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M E M O R A N D U M

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SUBJECT: AN OBSERVATIONAL STUDY: HAND DIPPING OF NURSERY STOCK, PROJECT 0506

Synopsis

Historically, California nursery operations dipped the roots of tree, rose and grape rootstock, as well as some bulbs, flowers and fruit plants, in pesticide solutions to control fungus and disease and to promote root growth. Although dipping can be done mechanically, the Department of Pesticide Regulation (DPR), Worker and Health Safety (WHS) Branch, Exposure Monitoring and Health Investigation Program (EMHIP) proposed to focus exclusively on the potentially higher exposures anticipated for manual dipping activities because of unavailable exposure data for these tasks[1].

Smith *et al*.[2] evaluated grapevine propagation worker exposure to captan residues while handling grafted plant material during and following immersion in a dilute captan solution. Schneider *et al*.[3] and Spencer *et al*.[4] conducted pesticide exposure studies of greenhouse workers, however they did not conduct exposure monitoring on workers dipping rootstock or cuttings (ornamental or commercial crop) in pesticide solutions.

The study protocol, "Nursery Stock Dipping Activities Observation, Project 0506," received approval on February 10, 2006, and proposed the following:

1) Survey of nursery and greenhouse managers to evaluate the types of dipping activities typically conducted by nursery stock workers,

2) Solicit nursery and greenhouse manager cooperation to observe workers while conducting dipping activities, and

3) Qualitatively evaluate pesticide exposure by observing and documenting activities of greenhouse and nursery workers involved in manually dipping rootstock, bulbs and/or plants in pesticide solutions.

EMHIP scientists attempted to contact 27 nursery and/or greenhouse managers. Twenty-three of the 27 nursery and/or greenhouse managers responded. During interviews, almost all of the managers stated to the EMHIP scientists that they rarely use "pesticide" dips, opting instead to use other means such as hot water dips[5], cold temperatures, and steamed planting beds for controlling insect pests and/or pathogens. Based on this information, EMHIP scientists visited seventeen nursery and greenhouse facilities to observe dipping operations and to ascertain the limited nature of the dipping activities. This memo summarizes the findings from the survey and informal observation visits.

Materials and Methods

In May 2006, EMHIP scientists contacted 27 California nurseries as prospective study cooperators. EMHIP scientists used sources such as the Fruit and Nut Producing Growers in California[6], California Nurseries Plants and Trees[7], Good Fruit Grower Buyer's Guide, 2006-2007 Edition[8], the California Cut Flower Commission Buyer's Guide, 2004, Third Edition[9] and the County Agricultural Commissioners to locate cooperators.

Twenty-three of the 27 nursery and/or greenhouse managers cooperated with this study. Four fruit and nut tree nursery managers did not return telephone calls. The business type and regional location are stated in table 1.

Table 1
Business Type and Location of Cooperating Nurseries

Business Type	Regional Location		
	San Joaquin Valley	Central Coast	Sacramento Valley
Fruit and Nut Tree Nursery	2	1	4
Vineyard Nursery	4	-	-
Vegetable Transplant Greenhouse	4	-	-
Flower Greenhouses	-	4	-
Ornamental Nursery	2	1	-
Forest Conifer Seedlings*	-	-	1

* large forest conifer seedling operation is the catalyst for nursery survey study.

Project Duration

Project 0506, Observational Study: Hand Dipping of Nursery Stock was initiated in February 2006 and concluding January 27, 2009.

Results

EMHIP scientists visited 17 nursery and/or greenhouse facilities and observed the daily operation of five floral greenhouses; four fruit and nut tree nurseries; four vegetable greenhouse establishments; two vineyard nurseries; one ornamental nursery and one conifer seedling operation. EMHIP scientists conducted telephone interviews with the six more distant nursery/greenhouses managers.

EMHIP scientists used a survey questionnaire (Appendix 1) and obtained the following dipping practice information from the 23 nursery/greenhouses:

Dipping:

- Twenty-two practice some sort of "dipping" or immersion of plant or of plant parts.
- One practices no dipping whatsoever.

Dipping methods:

- Eighteen "dip" or immerse plant or of plant parts in rooting hormone. The eighteen nursery and/or greenhouse managers do not consider rooting hormones as a pesticide; however, rooting hormones are registered pesticides.
- Four use "hot water dipping" to control fungus and disease and to promote root growth.
- One uses cold treatment [42ºF] to control fungus and disease and to promote root growth.

Dipping Types:

- Eighteen manually "dip" plants or plant parts;
- Four dip rootstock mechanically.
- One practices no dipping whatsoever.

Time of Year:

- Fourteen usually dip in the late Fall, Winter or early Spring while the trees and vines are dormant;
- Nine greenhouses provide a controlled environment and dipping occurs year around."

Work Tasks Involved:

Cooperative nursery/greenhouse managers described the following as common seasonal tasks potentially related to dipping:

Hardwood Cuttings – November through February: The cuttings are taken from the current season's mature, dormant wood. Pathogens may gain entrance through wounds caused by leaf removal. Hot water dips and dipping of the cuttings in a rooting hormone solution is necessary.

Softwood Cuttings – Generally taken in the spring, these cuttings root easily. Propagation difficulties occur due to fungal and bacterial diseases. Many woody species require a longer rooting time, which increases the stress on the softwood cuttings and their vulnerability to disease infection. Hot water dips and dipping in a rooting hormone solution is essential.

Grafting – Winter: Most tree, rose and grape rootstock grafting occurs during scion and rootstock dormancy. Immediately after grafting, the grape rootstock is dipped in a low-temperature paraffin wax (grafting wax) that seals the graft union. Some deciduous plant bare rootstock grafting also occurs during the winter time with the plant material placed in cold storage until spring planting.

Seasonal Treatment for Bulbs – Forced release of dormancy of Easter lilies: Bulb harvest occurs from May to late June. Prior to seeding or transplanting bulbs to the seedbeds or container pots, the standard industry practice dictates a 20-minute mechanical hot water dip to force the release of bulb dormancy. Nurseries may mechanically dip the bulbs in liquid fungicide solutions for 5 minutes, apply the fungicide as a soil drench post-transplant, or by incorporating the fungicide into the soil or compost to protect the germinating seed bulbs.

Hot Water Dips - Many nurseries/greenhouses commonly use hot water dips. Hot water dips involve submerging the plant materials in 120° Fahrenheit water for 5 minutes. Nurseries/ greenhouses use hot water dips to control mealy bugs, fungal diseases, nematodes, and other pests.

Rooting Hormones – Most tree, rose and grape rootstock. The cuttings are sprayed with a beneficial biological cocktail (such as trichoderma spp), dipped in rooting hormone, packed in hydrated vermiculite, and cold stored until spring planting.

EMHIP scientists observed the operations of a large forest conifer seedling operation. The workers harvest the conifer seedlings after one year and transport them to the packing shed. The packing shed workers (1) sort and grade the seedlings, discarding the spindly and crooked stemmed ones; (2) group the acceptable seedlings into bundles of 25; (3) trim the seedlings into nine-inch lengths; (4) place the seedlings into wax cardboard boxes; and (5) cover the seedlings with cedar shavings to hold in moisture. They then place the boxes in cold storage until sold for planting.

Trees may be grown in the field and/or in containers. Production typically starts with seeds or cuttings being used to produce a “liner” (young transplant). During root development, nurseries dip plant cuttings in rooting hormone and may spray or drench them with a fungicide to protect against fungal diseases in the propagation area. Nursery production is not as closely tied to seasonal activities as is typical with production of field crops, vegetable crops, row crops, and forages. Many nursery activities can occur at any time of year and may vary with the species being grown, geographic location, nursery practices, environment, and the market.

Table 2 “Tree Nursery and Worker Activities Associated with Potential Pesticide Exposure” summarizes the various nursery work activities and the potential pesticide exposures associated with each activity.

During nursery site visits, EMHIP scientists observed men and women working side by side. Normal work attire consisted of long pants, long sleeved shirt, jacket and/or sweatshirt, leather or chemical resistant gloves (latex, nitrile, or rubber), and appropriate footwear (leather work boots, water-resistant tennis shoes or rubber boots). Some workers wore a waterproof apron, and head covering (most commonly ball caps and knit watch caps). The workers wear multiple layers of clothing for warmth as they perform these work tasks in the winter and early spring. The extra clothing layers also provide dermal protection from scrapes and abrasions. Pictures in Appendix 2 (Figures 1-12) show typical

greenhouse and nursery operations, including harvesting, grafting, disbudding, hot water dipping, and rootstock cold storage.

After completing the interviews and observations, we learned of the following common practices amongst nurseries:

- All new or seasonal employees complete a safety and pesticide training program before they are given responsibility to work in the greenhouses and/or nursery facility.
- Whenever possible, the workers receive training in full-day increments and the training covers topics specific to the location and type of work involved.
- Experienced senior staff provides basic safety and comprehensive training concerning on-site operations, personal protective equipment (PPE), and specific plant cultural care such as transplanting, potting, and irrigating.
- The training generally occurs during the less busy periods of December or June and July. Training also occurs whenever a new employee begins work.
- The training includes a yearly review of the Spill Response Plan and other hazardous materials as necessary.

The nursery and greenhouse cooperating managers concurred with the claim that hand-dipping of plant parts occurs infrequently in California. They stated they prefer using alternative means of controlling diseases and pests (hot water dips, steam sterilization of planting beds, hydroponics).

Discussion

WHS Human Health Exposure Assessment scientists found literature describing an east coast nursery worker dipping evergreen tree seedlings in a clay slurry solution[10]. The literature showed the workers in the operation covered with the pesticide-treated clay solution. The scientists requested information concerning the possibility of similar exposure to California nursery/greenhouse workers performing similar work.

While visiting a large forest conifer operation in California, EMHIP scientists did not observe activities similar to the slurry solution dipping operation practiced in Maryland[1]. After expanding the observations to include floral greenhouses, fruit and nut tree nurseries, vineyard nurseries, and vegetable greenhouses, EMHIP scientists did not observe any “slurry solution” dipping/hand immersion operations. However, they did find several operations that dip plant cuttings in a pesticidal root hormone solution.

After interviewing the nursery/greenhouse managers and observing typical nursery/greenhouse workers performing their work tasks, EMHIP scientists found evidence of pesticide hand dipping practices occurring for limited periods of time and summarized as follows:

1. The flower, ornamental, and vegetable transplant nursery/greenhouse managers stated the only pesticides used with hand dipping practices are rooting hormones, and this takes place for a limited amount of time per day. For example, flower growers dip plant cuttings for ½ to

1 second per plant in rooting hormone, and typically involve two workers performing the task for approximately 30 minutes per day, four days a week annually for new starter plants.

2. The fruit and nut tree nursery managers stated workers dip the liners (cuttings) in rooting hormone for 3 - 5 seconds per tied bundle of twenty. Two workers perform this task for two to three hours per day, four days per week over approximately a two week period after the tree harvest season.
3. The vineyard nursery managers stated they mechanically dip grape rootstock in a hot water vat to help control pests and pathogens and involves only one worker to operate the dipping basket. The worker dips the basket filled with 4,000 – 5,000 rootstocks, [figure 6]) into a series of three water bath vats. The first bath vat contains water at a temperature of 90ºF. The worker submerges the basket in this bath for ten minutes to prepare the rootstock for the hot water treatment. The worker then lifts and trolleys the basket to the second water bath vat (130ºF) and submerges it for five minutes. He then lifts and trolleys the basket to the third water bath vat that contains cold well water and submerges it for five minutes to rapidly cool the rootstock. The worker performs this task for eight hours a day, five days a week for about six weeks starting just after the first hard frost in December.

WHS Pesticide Illness Surveillance Program (PISP) maintains a database of pesticide-related illnesses and injuries. PISP receives case reports from physicians and via Workers' Compensation records. After receipt of the medical records and investigative findings, PISP scientists evaluate the information and enter specific information into the PISP database. Evaluation of the information may show illness and injury trends produced by a particular pesticide or activity. A PISP database search from 2000 to 2006 yielded only two cases involving nursery/greenhouse applicators performing immersion applications. These are:

- In 2000, a forklift operator lowered pallets of bulbs into a fungicide dip tank. He decided to work out of class and help with maintenance of the dip tank by removing the dip tank filter. During this process, the fungicide soaked through his leather gloves. He had received no training and wore inadequate PPE;
- In 2000, bleach splashed into a worker's right eye as he dipped plastic flats (trays) into a disinfectant tub. The training records show the nursery worker was trained in working with antimicrobials. His supervisor stated the nursery provided all workers with goggles and chemical resistant gloves. However, the investigator could not locate the worker for an interview and could not confirm the use of PPE; and

From field observations and employer interviews, EMHIP Scientists found that California nursery/greenhouse managers train their workers before they begin work, make them aware of the hazards associated with pesticide use, and observe them to assure they wear the required PPE to mitigate pesticide exposure.

EMHIP Scientists also found California nursery/greenhouse managers preferred non-pesticidal alternatives to control insect pests and diseases. This preference for non-pesticidal control measures is supported by low number of reported illnesses (only two from 2000 – 2006). Unless new information shows a higher level of pesticide use than that found by the EMHIP Scientists, it is recommended that no further research on this activity be conducted at this time.

Table 2
Tree Nursery* and Worker Activities
Associated with Potential Pesticide Exposure

Nursery Activity	Time of Year	Frequency of Activity	Worker Activity Description	Potential Pesticide Exposure
Seed propagation	Winter	Once per crop (if seed is propagated)	Manually planting seeds in containers or in the field or assisting a mechanical planter	Seeds may have been treated with a fungicide
Cutting propagation	Year-round, but mostly in spring and summer	Once per crop (if cutting is propagated)	Pruning shears used to clip cuttings from plants are dipped in bleach; cuttings are dipped in rooting hormone; cuttings may be drenched, or sprayed with fungicide	Plants may contain pesticide residue; rooting hormone is applied to cuttings; fungicide drench, or spray may also be applied to cuttings
Liner production	Year-round	0-4 applications per crop of fungicides and insecticides	Applied with handheld sprayer or granular applicator	Mixing and applying pesticides
Field planting (field nurseries)	Fall and Winter	Once per crop	Use of mechanical planter or manually planting by hand, trowel, or shovel; fertilizer or herbicide applied by tractor or handheld sprayer or granular applicator	Application of herbicide by tractor or handheld sprayer or granular applicator; walking through treated nursery beds
Potting (container nurseries)	Year-round	Once per crop	Assisting potting machine or potting by hand	If plant will be sold within 1 year, potting substrate may contain insecticide (for fire ant control)

*A crop may require 1-6 years of growth before harvest and sale

Table 2
Tree Nursery* and Worker Activities
Associated with Potential Pesticide Exposure (Cont.)

Nursery Activity	Time of Year	Frequency of Activity	Worker Activity	Potential Pesticide Exposure
Staking	Year-round usually associated with planting, potting or repotting	Annually	Manual insertion of stake into soil or container; manual or mechanical tying of plant stems to the stake	Plants may contain pesticide residue; walking through the nursery beds
Pruning	Year-round	Usually performed 1-3 times per year	Manual or mechanical shearing or pruning	Walking through the nursery beds; plants may contain pesticide residue
Insect and mite management	Year-round	Varies with species, weather, nursery cultural, pest management practices; 0-12 applications of pesticide per year	Application with tractor or handheld sprayer or granular applicator	Mixing, loading, and applying pesticides
Disease management	Year-round	Varies with species, weather, nursery cultural, pest management practices; 0-4 applications of fungicides per year	Application with a tractor or handheld sprayer or granular applicator	Mixing, loading and applying pesticides
Pre-emergence weed management	Year-round	Varies with species, weather, nursery cultural and pest management practices; up to 5 - 6 applications per year of pre-emergence herbicides	Application with a tractor or handheld sprayer or granular applicator	Mixing, loading and applying pesticides

*A crop may require 1-6 years of growth before harvest and sale

Table 2
Tree Nursery* and Worker Activities
Associated with Potential Pesticide Exposure (Cont.)

Nursery Activity	Time of Year	Frequency of Activity	Worker Activity	Potential Pesticide Exposure
Post-emergence weed management (field nurseries)	Year-round	Varies with species, weather, nursery cultural and pest management practices; 0–6 applications per year of post-emergence herbicides; cultivation or mowing also may occur	Application with tractor or handheld sprayer; cultivation by tractor or manually; mowing by tractor	Mixing, loading, applying pesticides; if cultivation is manual, walking through the nursery beds
Post emergence weed management (container nurseries)	Year-round	Varies with species, weather, nursery cultural and pest management practices; 0–4 applications per year of post-emergence herbicides	Application with tractor or handheld sprayer	Mixing, loading, applying pesticides
Root pruning (field nurseries)	Fall or Winter	May never occur on some nurseries; annually or biennially otherwise	Use of tractor	
Irrigation	Year-round	Several times per day (container) to several times per year (field)	Usually by automatic irrigation system (remotely operated); occasionally irrigated by handheld hose or bucket	If done by hand, walking through the nursery beds
Irrigation system maintenance	Year-round	As needed (several times per year)	Manual inspection, cleaning, and repair of irrigation system	Walking through the nursery beds; use of pesticide to remove microbial growth in irrigation pipe

*A crop may require 1-6 years of growth before harvest and sale

Table 2
Tree Nursery* and Worker Activities
Associated with Potential Pesticide Exposure (Cont.)

Nursery Activity	Time of Year	Frequency of Activity	Worker Activity	Potential Pesticide Exposure
Fertilization	Year-round	1–12 times per year or with irrigation	By tractor or handheld applicator; may be incorporated into potting substrate and occur at potting; May be applied as a liquid fertilizer injected into the irrigation system	If manual, walking through the nursery beds
Container reset (container nurseries)	Year-round after disturbance by windstorms, animals, erosion, etc.	As needed (perhaps several times per year but usually only a small portion of the crop)	Manual	Plants, containers or potting substrate may contain pesticide residue; walking through the nursery beds
Digging (field nurseries)	Fall and Winter	Once per crop	Use of mechanical tree-spade, tractor, or by hand	If by hand, plants and soil may contain pesticide residue
Grading	Year-round, usually Winter and Spring	Once per crop	Manual	Plants may contain pesticide residue
Loading and Shipping	Year-round, usually Winter and Spring	Once per crop	Manual	Plants, root balls, nursery beds, soil, containers, or potting substrate may contain pesticide residue

*A crop may require 1-6 years of growth before harvest and sale

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Appendix 1
Nursery Information Form **Date:_____**
(Project 0506)

Nursery:_____ Nursery ID:_____ County:_____

Address:_____

Contact:_____ Phone:_____

Does your nursery practice dipping ☐ Yes ☐ No. If "Yes", continue. If "No", stop.

1. What stage(s) of production is dipping performed? _____

   _____

   Is dipping limited to certain times of the year?

   ☐ Yes. Explain: _____

   ☐ No. Explain: _____

2. What pesticides do you normally use for dipping and at what concentration? _____

   _____

3. How often do you dip? _____

   _____

4. How is dipping performed? ☐ Manually ☐ Mechanical
5. Approximately how many workers do you have working in your nursery? _____
6. Do you have workers specifically assigned to perform dipping? ☐ Yes ☐ No

   What is the extent of experience of workers assigned to dip? _____

   _____

7. Is dipping a whole day activity in your nursery? ☐ Yes ☐ No

   If it is not a whole day activity, what time of the day is it usually performed and for how long?

   Time of day (a.m., p.m., evening):_____ Duration: _____

8. Of the workers that perform dipping, are they:

   ☐ Assigned to both mix/load and dip? ☐ No assigned task; mix/load and/or dip as needed

   ☐ Assigned to either just mix/load or just dip? ☐ Other: _____

   ☐ Weighing dipping pesticide(s)

9. How many workers usually perform dipping at any given time? _____

10. If dipping is not a full-time activity, what other activity is that worker assigned (e.g. tying dipped bundles, taking them to storage, putting them on a media (saw-dust or other)?

    _____

11. Is permission granted to observe workers while dipping? ☐ Yes ☐ No

Name & Title of person granting permission: _____

WHS Staff Initials: _____ Date: _____

APPENDIX 2

Figure 1 - Harvesting field of dormant grape stock.
(Tree harvesting similarly done, using with larger harvester/digger)

Figure 2 - Trimming and grading of tree rootstock

Figure 3 - Disbudding to ensure no grape rootstock suckers form.

Figure 4 - Bench grafting of grape rootstock

Figure 5 - Waxing the graft unions of grape rootstock to reduce transpiration.

Figure 6 - Mechanical hot water dipping to protect against pests and pathogens.

Figures 7 & 8 - Hand dipping into rooting solution.
Note: Elbow length rubber gloves and rubber boots.

Figures 9 & 10 - Packed in bins of hydrated vermiculite for cold storage.

Figure 11 – Cooler (cold storage) entrance

Figure 12 - Bins of plants in a cooled, stress-free environment.