in addition to the protective clothing presently worn.

13. Based on the low amount of Thiram found in the breathing zone of the planters and nursery workers, respirators would have very little effect in reducing the individuals overall exposure. They should, however, be made available for those persons desiring to wear them. Disposable NIOSH approved respirators could be used by these individuals.

14. Encourage the nurseries to provide quality control in applying Thiram to the trees to apply the minimum amount needed to achieve the desired anti-browsing results. The levels ranged from 89 micrograms of Thiram per gram of tree to 8400 micrograms per gram of tree.

15. Care should be taken to prevent worker exposure to the spray, including down-wind exposure.

16. Employees should always stand upwind when burning the bags that contained Thiram-treated trees. The heat will vaporize the Thiram and thereby increase the chance for exposure.

17. If possible trees should be allowed to season between the time of the spraying and the time of packing.

18. A humid atmosphere is desirable during the packing process. With current practice the only nursery visited where this would pose a problem is in the plug facility where rubber bands are used to bundle the plugs and splashes might occur. Perhaps this could be addressed by finding some other means of bundling the plugs. Another approach would be to provide eye protection, but this would probably prove less satisfactory because of worker non-acceptance.

19. In the nursery, the floors are swept frequently throughout the day. This sweeping creases a dusty situation. Vacuuming in lieu of sweeping will reduce the dust levels.

20. The plugs that were grown in moulded styrofoam containers still had the silica chips on the dirt surface when sent out to be planted. The planters would shake the container to remove the chips and during the shaking, the Thiram also flaked off. The chips should be removed at the nursery where it could be done under controlled conditions (e.g., in a small bench-type hood equipped with local exhaust ventilation).

21. The "crummies", used to transport the planters and their equipment get contaminated with Thiram because some Thiram that is adhering to the clothing and equipment of the workers will fall off and be deposited in the crummies. The inside of the crummies should be washed or vacuumed and wiped down on a regular schedule.

22. Encourage research to find a non-toxic substitute for Thiram.

23. An educational program should be developed in the industry regarding employees' exposure to Thiram. This would include an explanation of the safe handling of Thiram, the importance of good personal hygiene, the symptoms caused by Thiram inhalation or ingestion, ways to prevent or reduce exposures, etc.

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TABLE I
CHARACTERIZATION OF WORKER SAMPLE

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

	MALE	FEMALE	TOTAL	AGE AVERAGE	AGE MEDIAN	AGE RANGE
A. Nursery Workers Total	20	74	94	36.1	33	18-76
Inside or Inside and Outside	3	55	58	37.2	35	18-76
Outside only	14	17	31	35.0	39	19-75
Spraying	3	2	5	29.0	28	21-42
Plug trees	1	25	26	32.2	29	18-54
Bare root trees	19	49	68	37.6	33	18-76
Seen but no Questionnaire completed (not included above)	1	1	2	--	--	--
B. Planters Total	67	6	73	27.3	25	18-58
Seen twice (once planting thiram, once planting "snow")	9	0	9	33.8	29	20-51
Planting thiram treated plug trees	10	0	10	26.6	26.5	18-40
Planting thiram treated bare root trees	28	0	28	28.8	24	18-58
Total planting thiram treated trees	38	0	38	28.2	24.5	18-58
Planting "snow" trees	23	0	23	29.7	26	20-51
Planting thiram free trees	15	6	21	25.9	25	19-39
Complete questionnaires, Experience with thiram	56	1	57	28.1	25	18-58
Abbreviated quest., Experience with thiram	6	1	7	29.3	28	22-39
Complete quest., no experience with thiram	5	4	9	23.4	24	19-27
Seen but no Questionnaire completed (not included above)	4	0	4	--	--	--

TABLE II

RESULTS OF PERSONAL BREATHING ZONE AIR SAMPLES COLLECTED DURING NURSERY OPERATIONS

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

COMPANY IDENTIFICATION NUMBER	JOB DESCRIPTION	TREATMENT	NUMBER POSITIVE* FOR THIRAM DETECTION	NUMBER NEGATIVE FOR THIRAM DETECTION	THIRAM CONCENTRATION mg/m^3	TOTAL NUMBER SAMPLES
1	Sprayers and Helpers	Thiram	0	16	4 < 0.02 1 < 0.04 5 < 0.03 6 < 0.05	16
	Pullers, Counters, Cullers, Baggers, Tying Bags	Thiram	0	15	9 < 0.01 6 < 0.02	15
	Cullers Packers	none (no Thiram	0	3	3 < 0.03	3
2	Nursery Plugs Sprayers and Helpers	Thiram	0	4	2 < 0.04 2 < 0.05	4
	Extractors, Cullers, Box Closer, Boxers	Thiram	0	11	11 < 0.03	11
	Bare Root Sprayers and Helpers	Thiram	0	1	1 < 0.01	1
	Lifters, Packers, Cullers, Sorters, Belt Loaders	Thiram	1	12	0.015 Hand Puller 9 < 0.01 3 < 0.02	13
	Packers	None (no Thiram)	0	5	5 < 0.02	5

*Minimum detectable amount of Thiram was 5.0 micrograms per filter.

TABLE III

RESULTS OF PERSONAL BREATHING ZONE AIR SAMPLES COLLECTED DURING TREE PLANTING OPERATIONS
THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

COMPANY IDENTIFICATION NUMBER	TYPE OF TREES PLANTED	TREE TREATMENT	NUMBER POSITIVE* FOR THIRAM DETECTION	NEGATIVE	THIRAM CONCENTRATION mg/m^3	TOTAL NUMBER SAMPLES
3	Bare Root	"Snow"**	0	10	10 < 0.02	10
	Bare Root	Thiram	4	6	0.029 0.028 0.030 0.157 6 < 0.02	10
4	Bare Root	"Snow"	0	9	9 < 0.01	9
	Bare Root	Thiram	3	14	0.021 0.021 0.018 14 < 0.02	17
5	Bare Root	Thiram	1	5	0.021 5 < 0.02	6
6	Bare Root	Thiram	0	3	3 < 0.02	3
	Plugs	Thiram	5	10	0.012 0.020 0.021 0.011 0.019 10 < 0.02	15
7	Bare Root	None (no Thiram or Snow)	0	7	7 < 0.02	7

* Minimum detectable amount of Thiram was 5.0 micrograms per filter.
** Snow - a substance similar in appearance to Thiram.

TABLE IV

THIRAM CONCENTRATION ON TREES
THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

SAMPLE NUMBER	HOW TREATED	TYPE AND SIZE OF TREE	RESULTS ug THIRAM/gm TREE*	WEIGHT OF TREE gm*
Tree 1	No Thiram	Plug Douglas Fir	0	2.0**
Tree 2	No Thiram	Plug Douglas Fir	0	2.4
Tree 3	Thiram	Plug Douglas Fir	1800	2.0**
Tree 4	Thiram	Plug Douglas Fir	1800	2.0**
Tree 5	"Snow"***	2-0 Douglas Fir	4	12.0**
Tree 6	"Snow"	2-0 Douglas Fir	6	12.0**
Tree 7	Thiram	2-0 Douglas Fir	105	13.8
Tree 8	Thiram	2-0 Douglas Fir	97	16.7
Tree 9	Thiram	2-1 Douglas Fir	89	19.8
Tree 10	Thiram	2-1 Douglas Fir	122	14.1
Tree 11	No Thiram	2-1 Douglas Fir	1	27.4
Tree 12	No Thiram	2-1 Douglas Fir	1	21.5
Tree 13	Thiram	2-0 Hemlock	707	4.2
Tree 14	Thiram	2-0 Hemlock	628	5.0

* Above Ground Portion of Tree

** Estimated Weight of Tree (Laboratory only reported total weight of Thiram found on these samples).

*** Snow - A substance similar in appearance to Thiram

TABLE IV, cont.

THIRAM CONCENTRATION ON TREES

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

SAMPLE NUMBER	HOW TREATED	TYPE AND SIZE OF TREE	RESULTS ug THIRAM/gm TREE*	WEIGHT OF TREE gm*
Tree 15	"Snow"	2-0 Douglas Fir	7	6.8
Tree 16	"Snow"	2-0 Douglas Fir	1	8.5
Tree 17	Thiram	2-1 Douglas Fir	3000	50.1
Tree 18	Thiram	2-1 Douglas Fir	2800	15.9
Tree 19	Thiram	1-1 Douglas Fir	3700	15.9
Tree 20	Thiram	1-1 Douglas Fir	4300	25.2
Tree 21	Thiram	2-0 Douglas Fir	3100	12.3
Tree 22	Thiram	2-0 Douglas Fir	3000	13.5
Tree 23	Thiram	2-1 Hemlock	400	18.1
Tree 24	Thiram	2-1 Hemlock	700	7.6
Tree 25	Thiram	Plug Douglas Fir	8400	3.1
Tree 26	Thiram	Plug Douglas Fir	6100	3.9

* Above ground portion of tree

TABLE V

THIRAM CONCENTRATION ON CIGARETTES

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

SAMPLE NUMBER	RESULTS ug/CIGARETTES
1	Non Detectable
2	Non Detectable
3	Non Detectable
4	Non Detectable
5	Non Detectable

TABLE VI
SYMPTOMATOLOGY BY EXPOSURE GROUP - NURSERY WORKERS

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

Symptoms Developing Over the Study Period

SYMPTOMS	INSIDE	OUTSIDE	SPRAYERS	TOTAL	PERCENT
Number of Workers	33	28	1	62	
Eye Complaints	6	5	1	12	19
Nasal Irritation	20	16	1	37	60
Throat Irritation	7	10	1	18	29
Cough	7	3	1	11	18
Chest Discomfort of Shortness of Breath	2	3	0	5	8
Skin Problems	7	4	1	12	19
Total with Local Symptoms Likely to be due to Thiram	24	20	1	45	73
Headaches	11	10	0	21	34
Dizziness or Lightheadedness	1	2	0	3	5
Fatigue	0	0	0	0	0
Nausea or Upset Stomach	5	4	0	9	15
Diarrhea	0	0	0	0	0
Alcohol Intolerance	0 of 2	0 of 3	0 of 1	0 of 6	
Total with Systemic Symptoms Likely to be due to Thiram	12	13	0	25	40
Kidney Complaints	0	1	0	1	2
Total with No Complaints	8	6	0	14	23

Note: The plug nursery workers were not administered the post exposure questionnaire and so are not included in this table.

TABLE VII
SYMPTOMATOLOGY BY EXPOSURE GROUP - NURSERY WORKERS

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

Symptoms by History

SYMPTOMS	INSIDE PLUGS	INSIDE BARE ROOT	INSIDE TOTAL	OUTSIDE	SPRAYERS	TOTAL	PERCENT
Number of Workers	22	36	58	31	5	94	
Self Health Assessment							
Good	21	33	54	26	3	83	88
Fair	1	3	4	5	2	11	12
Eye Complaints	10(1)*	11	21(1)*	5(1)*	2	28(2)*	30
Nasal Irritation	16(2)	10(1)	26(3)	8(1)	2	36(4)	38
Throat Irritation	8	7(3)	15(3)	6(2)	2	23(5)	24
Cough	1	0	1	0	0	1	1
Chest Discomfort or Shortness of Breath	1	2	3	1	0	4	4
Skin Problems	10(2)	17(1)	27(3)	12(2)	3	42(5)	45
Total with Local Symptoms Likely to be due to Thiram	19(2)	22(1)	41(3)	15(3)	4	60(6)	64
Headaches	4	5	9	3	2	14	15
Dizziness or Lightheaded	0	1	1	0	0	1	1
Fatigue	1	(1)	1(1)	1	0	2(1)	2
Nausea or Upset Stomach	2	2	4	0	1	5	5
Diarrhea	0	0	0	0	1	1	1
Abdominal Cramps	0	1	1	0	0	1	1
Alcohol Intolerance	3 of 7	0 of 19	3 of 26	0 of 18	0 of 2	3 of 46	7
Total with Systemic Symptoms Likely to be due to Thiram	6	6(1)	12(1)	3	3	18(1)	19
Problems with Menstrual Periods	3	2	5	1	0	6	8(n=74)
Problems with Other Sprays or Forest Products	2(1)	2	4(1)	1	0	5(1)	5
Total with these two plus other problems probably or definitely not related to Thiram	5(1)	10	15(1)	7	0	22(1)	23
Total with no health complaints	0	7	7	8	1	16	17

*Nature of the problem was insufficiently clear to definitely categorize it. These are not included in percentages. Workers with the questionable complaints were excluded from the "No health complaint" group.

TABLE VIII
SYMPTOMATOLOGY BY EXPOSURE GROUP - TREE PLANTERS

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

Symptoms Developing Over the Study Period

SYMPTOMS	THIRAM TREES				"SNOW" TREES		THIRAM FREE TREES	
	Plugs	Bare Root	Total	Percent		Percent		Percent
Number of Workers	9	26	35		20		9	
Eye Complaints	4	11	15	43	1	5	3	33
Nasal Irritation	1	15	16	46	6	30	4	44
Throat Irritation	1	5	6	17	10	50	1	11
Cough	3	5	8	23	4	20	2	22
Chest Discomfort or Shortness of Breath	2	5	7	20	5	25	3	33
Skin Problems	2	4	6	17	0	0	1	11
Total with Local Symptoms Likely to be due to Thiram in the Planters Planting Thiram Trees	6	20	26	74	12	60	7	78
Headaches	1	4	5	14	3	15	1	11
Dizziness or Lightheaded	1	5	6	17	2	10	1	11
Fatigue	0	0	0	0	0	0	0	0
Nausea or Upset Stomach	0	6	6	17	3	15	2	22
Diarrhea	0	0	0	0	0	0	0	0
Alcohol Intolerance	1 of 18	0 of 17	1 of 24		0 of 4		0 of 7	
Total with Systemic Symptoms Likely to be due to Thiram in the Planters Planting Thiram Trees	1	9	10	29	5	25	3	33
Kidney Complaints	3	3	6	17	1	5	1	11
Total with No Complaints	3	4	7	20	8	40	2	22

TABLE IX
SYMPTOMATOLOGY BY EXPOSURE GROUP - TREE PLANTERS

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

Symptoms by History, planters with past experience with Thiram

SYMPTOMS	COMPLETE QUESTIONNAIRE	PERCENT	ABREVIATED QUESTIONNAIRE	TOTAL	PERCENT
Number of Workers	57		7	64	
Self Health Assessment					
Good	48	84	6	54$	84
Fair	6#	11	1	7#	11
Fair to Poor	1	2	0	1	2
Poor	1	2	0	1	2
Omitted	1	--	0	1	--
Eye Complaints	25(1)*	44	0	25(1)*	39
Nasal Irritation	10(3)	18	0	10(3)	16
Throat Irritation	8(1)	14	0	8(1)	12
Cough	1	2	0	1	2
Chest Discomfort or Shortness of Breath	0	0	0	0	0
Skin Problems	17	30	1	18	28
Total with Local Symptoms Likely to be due to Thiram	35(5)	61	1	36(3)	56
Headaches	9(5)	16	1	10(5)	16
Dizziness or Lightheadedness	2(1)	4	0	2(1)	3
Fatigue	9(2)	16	1	10(2)	16
Increased Problem with Prolonged Work Week	4	7	2	6	9
Nausea or Upset Stomach	10(1)	18	2	12(1)	19
Diarrhea	7	12	2	9	14
Loss of Balance	0	0	1	1	2
Depression	0	0	1	1	2
Irritability	0	0	1	1	2
Alcohol Intolerance	7(3) of 49		1 of 5	8(3) of 54	15
Total with Systemic Symptoms Likely to be due to Thiram	20(7)	35	5	25(7)	39
Problems with menstrual periods	0	0	1	1	50(n=2)@
Total problems with menstrual periods & other problems probably or definitely not related to Thiram	12	21	1	13	20
Total with no health complaints	12	21	2	14	22

One planter who had just started planting was apparently coming down with the flu.

*Nature of the problem was insufficiently clear to definitely categorize it. These are not included in the percentages. Workers with the questionable complaints were excluded from the "No health complaint" group.

@Of 4 female planters with no experience with Thiram, one reported problems with her periods since she started planting.

$The 9 planters with no experience with Thiram all considered thier health to be good.

TABLE X
MEAN BLOOD PRESSURE AND PULSE BY WORKER GROUP - SEASONED WORKERS
(with 95% confidence interval of the mean)
THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

WORKER GROUP	MEAN BLOOD PRESSURE mm Hg # Systolic	# Diastolic	MEAN PULSE /min. #
Nursery Workers	94 117.8 ± 3.7	94 69.9 ± 2.6	94 72.6 ± 1.8
Planters - Thiram	25 125.4 ± 4.0*	25 69.6 ± 4.2	25 74.4 ± 3.7
Planters - "Snow"	20 117.6 ± 6.9	20 66.6 ± 4.4	20 73.1 ± 5.2
Planters - Thiram Free	15 110.3 ± 4.8*	15 64.8 ± 3.9	15 66.6 ± 3.3

*Because these means with their 95% confidence limits do not overlap, they are statistically significantly different.

TABLE XI
PRE-TEST BLOOD LEVELS OF THIRAM

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

GROUP	NUMBER IN GROUP	NUMBER WITH THIRAM LEVELS LESS THAN 1 ppm	1 ppm	GREATER THAN 1 ppm	ACTUAL THIRAM IF GREATER THAN 1 ppm
Total Study	161	132	6	23	
Pre-Test Exposure for the few weeks prior to the testing					
None	15	13	2	0	--
Intermittent Nursery, excepting spraying or outside only	61	44	2	15	1.2,1.6,1.7,1.8,2, 2,2.1,2.1,2.7,3.1, 4.7,4.8,4.8,6,18
Nursery, Outside only	17	13	2	2	2.4,4.8
Nursery, Spraying	7	5	0	2	2.2,3.4
Planting Thiram Trees	38	37	0	1	30
Planting "Snow" Trees	18	17	0	1	12

The greatest statistical significance (chi square 13.920; probability of being due to chance 0.001) was found by grouping the data as follows:

GROUP	NUMBER IN GROUP	THIRAM LEVELS GREATER THAN 1 ppm NUMBER	PERCENT
Intermittent Nursery, including Sprayers but excluding Outside only	68	17	25
Planters - Thiram and "Snow" and Nursery Outside only	73	4	5
No Exposure	15	0	0
Totals	156	21	13

In comparing pre-test planting thiram trees with pre-test planting "snow" trees on the 8 planters seen both times, none showed a thiram level when the pre-test exposure was to planting thiram trees, one showed a thiram level of 12 ppm when the pre-test exposure was to planting "snow" trees.

TABLE XII
PRE-TEST SERUM LEVELS OF DOPAMINE BETA-HYDROXYLASE

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

GROUP	NUMBER IN GROUP	MEAN VALUE UNITS/LITER	95% CONFIDENCE INTERVAL OF MEAN
Total Study	161	37.89	± 4.47
Pre-Test Exposure for the few weeks prior to the testing			
None	15	47.73	± 17.26
Male	10	52.50	± 24.60
Female	5	38.20	± 29.64
Intermittent Nursery, excepting spraying or outside only	61	35.58	± 4.87
Nursery, Outside only	17	26.41	± 10.57
Nursery, Sprayers	7	35.50	± 18.26
Planting Thiram Trees	38	47.47	± 14.18

Note: There are no statistically significant differences between these means. The interval between 33.42 and 34.48 lies within the 95% confidence limits of all these means. Furthermore, any value from 0 to 95.14 would lie within 2 standard deviations of the mean.

Pre-Test Planting Trees minus Pre-Test Planting "Snow" Trees (Paired Data)	8	07.56	± 5.18

TABLE XIII
ANALYSIS OF VARIANCE FOR PRE MINUS POST WORK
CHANGES IN BLOOD THIRAM LEVEL

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIFICANCE OF F
Main Effects	20.4	11	1.9	0.43	0.99*
Sex	2.6	1	2.6	0.60	0.99
Pretest Exposure	1.4	3	0.5	0.11	0.99
Exposure Type	0.5	3	0.2	0.04	0.99
Exposure Length	4.7	4	1.2	0.27	0.99
Residual	489.4	113	4.3		
Total	509.8	124	4.1		

Variable & Category	Pre minus Post Changes in Thiram Level ppm Raw Mean	Adjusted Mean
Exposure Type		
Planting Thiram Free	0.00	4.31
Nursery, Outside only	0.17	-0.34
Nursery except Outside only	-0.56	-0.57
Planting Thiram and Spraying	0.00	-0.67
Exposure Length		
Two Hours	-0.49	0.10
Half Day	0.00	-4.57
One Day	0.00	0.36
Two Days	-0.04	0.35
Four Days	-0.37	-0.27

*This is interpreted as statistically insignificant

Note: Among two groups of planters planting thiram trees the planting period was interrupted by a day off due to weather. Length of exposure was taken as the greatest number of consecutive days worked.

TABLE XIV
ANALYSIS OF VARIANCE FOR PRE MINUS POST WORK CHANGES
IN SERUM DOPAMINE BETA-HYDROXYLASE LEVELS

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIFICANCE OF F
Main Effects	1544.9	11	140.4	1.75	0.07
Sex	25.3	1	25.3	0.31	0.99
Pretest Exposure	421.0	3	80.3	1.00	0.40
Exposure Type	438.4	3	146.1	1.82	0.14
Exposure Length	1198.8	4	299.7	3.74	0.007*
Residual	9056.1	113	80.1		
Total	10601.1	124	85.5		

Variable & Category	Pre minus Post Changed in DBH Level Units/liter Raw Mean	Adjusted Mean
Exposure Type		
Planting Thiram Free	2.67	-134.13
Nursery Outside only	4.15	17.60
Nursery except Outside only	2.71	10.56
Planting Thiram and Spraying	1.71	14.05
Exposure Length		
Two Hours	8.73	0.33
Half Day	2.67	136.03
One Day	0.67	-10.87
Two Days	1.33	-9.77
Four Days	1.76	-8.24

*This is interpreted as statistically significant

Note: Among two groups of planters planting thiram trees the planting period was interrupted by a day off due to weather. Length of exposure was taken as the greatest number of consecutive days worked.

TABLE XV

PRE MINUS POST WORK CHANGES IN SERUM DOMPAMINE BETA-HYDROXYLASE LEVELS

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

EXPOSURE GROUP	EXPOSURE LENGTH	NUMBER IN GROUP	MEAN VALUE UNITS/LITER	95% CONFIDENCE INTERVAL
Nursery Workers (except sprayers)	All	85	2.96	± 2.02*
	2 hr. (plugs)	24	8.33	+ 4.76*
	2 days	32	0.02	± 3.20
	4 days	29	1.76	± 2.30
Planters, Thiram Free	1/2 day	9	3.78	± 8.08
Planters, "Snow"	All	17	-1.12	± 3.77
	1 day	9	-1.39	± 5.07
	3 days	8	-0.81	± 7.19
Planters, Thiram	All	34	1.88	± 2.90
	1 + 1 days (bare root)	9	0.67	± 2.85
	2 days (bare root)	7	2.14	± 4.15
	2 days (plugs)	8	0.50	±13.24
	All 2 day	24	1.04	± 3.93
	2 + 1 days (bare root)	10	3.90	± 3.58*

*Since 0 is not included in the 95% confidence interval, these changes are statistically significant.

TABLE XVI
BLOOD THIRAM LEVELS IN RELATION TO SYSTEMIC SYMPTOMS
OVER THE STUDY EXPOSURE

THIRAM STUDY, REFORESTATION, PACIFIC NORTHWEST

MAXIMUM THIRAM LEVEL ppm	NUMBER OF WORKERS CLAIMING SYMPTOM			
	CLINICALLY ILL	HEADACHE	STOMACH UPSET	NO SYSTEMIC SYMPTOMS
20.1 - 30.0	1			
15.1 - 20.0	0	2		
10.1 - 15.0	0	1		1
6.1 - 10.0	0	0		0
3.1 - 6.0	0	1		4
1.1 - 3.0	0	1	2	8
0 - 1.0	1	24	18	72
Total	2	29	20	85

APPENDIX A

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
522 POST OFFICE BUILDING
CINCINNATI, OHIO 45202

CONSENT

I voluntarily agree to participate in a study conducted by the Public Health Service to evaluate the health effects of the use of Thiram (tetramethyl-thiuram disulfide) in the forestry industry in the Pacific Northwest. I understand that the medical evaluation will consist of my answering questions about my health; a limited physical examination of head, chest, skin, pulse and blood pressure; and the taking of two or three separate samples of blood from my arm.

I understand that my participation in this study is voluntary and that all information obtained will be considered confidential in accordance with U.S. Public Health Service Regulation (42 CFR Part 1). The information will be utilized statistically, but I will not be identified as an individual without my expressed consent. I am free to withdraw from the study at any time.

DATE_____ SIGNATURE_____

AUTHORITY TO GIVE MEDICAL REPORT

In addition to notifying me whether my tests are normal or need further study, I agree to allow the Public Health Service to inform:

A. My Personal Physician Yes ____ No ____

NAME_____

ADDRESS_____ _____
Signature

CITY_____

B. Company Physician Yes ____ No ____

ADDRESS_____ _____
Signature

CITY_____

of any significant results of this study.

Information obtained in this study will be kept confidential in accordance with U.S. Public Health Service Regulation (42 CFR Part 1).

THIRAM STUDY

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

DATE_____

1. NAME_____
Last First Middle

2. CURRENT ADDRESS: (Number, Street or Rural Route, City or Town, County, State, Zip Code)

_____

_____

_____

3. PHONE NUMBER _____

4. SOCIAL SECURITY NO. _____

5. BIRTHDAY (Month, Day, Year)_____

6. AGE LAST BIRTHDAY _____

7. SEX: Male_____ Female____

8. RACE: White ____ Black ____ Other_____

9. PAST JOBS (back to time of being a full time student)

INDUSTRY & LOCATION	LENGTH OF EMPLOYMENT	SPECIFIC JOB	ANY MEDICAL PROBLEM RESULTING FROM THE JOB

EMPLOYEE'S OWN HEALTH APPRAISAL

10. How would you describe your general health:

_____Good _____Fair _____Poor

11. Do you have any health problems which you believe are related to your work?

If so, describe. _____

_____

_____

12. Do you have ano other health problems?

If so, describe. _____

_____

_____

SYSTEMATIC QUESTIONING

HAVE YOU HAD ANY OF THE FOLLOWING PROBLEMS?

PROBLEM	NO	IF RELATED TO WORK: RELATED TO WHAT	HOW OFTEN EXPOSED	DURATION OF EXPOSURE	DURATION OF SYMPTOMS	DOES IT ALWAYS CAUSE SYMPTOMS	DO YOU HAVE THIS PROBLEM TODAY
13. THROAT IRRITATION							
14. EYE IRRITATION							
14A BLURRED VISION							
15. NASAL IRRITATION							
16. NASAL STUFFINESS							
17. SINUS PROBLEMS							
18. PROBLEMS WITH TASTE OR SMELL							
19. HEADACHES							
20. DIZZINESS OR LIGHTHEADEDNESS							
21. COUGH							
22. CHEST DISCOMFORT							
23. WHEEZING OR WHISTLING							
24. SHORTNESS OF BREATH							
25. HEART TROUBLE							
26. HIGH BLOOD PRESSURE							
27. ANEMIA							

SYSTEMATIC QUESTIONING

HAVE YOU HAD ANY OF THE FOLLOWING PROBLEMS?

PROBLEM	NO	IF RELATED TO WORK: RELATED TO WHAT	HOW OFTEN EXPOSED	DURATION OF EXPOSURE	DURATION OF SYMPTOMS	DOES IT ALWAYS CAUSE SYMPTOMS	DO YOU HAVE THIS PROBLEM TODAY
28. NAUSEA							
29. UPSET STOMACH							
30. OTHER ABDOMINAL PROBLEMS							
31. PAINFUL URINATION							
32. KIDNEY PROBLEMS							
33. ITCHING							
34. FLUSHING							
35. ACNE OR EXCESSIVELY OILY SKIN							
36. DERMATITIS OR OTHER SKIN PROBLEMS							
37. FEVERS							
38. FATIGUE							
39. WEAKNESS							
40. WEIGHT LOSS							
41. MENTAL CONFUSION							
42. CHANGES IN MENSTRUAL PERIODS							
43. OTHER							

ADDITIONAL NOTES: _____

DO YOU HAVE ANY PRESENT PROBLEMS FOR WHICH YOU ARE SEEING A DOCTOR?

44. HEART PROBLEMS ___ YES ___ NO

45. LUNG PROBLEMS ___ YES ___ NO

46. STOMACH PROBLEMS ___ YES ___ NO

47. KIDNEY PROBLEMS ___ YES ___ NO

48. SKIN PROBLEMS ___ YES ___ NO

49. OTHER PROBLEMS--SPECIFY_____ ___ YES ___ NO

50. ARE YOU PRESENTLY TAKING ANY MEDICATION? ___ YES ___ NO

51. IF "YES" - WHAT MEDICATION?_____

DO YOU HAVE OR HAVE YOU HAD IN THE PAST ANY ALLERGIES?

	NONE	PRESENT	PAST	IF PRESENT OR PAST DID YOU HAVE THIS BEFORE WORKING IN THE PLANT?	
52. HAY FEVER?	____	____	____	___ YES	___ NO
53. DUST?	____	____	____	___ YES	___ NO
54. POLLEN?	____	____	____	___ YES	___ NO
55. CHEMICALS?	____	____	____	___ YES	___ NO
56. DRUGS?	____	____	____	___ YES	___ NO
57. FOOD?	____	____	____	___ YES	___ NO
58. SKIN CONDITION?	____	____	____	___ YES	___ NO
59. SINUS PROBLEMS?	____	____	____	___ YES	___ NO
60. ASTHMA?	____	____	____	___ YES	___ NO

IF ANY POSITIVE RESPONSES -

61. IF THE PROBLEM STARTED SINCE YOU STARTED WORK HERE, DO YOU THINK IT IS RELATED TO YOUR WORK?

_____

_____

DETAILED WORK HISTORY

1. How many seasons have you worked with trees?

   A. Thiram treated_____ B. Only non-thiram_____

   Spraying_____ _____

   Packing_____ _____

   Planting_____ _____

   Other_____ _____

2. Do you wear any protective clothing or equipment while with with

   Thiram?_____ At other times?_____

Gloves	___Yes	___No	___Yes	___No
Coveralls	___Yes	___No	___Yes	___No
Respirators	___Yes	___No	___Yes	___No
Other	___Yes	___No	___Yes	___No

   Describe_____

   _____

   _____

3. Working Time

   How many hours a day do you usually work? _____

   How many days a week do you usually work? _____

   How many days in a row do you usually work? _____

   How many trees to you handle a day? _____

   Are you paid by the hour? _____

   by the tree? _____

   Both? _____

4. How often are you working with thiram?_____

_____

_____

5. How many different areas do you usually work in during the season?

_____

_____

6. What sort of living accomodations do you use while working with trees?

At Home_____

Motel Only_____

Other, describe_____

_____

_____

7. Personal Hygiene

Are you able to wash - before smoking? ___Yes ___No

- before eating? ___Yes ___No

- at the end of work? ___Yes ___No

Do you change cloths after work? ___Yes ___No

At work? ___Yes ___No

At home? ___Yes ___No

Other?_____

Where are your work cloths washed?

At work, or handled through work? ___Yes ___No

At home? ___Yes ___No

At a laundermat? ___Yes ___No

Sent to a commercial laundry by the individuals? ___Yes ___No

Other_____

Do you bath right after work? ___Yes ___No

At work_____ At home _____ Other_____

Do you bath every day? ___Yes ___No

Other invervals_____

8. Does working with thiram seem be make any difference to you? ___Yes ___No

What difference do you notice?_____

_____

_____

9. Does the weather, work practices, accomodations, or other things seem to make a difference in how thiram affects you?

Describe_____

_____

_____

_____

SMOKING HISTORY

1. Do you now smoke cigarettes? ___Yes ___No

   If "yes" go right to question 4.

2. Have you ever smoked cigarettes? ___Yes ___No ___NA

   If "no" go right to question 9.

3. Have you smoked at least as many as five packs of cigarettes, that is, 100 cigarettes during your entire life?

   ___Yes ___No ___NA

   If "yes" go on to question 4.

   If "no" go to question 9.

4. How old were you when you started smoking cigarettes regularly?

   _____
   Age in years

   If an ex-cigarette smoker, ask:

5. How old were you when you last give up smoking cigarettes?

   _____
   Age in years

6. During the years you were smoking cigarettes, did you even quit for a year or more?

   ___Yes ___No

7. If "yes" how many years? _____Years

8. How much do/did you smoke on the avareage?

   _____ (1 pack = 20 cigarettes)
   cigarettes per day (Use "did" only for ex-smokers)

9. Do you or did you smoke cigars? ___Yes ___No

   Do you or did you smoke a pipe? ___Yes ___No

10. If "yes" how many years? _____Years

11. Are you still smoking a pipe or cigars? ___Yes ___No

DRINKING HABITS

1. Do you now drink beer or ale ___Yes ___No Wine ___Yes ___No

   Distilled liquors or mixed drinks? ___Yes ___No

   If "yes" go right to question 3.

2. In the past have you drunk beer or ale

   ___Yes ___No Wine ___Yes ___No

   Distilled liquors or mixed drinks? ___Yes ___No

   If "no" omit the remainder of this section.

3. Do/did you modify your drinking habits when you work(ed) with thiram?

   ___Yes ___No

3A. How? (Stopped because of Thiram) _____Other: _____

_____

_____

3B. Why?_____

_____

_____

4. About how much do/did you drink and how often?

_____

_____

EXAMINATION

PULSE _____ BLOOD PRESSURE _____

	Normal	Erythema	Other
Conjunctiva	_____	_____	_____
Nasal Mucosa	_____	_____	_____
Pharynx	_____	_____	_____

SKIN: Normal_____ Excoriation_____

Eczematoid Changes_____ Other_____

CHEST & BREATHING: Normal_____ Abnormal Sounds_____

Other_____

What_____

NOTES:_____

_____

_____

_____

_____

APPENDIX B

POST EXPOSURE QUESTIONNAIRE

THIRAM STUDY

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

NAME _____
Last First Middle

During the last three days have you had any of the following problems? (If so describe on back)

dry throat or sore throat	___Yes	___No
burning or itching eyes	___Yes	___No
tearing of the eyes	___Yes	___No
stuffy nose	___Yes	___No
runny nose	___Yes	___No
headache	___Yes	___No
dizziness or lightheadedness	___Yes	___No
coughing	___Yes	___No
chest tightness, soreness, or heaviness	___Yes	___No
wheezing or whistling in your chest	___Yes	___No
shortness of breath	___Yes	___No
stomach pains	___Yes	___No
nausea or upset stomach	___Yes	___No
painful or burning urination	___Yes	___No
frequent urination	___Yes	___No
skin irritation or rash	___Yes	___No
other _____	___Yes	___No

_____

Have you drunk any beer, wine or other alcoholic beverages?	___Yes	___No
If yes, did it cause any problem?	___Yes	___No
Describe any protective equipment you wore during this exposure (use back of sheet)	___Yes	___No

THIRAM IN AIR APPENDIX C

Measurements Support Branch

Analytical Method

Analyte: Thiram (tetramethyl-thiuram disulfide)	Method No.: P&CAM 228
Matrix: Air	Range: 0.1 to 5.0 mg/m³ in a 50-liter sample
Procedure: Filter collection; chloroform elution; spectrophotometric determination	Precision(CV): 0.23 over the range 5 to 20 μg/mℓ
Date Issued: 6/30/76	Classification: D(Operational)
Date Revised:	

1. Principle of the Method

Thiram in air is collected on a membrane filter. The filter is extracted with chloroform. If acrylamide polymers are present, they are removed by precipitation with acetone. Cuprous iodide is added to the chloroform solution of thiram to form cupric dimethyldithiocarbamate. The absorbance of the solution at 440 nm is measured spectrophotometrically and the concentration of thiram is determined from a calibration curve.

2. Range and Sensitivity

2.1 The linear range of the calibration curve extends from about 5.0 μg/mℓ to 25 μg/mℓ of final solution. Taking into account the volume of chloroform (10 mℓ) used to extract the filter, this range is calculated to correspond to 1.0 to 5.0 mg/m³ of thiram in a 50-liter sample of air. The upper limit of the range can be increased by dilution of the extract prior to the development of color; however, the variability of results also is increased.

2.2 The detection limit of the analytical method is about 2.5 μg/mℓ, which corresponds to 0.5 mg/m³ in a 50-liter sample of air. However, for thiram dissolved in latex paint, the detection limit is only about 5.0 μg/mℓ because the extraction efficiency is lower.

3. Interferences

3.1 Acrylamide polymers interfere with the extraction and determination of thiram.

3.2 Other dithiocarbamates such as ferbam and ziram intensify the color and cause erroneously high values.

3.3 The presence of metallic chelates and iron and other metal compounds will interfere with the spectrophotometric determination of thiram.

3.4 The collection on a filter of airborne particles of latex may reduce the amount of thiram that can be collected before the filter becomes clogged.

3.5 The precision and accuracy of the method are particularly sensitive to the type and amount of latex paint collected on the filter. A sample of the bulk paint should be submitted at the same time as the filter samples to allow determination of the extraction efficiency and the reproducibility of the determination of thiram in the presence of the paint.

4. Precision and Accuracy

4.1 The precision of the total sampling and analytical method has not been determined. However, the coefficient of variation for the analytical procedure has been found to be 0.23 over the range of 5 to 20 $\mu g/m\ell$.

4.2 The accuracy of the procedure has not been determined. The recovery of thiram by this method ranged from 84 to 98% in twenty spiked filter samples.

5. Advantages and Disadvantages

5.1 The nonspecificity of the reaction of cuprous iodide with dithiocarbamates and other sulfur compounds is a disadvantage.

5.2 The deterioration of the standard solutions of thiram in chloroform is a disadvantage. (Refrigeration retards deterioration.)

5.3 Thiram is sensitive to heat and light, especially in the presence of latex paint. Samples should be stored in a cool, dry, and dark place and analyzed as soon as possible.

5.4 In the absence of interferences the method is simple, rapid, and sensitive.

6. Apparatus

6.1 Air Sampling Equipment

6.1.1 Cellulose ester membrane filters, 0.8-μm pore size, 37-mm diameter, Millipore Type AA, or equivalent. Plain white, white-gridded, or black-gridded filters may be used.

6.1.2 Personal sampling pump capable of operation at 1.5 to 2.0 ℓ/min for extended periods of time. The pump should be calibrated with a representative filter unit in the sampling line. A wet or dry test meter or a glass rotameter capable of measuring a flow rate of 1.5 to 2.0 ℓ/min to within 5% may be used in the calibration.

6.2 Spectrophotometer, for use at 440 nm, with matched glass cells or cuvettes, 1-cm path length.

6.3 Vortex mixer.

6.4 Centrifuge capable of attaining 2500 rpm.

6.5 Centrifuge tubes, glass-stoppered, 15 mℓ.

6.6 Water bath, 60 ± 5°C.

6.7 Filter paper, Whatman No. 42, or equivalent, and long-stem filter funnels.

6.8 Volumetric flasks, 10, 25, and 100 mℓ.

6.9 Volumetric pipettes, assorted sizes.

6.10 Burette, 25 mℓ.

7. Reagents

7.1 Chloroform, spectro grade.

7.2 Acetone, spectro grade.

7.3 Thiram Standard Solutions

7.3.1 Stock Solution (500 μg/mℓ). Dissolve 50 mg of thiram in chloroform and dilute the solution with chloroform to 100 mℓ in a volumetric flask.

7.3.2 Working Solution (25 μg/mℓ). Dilute 5 mℓ of the stock solution to 100 mℓ with chloroform in a volumetric flask.

7.4 Cuprous iodide, purified.

7.5 Nitrogen, prepurified, water-pumped.

8. Procedure

8.1 Cleaning of Equipment. Rinse all glassware with acid, deionized water, and chloroform, and allow to dry. Store the cleaned glassware in such a manner as to prevent contamination.

8.2 Collection and Shipping of Samples

8.2.1 Connect the filter unit to the pump and sample at a rate of 1.7 ℓ/min for a period of time anticipated to provide sufficient thiram for analysis. Measure as accurately as possible the flow rate and time, or volume.

8.2.2 After the sampling is completed, tape in place the top and bottom plugs for the inlet and outlet of the filter unit.

8.2.3 Wrap the filter unit in toweling or packaging material and place it in a suitable container for shipment to the laboratory.

8.2.4 Handle one filter unit in the same manner as the filter units exposed to thiram, but sample no air through it. Label this unit as a blank and ship it to the laboratory with the unknown samples.

8.2.5 Ship to the laboratory in a separate container samples of the bulk substances contaminating the workplace atmosphere. These substances may include thiram, latex paint, and thiram in latex paint.

8.2.6 After their receipt in the laboratory, store the samples in a cool, dry, and dark area to prevent oxidative and photocatalyzed degradation.

8.3 Analysis of Samples

8.3.1 Disassemble the filter unit. Remove the membrane filter with tweezers and place it in a 15-mℓ centrifuge tube.

8.3.2 Add 8 mℓ of chloroform to the centrifuge tube and agitate with a vortex mixer for 2 min. Then centrifuge the tube at 2500 rpm for 4 to 6 min. If the solution is cloudy, proceed to Section 8.3.3 If no cloudiness is apparent, transfer the solution quantitatively to a 10-mℓ volumetric flask and dilute to the mark with chloroform; proceed to Section 8.3.4.

8.3.3 Cloudiness indicates the presence of acrylamide polymers. Decant the supernatant and add acetone to it dropwise until the polymers precipitate out of solution. Recentrifuge and decant again. Evaporate the solution to dryness under nitrogen on a water bath at 60°C. Add 8 mℓ of chloroform to the dry residue. (If no precipitate forms on the addition of a few drops of acetone, the solution should be recentrifuged, but need not be evaporated to dryness.) Quantitatively transfer the solution to a 10-mℓ volumetric flask and bring to volume with chloroform. Proceed to Section 8.3.4.

8.3.4 Add 30 ± 1 mg of cuprous iodide to the 10-mℓ volumetric flask. Allow the color to develop for 60 ± 5 min. Shake the flask at least five times during this time span. The color is stable for about 30 min after it is developed. Filter the sample solution through Whatman No. 42 filter paper into another 10-mℓ volumetric flask. Measure the absorbance of the sample solution at 440 nm with a reagent blank as the reference.

8.4 Determination of Extraction Efficiency

8.4.1 Place a blank membrane filter into each of five centrifuge tubes. From a 25-mℓ burette add 0.8, 2, 4, 6, and 10 mℓ of the thiram working standard (25 μg/mℓ) to the respective tubes. Without removing the filters evaporate the chloroform under nitrogen at room temperature. Then add 8 mℓ of chloroform to each tube and proceed as described in Sections 8.3.2 and 8.3.4.

8.4.2 The extraction efficiency is found by comparing the results of the analyses of these "spiked" filters to the results of the analyses of the standard solutions of thiram as described in Section 9.1.

8.4.3 If the unknown samples contain latex paint, a thiram and latex paint mixture should be spiked on the filter to ascertain the effect on extraction efficiency. The analysis procedure for filters spiked with the thiram in latex paint must include the precipitation of acrylamide polymers with acetone.

9. Calibration and Standards

9.1 Prepare standards by adding 0.8, 2, 4, 6, and 10 mℓ of the thiram working solution to separate volumetric flasks and diluting to the mark with chloroform. Respectively, the standards contain 20, 50, 100, 150, and 250 μg of thiram. For their analysis follow the procedure described in Section 8.3.4. Plot absorbance versus the amount (in μg) of thiram in the standard.

9.2 Prepare a calibration curve daily; the curve should cover the anticipated range of the sample unknowns. Maintain a quality control chart for the replicate determinations of standards. (See Reference 11.3.)

10. Calculations

10.1 From the calibration curve, read the amount (in μg) of thiram found in the sample solutions. Correct this amount for any dilution of the chloroform extract beyond that called for in Section 8.3.4. Also correct for any thiram found on the blank filter and for the extraction efficiency. These calculations are summarized in the following equation.

$$W = \frac{(W_S \times D) - W_b}{E}$$

where:
- W = the net amount of thiram found on the sample filter.
- W_S = the amount of thiram found in the sample solution.
- D = the dilution factor
- W_b = the amount of thiram found on the blank filter
- E = the average extraction efficiency.

10.2 The concentration of thiram in air may be expressed in mg/m^3:

$$mg/m^3 = \frac{W\ (\mu g)}{V\ (\ell)}$$

where: V = volume of air sampled.

11. References

11.1 Horwitz, W., Ed., *"Methods of Analysis of the Association of Official Analytical Chemists,"* 12th ed, A.O.A.C., Washington, D.C., 1975, pp 551-552.

11.2 Linch, A. L., *"Evaluation of Ambient Air Quality by Personnel Monitoring,"* CRC Press, Cleveland, Ohio, 1974, pp 127-171.

11.3 *"Handbook for Analytical Control in Water and Wastewater Laboratories,"* Analytical Quality Control Laboratory, National Environmental Research Center, Cincinnati, Ohio, 1972.

11.4 *"Pesticide Analytical Manual,"* Vol. II U. S. Dept. of Health, Education and Welfare, Federal Drug Administration, Rockville, Maryland.

11.5 Sunshine, I., Ed., *"Handbook of Analytical Toxicity,"* CRC Press, 1969.

APPENDIX

Analysis of Tree Samples for Thiram

Weigh each tree, cutting into pieces when necessary. Place the tree in a centrifuge tube. Wash with 20 mℓ of chloroform, centrifuge, and filter into a 25-mℓ volumetric flask. Add 30 mg of cuprous iodide. Allow the color to develop for 60 ± 5 min, shaking the flask every 10 min. Filter and measure the absorbance at 440 nm. If the concentration of thiram is high, further dilution may be necessary. Calculate the total micrograms of thiram and the micrograms of thiram per tree.

APPENDIX D

CAUTION

These seedlings have been treated with an animal repellent containing THIRAM, which may flake off the seedlings during handling. Consumption of alcohol before or after exposure to THIRAM may result in symptoms of nausea, headaches, vomiting, fatigue or flushness. Exposure to THIRAM may also cause irritation of the eyes, nose, throat or skin.

SAFETY MEASURES

Keep treated seedlings moist in planting pouch.

1. Do not consume alcoholic beverages or apply alcohol base cremes or lotions 12 hours before or 48 hours after exposure.
2. Apply silicone-base cremes to exposed skin areas prior to exposure.
3. Wear clean fiber dust mask and clean rubber or silicone-treated cloth gloves.
4. Wear full length pants and long sleeved shirts treated with silicone.
5. Wash exposed skin areas thoroughly after handling treated seedlings and before smoking, drinking or eating.
6. If THIRAM flakes come in contact with eyes, immediately flush eyes freely with water.
7. Bathe and change clothes daily.

PRECAUCION

Estas plantas han sido tratadas con un repelente contra animales que tiene la substancia THIRAM, puede desaparacer en manosco. Consuncion de alcohól antes o despues de contacto con THIRAM puede resultar en síntomas de náusea, dolor de cabesa, vomitando, fatiga o rubor. Contacto con THIRAM puede causar irritación de los ojos, nariz, garganta o piel.

MEDIDAS DE PRECAUCION

Guardar mojadas las plantas en bolsa de plantar.

1. No tomar bebidas alcoholicas, ni aplicar crema o lución con base de alcohól dentro de 12 horas antes de ser expuesto o hasta 48 horas despues.
2. Aplicar crema con base de silicona a las partes de la piel que esten al descubierto antes de que entren en contacto con esta substancia.
3. Ponerse mascarilla contra polvo limpio y usar guantes de hule o de tela con tratamiento de silicona.
4. Ponerse pantalones largas y camisa con mangas largas con tratamiento de silicona.
5. Lavar bien la piel que han sido contaminada antes de fumar tomar o comer.
6. Si cascaras de THIRAM tocan los ojos, limpiar inmediatamente con un chorro de agua.
7. Bañarse y cambiar de ropa cada dia.