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Assessment of the Occupational Health of Greenhouse Workers

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The creation of a special environment for the enhancement of plant growth, outside the normal growing season, dates back to 500 B.C. The Gardens of Adonis, in ancient Greece, saw the first application of covering and protective materials to foster the growth and propagation of ornamental flowers. Another historical milestone occurred when Tiberius Caesar instructed his gardeners to provide a supply of cucumbers throughout the entire year (Walls, 1988). History gives credit to the gardener for producing cucumbers in an enclosed structure. However, the physician who prescribed a cucumber each day for Caesar may not be as highly regarded by his contemporaries.

The modern greenhouse draws on technology from agricultural and engineering sciences. Elaborate environmental control systems create optimal plant growing conditions in a modern greenhouse. Chemicals are used to enhance or retard plant growth and to combat pest problems. The rapid expansion of the modern greenhouse industry gives rise to concern for the occupational safety and health of greenhouse workers. This study was completed to address the following concerns:

- The greenhouse environment presents an unusual ensemble of physical and chemical elements that may be a significant hazard to human health.
- The need to safeguard the health of thousands of individuals employed in commercial greenhouses.
- The virtual absence of information on greenhouse workers, as such, in the medical literature.

METHODS

Seven of the eight commercial greenhouses located in the greater Lexington, Kentucky area were studied in February and March 1990. The major objectives were to determine:

- The demographic characteristics of greenhouse workers;
- The nature of greenhouse work;
- Materials used in greenhouse work and worker exposure to them;
- Self-reported adverse health affects related to greenhouse employment;
- Measures taken to prevent noxious exposures or work injuries;
- How the greenhouse work environment may be improved for employee safety.

Worksite Evaluations - A walking tour of each greenhouse was conducted with an owner or similarly responsible supervisor during working hours. The structural and physical characteristics of each greenhouse were noted. Particular attention was directed at the activities of greenhouse workers and the distribution of chemicals and debris throughout each facility. Storage of hazardous materials and availability of safety equipment were also assessed. Quantitative measurements of ambient particulates or chemical residues were not made.

Survey of Worker Occupational Health - Sixty-two workers (82 % of the total work force at the seven greenhouses) completed a detailed interviewer administered occupational and personal health questionnaire. Workers were identified as those employed with the care of greenhouse plants or the

maintenance of the greenhouse or greenhouse equipment for at least 20 hours per week; office staff and delivery personnel were not considered greenhouse workers. The questionnaire posed 296 questions concerning current and past medical conditions. The physician investigator was available to answer questions and assist the workers as needed. Greenhouse workers were asked to identify any materials or activities that concerned them from a health standpoint and list any symptoms or illnesses that could be associated with work activities. In addition, questions on recreational activities or contact with specific chemical agents were used to determine non-occupational confounders of chemical exposure.

RESULTS AND DISCUSSION

Worksite Evaluation - The greenhouses studied varied in size, age, type of construction and quality of conditions for the workers (Table 1).

Table 1. Characteristics of the greenhouses studied.

Size of growing space	6,000 sq. ft. to 6 acres
Number of employees	3 to 28 workers, including owner
Age of business	4 to 60 years
Layout	Freestanding and gutter-connected greenhouses
Greenhouse cover	Polyethylene film, fiberglass, glass
Greenhouse structure	Wood, metal
Greenhouse benches	Wood, transite, expanded metal
Heating system	Hot water, steam, space heaters
Fuel	Coal, natural gas, propane, oil

Occupational Health Hazards Observed

- Plants in containers were placed on the ground or on a bench 6 to 50 inches tall. Low benches require excessive bending for workers to evaluate or move plants.
- Heating pipes often obstructed the safe passage of workers through the greenhouse.
- Large accumulations of coal dust were observed at each site that used coal.
- Ventilation and air circulation fans moved large volumes of air to control temperatures and prevent foliar plant diseases. This air movement created worker discomfort when they worked is specific locations in the greenhouse.
- Some greenhouse floors had wide cement walkways; others had irregular soil and gravel surfaces that made worker movement difficult. Often the irregular soil and gravel surfaces were wet or under water and dangerously slippery.
- The accumulation of several inches of soilless growing media was evident in numerous greenhouses. This debris probably contained chemical residues from the wide variety of materials and waste products handled in the greenhouse environment. The largest amounts were noted in the areas where pots or flats were filled. Some of these materials were packaged in a dry, brittle form that liberated clouds of dust when handled (Table 2). It is most probable that these dust particles may act as a vehicle to distribute chemical residues present in the greenhouse environment.

Table 2. Composition of greenhouse dust evaluated in this study.

Inorganic components ➢ From growing media debris o vermiculite, perlite, silica, asbestos.
Organic components ➢ From insect or mite decomposition o Bacteria, bacterial endotoxin, microbial proteolytic enzymes ➢ From plant debris o Plant tissue debris, fungal spores, actinomycetes ➢ From growing media debris o Peat moss fragments

- Only designated individuals qualified to handle pesticides did so. Although compliance was not evaluated, each facility contained appropriate protective equipment, i.e. full dress suits, respirators, gloves and boots.
- Workers who did not handle pesticides were seen wearing gloves while working with growing media. Most employees dressed according to the temperature in the greenhouse, some wearing shorts and sandals. No workers kept a designated pair of work shoes for use in the greenhouse.

- Fertilizers; acids used to correct water pH.
- Evaporative cooling systems were treated periodically with a bromide solution to control algae.
- Often workers ate their meals in the greenhouse. Few were seen to wash hands carefully. In some cases, meals were eaten on a workbench used for potting, chemical fertilizer preparation or storage of hazardous materials.

RESULTS OF SURVEY OF WORKER OCCUPATIONAL HEALTH

Demographics - The median age of the 62 greenhouse workers studied was 22 and ages ranged from 19 to 89 (Table 3). Females out numbered male workers three to one and 62% of females were of childbearing age (less than 40).

Table 3. The age and gender distribution of greenhouse workers who participated in this study.

Worker Age	Female	Male	Age group as a percent of the workforce
Teens	1	0	2 %
20's	16	4	34
30's	12	6	27
40's	6	1	11
50's	6	1	11
60's	4	3	11
70's +	2	0	4
Total	47 (75%)	15 (25%)	

The median duration of employment was one year. No workers under age thirty had five or more years of experience. This high turnover may be due to low pay and to the nature of the hurried and physically demanding work. The proportion of workers with more than five years experience was found to be much greater, 92% and 69%, in the 30-49 and over 50 age groups, respectively. This reflects the owners who are still active in their greenhouse work and a small number of workers who have elected to continue greenhouse work as a vocation.

Dermatitis – There were nine complaints of skin related disorders among the 62 greenhouse workers tested. A rash affecting the arms, hives, dandruff, excessive perspiration and sores, that were slow to heal, were also reported.

Occupational skin disease is responsible for approximately 40% of all occupational disease (Adams, 1986). This figure is reported to be higher among other agricultural workers (Wyngarden, 1988). Contact dermatitis is associated with direct contact to a wide variety of plants as well as pesticides (Goldfrank, 1986). Details may be found in the Pesticide Fact Handbook (USEPA, 1988) or the MSDS Reference for Crop Protection Chemicals (1989). Agribrom, used for algae control, may come in contact with greenhouse workers on a regular basis. Bromides have striking, pulmonary, neurologic and renal toxic manifestations (Sax, 1979). They may result in bromodermia, as free bromides displace other halogens in the body (Goldfrank, 1986). The risk of sunburn and sun exposure related malignancies are limited under the glass or plastic greenhouse coverings that absorb UV-B.

Musculoskeletal Disorders - The most costly occupational disorders in the United States are the results of musculoskeletal injuries (Wyngarden, 1988). Low back pain and cumulative trauma disorders are the most frequently encountered musculoskeletal disorders. It is not surprising that one half of the greenhouse workers tested reported musculoskeletal pain (Table 4). Approximately one half of these workers took analgesics during the study period for this problem.

Table 4. Frequency of musculoskeletal complaints from greenhouse workers who participated in this study.

	Number of worker complaints	Workers using analgesics
	Percent	
All musculoskeletal pain	50	52
Back pain	31	47
Polyarthralgias	19	58
Upper extremity	11	43
Lower extremity	8	
Neck	2	

The most frequent symptom was back pain. Greenhouse activities require each worker to be able to perform a variety of repetitive tasks quickly.

Workers may participate in seeding, potting, transplanting or transporting plants and materials throughout the greenhouse. Of particular concern was the lack of sufficient waist height bench space. This is a precious and costly item. Each greenhouse owner expressed the desire to make these improvements. Workers can easily become fatigued working in a bent over position for any prolonged period of time, or from excessive bending. The problem was further aggravated when a worker must exert force to move plants while in a bent over position. Such maneuvers require rotation of the lower spine and may place undo strain on the supporting musculature and supportive ligamentous structures. It is not a realistic expectation to have workers bend at the knees while performing activities at ground or near ground level. Excessive knee bending may predispose to other lower extremity musculoskeletal disorders. The installation of waist high benches may be the single most important preventive measure that a greenhouse owner can implement to reduce the incidence of back-related disorders.

Pinching and disbudding require fine coordination that can strain the back, neck and upper extremity muscles in addition to causing some degree of eyestrain depending on the amount of light and size of the buds. The thumb and index finger of the dominant hand are used as a cutting tool in both pinching and disbudding.

Plants are stacked into tall carts with small wheels. The lack of hard and smooth surfaces can make it difficult to push these carts, in some cases, even difficult to walk across. Repetitive pushing may result in upper and lower extremity pain; possibly back pain if lifting is done.

Respiratory Effects - Greenhouse workers are exposed to many organic and inorganic dusts and chemicals during a typical day (Table 1). The elevated humidity and the constant rapid air flow in a greenhouse further enhance the formation and absorption of complex aerosols which may cause the following diseases:

- Occupational Asthma
- Bronchitis
- Allergic Alveolities
- Rhinitis
- Organic Dust Toxic Syndrome (ODTS)
- Mucus Membrane Irritation Syndrome (MMIR)
- Asbestoses

The etiology and pathology of occupational asthma, bronchitis, allergic alveolities and asbestoses are well described (Wyngarden, 1988; Zenz, 1988). Organic dust toxic syndrome (ODTS) is a febrile reaction associated with exposure to spores from molds, actinomycetes and from gram-negative enterotoxins. These problems may also cause allergic alveolitis. The incidence of ODTS among dairy farmers has been estimated to be 30 to 50 times greater than that of allergic alveolitis (Malmborg, 1990). Mucus membrane irritation syndrome (MMIS) encompasses acute irritation from noxious agents that may cause rhinitis, conjunctivitis, pharyngitis, and laryngitis (Enarson, 1990; Malmborg, 1990). Bromide, acids, pesticides, and growing media may be implicated in greenhouse MMIS.

Greenhouse exposure to asbestos has two identifiable sources; structural transite and asbestos contaminates of vermiculite. Hessel and Sluis-Cremer (1989) reported the presence of amphibole asbestos of the tremolite-actinolite series in U.S. mined vermiculite, however, no significant pulmonary problems were found in South African miners who mined mica with a very low concentration of asbestos. This does not exclude the possibility of pulmonary insult from vermiculite because it represents the only study to address this question. Similarly, little is known of perlite, another mineral used in planting media.

Peat is a product of the decay of sphagnum moss that is mined from bogs and used as a main component of growing media. Sandstrom (1990) reported that exposure to peat dust was not associated with ODTS or allergic alveolitis; however, a significant decrease in FEV was linked to peat dust exposure. Only individuals with known asthma were clinically affected.

The results of respiratory and oral, nasal and throat complaints suggest no increased incidence of complaints, especially considering the winter season was not over and the smoking habits of the study group (Table 5). Thirty-nine smokers (63%) were identified and they smoked a mean of 20 pack-years. Eighteen workers (29%) reported respiratory symptoms. Four of those workers were non-smokers. Three complained of frequent colds and one was intermittently short of breath secondary to anxiety. Each of the four asthmatics was a smoker. Only one asthmatic described an exacerbation of symptoms while working in the greenhouse during particularly humid and hot conditions. Bronchitis was reported in

eight workers (13%), each of whom was a smoker. In this group, the lowest level of smoking was 13 pack-years in a twenty-two year old with six months experience. Frequent colds were reported by nine workers (15%).

Table 5. Frequency of respiratory or oral, nasal and throat complaints of greenhouse workers in this study.

	Complaint percentage
Respiratory	
All complaints	29 %
Asthma	6
Bronchitis	13
Frequent colds	15
Pneumonia	5
Hemoptysis	3
Oral, Nasal, Throat	
All complaints	18 %
Epistaxis	10
Rhinitis	8
Pharyngitis	5
Laryngitis	3
Gingival pain	2

Neurologic Disorders – Seventeen workers, 27% of the greenhouse workers tested, reported neurologic disturbances (Table 7). Complaints of chronic headaches accounted for thirteen of the cases. With one exception, each of these thirteen workers had less than two years experience. None of these workers was responsible for application hazardous chemicals. All but two were female.

Although this group would appear to have a hyper susceptibility for headaches, it was difficult to speculate on the validity of this hypothesis without obtaining individual histories and observing individual response outside of the greenhouse environment for a considerable length of time. A similar situation is posed by the four workers with depression and five workers with neuroses. The isolated report of tremor came from a very young and inexperienced worker who consumed diet pills, antacids and analgesics on a regular basis even before greenhouse employment.

Table 6. Frequency of neurological complaints of greenhouse workers in this study.

	Complaint percentage
All neurologic complaints	27 %
Headache	21
Depression	6
Nervousness	8
Tremor	2

SUMMARY

The health concerns related to greenhouse work are complex. In this study, the health determinants of greenhouse work were sought by workplace evaluation and solicitation of worker perceived health status as influenced by occupational activities. The results were clouded by significant differences in greenhouse sophistication and a high worker turnover. For these reasons, the estimation of the long term or chronic disease processes would be conjectural at best. Only acute phenomena are described in this study.

The high incidence of musculoskeletal injury reported by workers was consistent with the nature of greenhouse work.

The complex aerosols found in the greenhouse environment lead one to anticipate considerable complaints of skin or respiratory disorders. This was not reflected in worker response to pertinent questions. This does not preclude the possibility or even likelihood of sub clinical disease. The high incidence of headaches in a very specific group is puzzling. Plausible answers would suggest a hyper susceptibility to noxious aerosols or the presence of a non-occupational confounder. This question that invites further study.

How should efforts be directed at improving the greenhouse workplace?

- It would make sense to correct the ergonomic problems that are responsible for the abundance of musculoskeletal complaints.

- Care should be taken to improve hygiene. Workers must wash before meals and eat in a different location. Work clothes should be changed more frequently, especially with regard to foot apparel that can transport harmful residues to the home.
- Sanitary conditions would be immeasurably improved if washable floors were adopted. This would facilitate the removal of harmful chemical residues and decaying plant and pest materials.
- Perhaps tighter greenhouses could be built which could filter all incoming air similar to the operation of recombinant greenhouses. This would reduce the need for pesticides considerably.
- Worker education is a cornerstone of occupational safety and health. MSDS information should be maintained current and discussed with all employees, not just those certified for pesticide application. Until the precise risks involved with chemical usage are determined, it would be advisable to initiate a health surveillance program. This should include the recording of all exposures. Determination of exposures by analytical means is best performed by an industrial hygiene specialist, and biological monitoring. If a database could be established for greenhouse workers, the entire industry would benefit.

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