Cut Flowers: A Potential Pesticide Hazard

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Abstract: Following reports of ten cases of possible organophosphate pesticide poisoning in florists exposed to pesticide residues on cut flowers, we conducted a prospective random-sample survey to determine residual pesticide levels on flowers imported into the United States via Miami, Florida. A sample of all flowers imported into Miami on three days in January 1977 showed that 18 (17.7 per cent) of 105 lots contained pesticide residue levels >5 ppm, and that three lots had levels >400 ppm. Azodrin (monocrotophos) was the most important contaminant with levels of 7.7–4,750 ppm detected in nine lots. We examined 20 quarantine workers in Miami and 12 commercial florists exposed to contaminated flowers. Occasional nonspecific symptoms compatible with possible organophosphate exposure were noted, but we found no abnormalities in plasma or red blood cell cholinesterase levels. This study documents a previously unrecognized potential source of occupational pesticide exposure and suggests that safety standards should be set for residue levels on cut flowers. (Am. J. Public Health 69:53–56, 1979).

Introduction

Each year 350 million cut flowers are imported into the United States. Canada and Europe import a similar number. Most imported flowers originate in South and Central America, with Colombia producing 90 per cent.[1] Carnations, pompon chrysanthemums, and standard chrysanthemums make up 95 per cent of the market.[2]

All plants and flowers entering the United States must meet stringent United States Department of Agriculture (USDA) regulations designed to prevent importation of pests and plant diseases; there are, however, no regulations regarding contamination with pesticides or other toxic materials. As a result, imported flowers frequently receive heavy pesticide applications prior to shipment. Many of the pesticides applied are fat-soluble and can be absorbed through skin contact. Thus, individuals handling large numbers of pesticide contaminated flowers may be at risk of increased pesticide absorption. Such absorption may have been responsible for symptoms of diplopia, headaches, blurred vision, paresthesias, and muscle weakness recently noted in ten Colorado flowershop employees.[3]

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In January 1977 we investigated the extent and severity of pesticide contamination of flowers of imported through Miami, Florida, the major United States entry point for imported flowers. We found pesticide concentrations on several lots of flowers high enough to be capable of causing illness. This report presents the results of our investigation.

Methods

Flower Surveillance

On January 11, 18, and 25, 1977, 105 lots of imported cut flowers were sampled in Miami to assess the prevalence of pesticide contamination.* We estimated the minimum sample size required to detect a 10 per cent level of contamination when a 0 per cent level is expected to be 77 samples. A random sample of approximately 120 was considered sufficient to include 77 samples from Colombia, the major flower exporter, and to allow some representation of other countries' flowers. Only carnations, pompon chrysanthemums, and standard chrysanthemums were sampled. On each sample day a box of each of these flower types from each grower was randomly selected for inspection. Two flowers were taken at random from each box, placed in an aluminum foil lined bag, frozen, and shipped to the laboratory within 24 hours. Gas liquid chromatographic and mass

*Contamination was defined as <5 ppm total pesticide residue on one flower specimen.

TABLE 1—Pesticide Levels in 105 Lots of Imported Flowers, Miami, Florida, January 1977

Total Pesticide Concentration (ppm)	Specimens with Pesticide Residues	
	No.	%
None	16	15.2
.01– 0.99	38	36.2
1.00– 4.99	33	31.4
5.00– 9.99	7	6.7
10.0 – 399.99	8	7.6
400.0 –4,751.30	3	2.9
TOTAL	105	100.00

spectrometric analysis was performed on the complete flower sample by the National Monitoring and Residue Analysis Laboratory, Animal and Plant Health Inspection Service, USDA, Gulfport, Mississippi. Flower specimens were screened for a wide spectrum of pesticides, including carbamates, organophosphates, endosulfans, and chlorinated hydrocarbons.

Health Effects Evaluation

On January 11 and 12 we interviewed as many current Miami Plant Protection and Quarantine (PPQ), USDA employees as were willing to participate in the study. The questionnaire covered basic demographic information, work history, symptoms associated with pesticide poisoning, personal habits, and nonoccupational sources of pesticide exposure. Each employee was physically examined with special attention given to the nervous system; vibratory sensation was tested by means of a tuning fork. Blood specimens were collected in heparinized tubes, kept on ice, and red blood cells and plasma were separated within two hours of collection. Cholinesterase levels were determined by the Michel method[4] within 24 hours of sample collection.

After the lots of highly contaminated flowers were identified, wholesale florists receiving the contaminated flowers were contacted. Twelve employees of two wholesale florists in Alexandria, Virginia, and Newark, New Jersey, were medically evaluated. Cholinesterase levels were measured by the pH-stat method[5].

Results

Flower Testing

One hundred five flower specimens from 43 different growers were analyzed: 102 from Colombia, two from Nicaragua, and one from Guatemala. Eighty-nine (85 per cent) of the samples had one or more pesticide residues. Eighteen of 105 lots (17.1 per cent) had total pesticide residues >5 ppm; three had concentrations >400 ppm (Table 1).

Sixteen pesticides of varying toxicity,[6, 7] including eight organophosphates and eight chlorinated hydrocarbons, were detected (Table 2). Endosulfan, diazinon, and phosphamidon occurred most frequently. The most significant contaminant was Azodrin** (monocrotophos), a moderately toxic organophosphate (rat oral LD_{50} = 19 mg/kg) found in nine of the contaminated lots. Azodrin occurred in the highest concentration, had the highest geometric mean concentration, and had the highest percentage of its detected samples with a concentration >5 ppm (100 per cent).

Pesticide concentrations varied widely by sampling day and by type of flower. Concentrations >5 ppm occurred in none of the first week's samples, in 17 per cent of the second week's, and in 36 per cent of the third week's. Seven different pesticides were detected in the first week, 13 in the second, and 12 in the third. Of the three flower types samples, standard chrysanthemums and pompon chrysanthemums had the highest levels of contamination and carnations the lowest (Table 3). Twenty-eight (67 per cent) of 42 residues from the most toxic group of pesticides occurred in pompons.

High-level residues, >5 ppm, were found in flowers from 17 (40 per cent) of 43 growers: 16 from Colombia, one from Guatemala. Not enough samples were analyzed from each grower to determine a pattern of contamination; however, flowers from 1 grower had residues of the same pesticide, Azodrin, in concentrations >400 ppm on 2 consecutive weeks. Organophosphates accounted for 63 per cent of total residues and 83 per cent of lots with concentrations >5 ppm. Highly contaminated flowers could not be detected by visual inspection as after such inspection, the 3 lots of flowers with the highest measured residues were described as having minimal residues.

Health Effects Evaluation

1. *Flower Inspectors*. Twenty PPQ employees participated in the study. Included in the 20 were 17 (61 per cent) of 28 inspectors, including 8 (89 per cent) of the nine inspectors who had the greatest exposure.

Questionnaire Data. All participants were males and 19 (95 per cent) were white. The average age was 44 years, with an average present job PPQ work history of 7.8 years. Employees had a spectrum of manual exposure to cut flowers and plants over the previous month: three employees had heavy (> 160 hours), four had moderate (21–40 hours), seven had light (5–20 hours), and six had essentially no (0–2 hours) exposure. Thirteen (65 per cent) also had pesticide exposure at home.

Symptoms. Headaches (20 per cent), skin irritation (20 per cent), and watery eyes (20 per cent) were the most frequently reported symptoms. Skin irritation was the only symptom that workers themselves associated with flower handling. Nonspecific symptoms possibly related to organophosphate exposure were reported rarely, but did occur in the 14 workers with flower and plant exposure. There were no episodes of acute organophosphate poisoning.

Signs. Six workers (30 per cent) had decreased vibratory sensation in the lower extremities. This sign occurred in five of the seven individuals with greatest recent exposure to

**Inclusion of trade names is for identification only and does not imply endorsement by the Public Health Service or the U.S. Department of Health, Education, and Welfare.

TABLE 2 - Pesticides Detected on 105 Lots of Imported Flowers, Miami, Florida, January 1977

Pesticide (Listed by Order of Toxicity)	No. of Samples with Pesticide Present	No. of Samples** with Pesticide >5 ppm	Geometric Mean Per Detected Sample (ppm)
Organophosphates			
mevinphos	8	0	.05
ethyl parathion	6	0	.41
dicrotophos	6	4	3.91
methyl parathion	11	1	.30
monocrotophos	9	9	84.18
phosphamidon	40	0	.29
diazinon	52	3	.20
malathion	3	0	.19
Chlorinated hydrocarbons			
endrin	2	0	.06
dieldrin	1	0	.07
endosulfan	53	2	.27
heptachlor	4	0	.04
chlordane	1	0	.04
toxophene	4	1	3.78
lindane	2	0	.08
DDT & derivatives*	12	0	.23

* = P,p^1-DDE, O,p^1-DDT, P,p^1-TDE
** = Some samples had more than 1.

plants and flowers, and in only one of the 13 with least exposure ($p < .01$, Fisher's Exact Test). The mean age in the heavily exposed group was 43 years compared with 45 years in the less heavily exposed group. Within the heavily exposed group, the older workers were the ones affected. There was no correlation between decreased vibratory sensation and length of employment or with duration of residue exposure.

Laboratory Findings. Red blood cell and plasma cholinesterase levels were normal in all persons tested. There were no differences in cholinesterase levels by job category, exposure history, or past symptoms.

2. *Florists.* A telephone survey of six wholesale establishments receiving flowers contaminated with the highest levels of pesticide residues revealed no record of overt illnesses. We interviewed 12 employees who had been exposed to contaminated flowers at two of these wholesale organizations in New Jersey and Virginia and collected blood samples for cholinesterase determinations. Only one individual had experienced symptoms compatible with possible organophosphate exposure. All 12 cholinesterase levels collected three weeks after the employees' exposure were normal. No organophosphate metabolites were detected in blood specimens from the seven New Jersey workers. Flower distribution could not be traced further.

Discussion

This study documented the occurrence of sporadic, high-level pesticide contamination of flowers imported into the United States from South and Central America. Toxic organophosphate pesticides were detected on flowers in levels up to 4,750 ppm, concentrations that could cause illness as the result of skin contact. We detected no overt pesticide-related illness in workers with minimal exposure to these flowers, but we did find occasional nonspecific symptoms possibly related to organophosphate exposure.

Although sensory abnormalities were noted in some individuals with recent flower and plant exposure, these abnormalities correlated best with age, testing was not double blind, and there was no correlation with duration of ex-

TABLE 3—Pesticide Residues on Imported Flowers, by Flower Type, Miami, Florida, January 1977

Flower Type	Number of Specimens	Specimens with Residue >5 ppm		Average Number of Pesticides Present
		Number	%	
Standard chrysanthemums	9	3	33	2.7
Pompon chrysanthemums	32	9	28	2.8
Carnations	64	6	9	1.8
TOTAL	105	18	17.1	2.06

posure. However, the high correlation between decreased vibratory sensation and recent exposure ($p < .01$, Fisher's Exact Text), and the fact that organophosphate induced peripheral neuropathy has been described previously,[8] suggest that further study is needed to clarify the significance of this association.[6]

High pesticide levels on imported cut flowers were apparently related to excessive rates of pesticide application by Central and South American growers. This pattern of use may have been related to stringent USDA regulations that restrict importation of flowers and plants with various pests and plant diseases, but do not restrict importation of flowers with pesticide or toxic chemical contamination. In contrast, most pesticide residues on food products, where potential exposure is more obvious, are limited to >1 ppm. Pesticides are usually less toxic from dermal than oral exposure, but persons who handle large numbers of flowers could become ill because of percutaneous adsorption.

Control of pesticide use is the preferred method of reducing exposure to these compounds. We feel that such control may best be achieved by establishing tolerance guidelines which will help to monitor excesses. These guidelines should, as in the case of food pesticide tolerances, be based on agricultural practices, average exposure, and acceptable daily intake.[9]

In the interim, recommendations for decreasing pesticide contamination have been forwarded to foreign growers. The USDA is taking steps to monitor and decrease residues and preliminary reports indicate that pesticide contamination has decreased. The Center for Disease Control (CDC) has sent information on the problem to the World Health Organization, to U.S. florist representatives, to foreign flower growers, and to countries that import flowers.

Physicians should be alerted to the potential for organophosphate exposure in inspectors, florists, and others who handle significant numbers of flowers (or in children, who may inadvertently eat flowers). Familiarity with the potential problem is helpful since symptoms are often nonspecific (nausea, tearing, weakness) and sources of exposure are not always readily apparent.

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Physician's Fees

The English physician, Thomas, Dimsdale, probably established a record (fee-for-service) for all time when he received fifty thousand dollars cash, an annual pension of ten thousand dollars, and a Russian baronetcy, all for vaccinating Catherine the Great and her son.

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