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Field Worker Exposure and Helicopter Spray Pattern of 2,4,5-T[1]

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The herbicide 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) has proved to be very effective in the control of broadleaf species in rice fields, grasslands, and forests. The herbicide breaks down rapidly in the soil (WHITESIDE and ALEXANDER 1960) and leaves little or no residual effects upon the environment. However, because questions have arisen on the safety of direct exposure to 2,4,5-T, the herbicide has been placed on the Environmental Protection Agency's (EPA) list for Rebuttable Presumption Against Registration, a process designed to allow clear evaluation of the benefits and risks involved with a compound before it is released for future use. Position Document 1 on 2,4,5-T issued by the EPA indicates that data are inadequate on measurement of 2,4,5-T exposure to field workers involved in actual spraying operations. Some earlier research suggests that the herbicide is fetotoxic and possibly teratogenic for mice in doses above 20 mg/kg/day (ROLL, 1971) and is fetotoxic for rats at 25 to 150 mg/kg/day (SPARSCHU et al. 1971).

The objectives of this study were to measure the direct exposure encountered by people in the actual spray area and to determine the distribution range of 2,4,5-T sprayed from a helicopter.

MATERIALS AND METHODS

Applicators and other crew members in the following operations were used to gather the human exposure data: helicopter (5-man crew), a tractor driver spraying rice levees, tractor mist blower (4-man crew), and forest backpack spray workers (12-man crew).

The spray materials used were low volatile ester formulations of 2,4,5-T. The actual materials included Thompson Hayward's DedWeed LV-6 and Dow Chemical Company's ESTERON 245. These materials were applied

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at rates of 2 lb/A (active ingredients) in water. Applications by helicopter and tractor used 5 gallons of water per acre, and the backpack spray contained 10 gallons per acre. The rice levee was sprayed in the afternoon and other operations were begun in early morning when wind was less than 5 mph. Studies were completed between July and October, 1978, with air temperatures ranging from 18 to 32 C. Time in the field for each operation included: helicopter, 116 min; tractor rice spraying, 65 min; tractor mist blower in forest, 245 min; and backpack, 180 min. All crew members were instructed to work in a manner no different from their normal operations.

An attempt was made to calculate respiratory exposure. Vapors and air borne particles of 2,4,5-T in the spray material were collected through a face mask respirator. This triangular shaped device was placed over the nose and mouth to filter all air breathed by each worker. A polyurethane filter set in the mask had been preextracted before use to prevent any interfering peaks on the analytic chromatogram. After these filters were exposed to the spraying operation, they were taken from the masks and stored in methanol. In spite of the preextractions, interfering peaks occurred that prevented effective analyses.

External exposure was measured by attaching 100-cm^2 gauze patches to the outer garments of all crew members. The patches were constructed by modifying a procedure used by WOLFE et al. (1975). Nine layers of cotton gauze, backed with two layers of Whatman No. 1 filter paper, were taped along the borders with masking tape. At spray time in the field the patches were attached in six locations for each worker: upper back, upper chest, bicep-deltoid area of each arm, and upper front of each thigh. Immediately after the spray application, the patches were removed from the clothing. To minimize contamination, only project supervisors were permitted to remove patches. As the patches were removed, the masking tape was cut from the edges to prevent the glue on the tape from interfering with subsequent gas chromatographic determinations and to allow each patch to be disassembled as it was placed in an individual amber-colored jar containing methanol as a storing, extracting solvent. The jars were kept at a controlled room temperature (4 C) until analyzed. For calculation of exposure based upon these patches, each worker was weighed and photographed in his work clothes, his exposed skin area was noted, and a formula derived from WOLFE et al. (1975) was employed.

An additional effort was made to calculate exposure to individuals who might inadvertently be in an area

being sprayed with 2,4,5-T. For this test one individual with gauze patches attached to clothing on his head, shoulders, arms, chest, and front and back thighs, stood directly under the path of the helicopter from which crewmen sprayed. Another individual equipped with six patches, arranged as on crew members, walked through the area that had been sprayed with ESTERON 245 two hours before.

To measure the width of a helicopter spray pattern and to obtain information on drift (with the helicopter at an 80-ft height applying 2,4,5-T with a microfoil boom), mylar sheets (9 X 9 in) were placed on the ground at intervals of 80, 160, 320, 640, and 960 feet on each side of the spray path. A total of three replications were included in the study. The mylar sheets were attached to 9 X 9-in floor tile to keep them from being moved by the wind or helicopter. Immediately after the spraying was completed, the mylar strips were removed from the tile and placed in jars of methanol in a manner similar to that used with the gauze patches.

Analyses for 2,4,5-T employed the ^{63}Ni gas chromatographic analytical procedures of MATTICE et al. (1979). All values in this study are reported as the methyl ester of 2,4,5-T unless otherwise stated.

RESULTS AND DISCUSSION

Helicopter crews received low levels of 2,4,5-T on their patches (Table 1). In general their patch exposures were relatively uniform, except for the mixer of

TABLE 1

Milligrams of 2,4,5-T Detected on Individual 100 cm^2 Gauze Patches of Crews Applying the Herbicide.

Crew and Duty	Body wt	Chest	Back	Left arm	Right arm	Left thigh	Right thigh	Ave./ $\bar{X}$
	(kg)				(mg)			
Helicopter pilot	72.6	ND	ND	ND	0.010	0.034	0.094[a]	
flagman	86.3	0.052	0.058	0.046	0.067	0.014	0.010	
flagman	95.8	0.024	0.023	0.031	0.028	0.006	0.007	
mixer	86.3	0.051	0.039	0.012	0.011	0.263[a]	0.088	
super-visor	81.7	0.028	0.103	0.058	0.064	0.037	0.018	
								0.043

Crew and Duty	Body wt	Chest	Back	Left arm	Right arm	Left thigh	Right thigh	Ave./ $\bar{X}$
	(kg)	- - - - - - - - - - - -			(mg)	- - - - - - - - - -		
Rice Levee driver		0.02	0.02	0.03	0.03	0.59[a]	0.03	
Mist blower driver	84.0	0.31	1.02	0.44	0.57	0.17	1.01	
driver	106.7	0.58	1.11	1.56	0.66	0.58	0.77	
mixer	79.5	0.74	0.08	0.02	4.49	1.08	8.76[a]	
super-visor	95.3	0.27	0.38	0.52	0.47	0.64	1.30	
								0.94
Backpack sprayer		0.07	0.65	0.27	0.20	0.55	0.75	
sprayer		0.75	[b]	2.33	2.40	6.10	22.47[a]	
sprayer		5.61	1.86	1.77	1.47	0.18	68.93[a]	
sprayer		0.79	0.91	2.01	1.19	2.82	6.19	
sprayer		0.95	17.96	2.11	54.85[a]	1.80	1.06	
sprayer		2.41	2.46	1.23	1.19	24.18	25.65	
sprayer		1.31	0.63	0.53	0.76	0.68	1.79	
sprayer		2.25[a]	0.01	0.40	0.53	0.04	0.08	
sprayer		1.57	[b]	2.00	4.01	31.76	2.73	
sprayer		0.54	0.65	2.92	2.53	0.30	2.47	
sprayer		1.52	2.57	0.98	0.60	1.98	11.09[a]	
sprayer		2.26	1.34	8.01	4.32	3.61	15.32	
								5.43

[a]This value exceeds 50% of the total 2,4,5-T detected on all six patches, thus indicating that non-uniform deposition occurred.
[b]Sample was lost.

the mist blower crew who received considerably more exposure than did his fellow workers. The average exposures for the operators of backpack sprayers were greater than those for the other studies. The members of this crew who received the highest 2,4,5-T amounts on their patches received more than twice the patch exposure of workers with highest amounts in the other studies.

Calculations based upon the formula derived from WOLFE et al. (1975), the photographs revealing exposed skin areas, and the 2,4,5-T analyses from the gauze patches indicated that external exposure values ranged from 0.0036 to 0.0136 mg/kg for helicopter crews. Values for the mist blower crew were from 0.046 to 0.205 mg/kg, while those of the backpack crew ranged from 0.081 to 1.85 mg/kg. The exposure of the tractor driver spraying the rice levees was 0.046 mg/kg.

For 8 of the 22 applicators more than half of the detected 2,4,5-T was located on one patch (Table 1). For these 8, the thigh patches contained the highest amount of 2,4,5-T, an indication that thigh areas received more exposure than other locations chosen for patches or that hands habitually were rubbed on this area to clean or dry them off. Thus, extrapolations of values based on any one patch or on an average patch concentration in relation to dermal exposure would not necessarily result in the correctly calculated exposure.

The exposure received on different portions of the body of a person directly under the spray path of the helicopter varied from 0.01 on the chest to 6.48 mg on the left front thigh. If we assume that the sprayed individual weighed 76 kg and was wearing shoes, short sleeves, long trousers and no hat, the calculated potential exposure for this individual is 0.86 mg/kg. There was considerable variation in amounts of 2,4,5-T on the patches worn by this individual; however, the average amount detected per 100-cm^2 patch was 2.07 milligrams on a acid equivalent basis. Calculations for 2 lb/A active ingredient (acid) indicate that a helicopter should deliver to the land surface a total of 2.23 milligrams per each 100 cm^2. The exposure received by this individual directly under the spray path of the helicopter should represent the maximum 2,4,5-T external exposure that could occur to someone who was inadvertently exposed to the forest operation.

Although 2,4,5-T was detected on the gauze patches, it should be pointed out that in the recent human exposure study conducted by LAVY et al. (1979) there was relatively low correlation (0.45) between the amount of 2,4,5-T detected on gauze patches and the 2,4,5-T excreted in the urine of exposed individuals. In that study a value of 0.04 was obtained when the milligrams of 2,4,5-T excreted in the urine of each worker was divided by the milligrams of 2,4,5-T body exposure as estimated from analyzing the gauze patches from each worker. Using this information, if we assume that 4% of the 2,4,5-T which was predicted to come in contact with exposed dermal area was actually absorbed and consequently excreted in urine, the individual directly under a helicopter spray path would have absorbed and excreted 0.034 mg/kg 2,4,5-T.

The worker walking through a field which had been sprayed with ESTERON 245 two hours earlier was outfitted with a set of six patches. Analysis of these patches revealed no detectable 2,4,5-T. Sensitivity limits of the technique would have detected 2,4,5-T in excess of 10 micrograms.

Measurements of 2,4,5-T on each of the mylar pads (81 in^2) revealed that over 84% of the 2,4,5-T applied by the helicopter was deposited within 80 feet of the spray path while 99% of the spray was delivered within 160 feet from the spray path (Table 2).

TABLE 2

2,4,5-T Deposition Pattern When Applied by Helicopter using a Microfoil Boom.

Distance from Spray Path (ft)					
0	80	160	320	640	960
		(mg/pad)*			
2.78	0.30	0.06	0.03	ND	ND
0.98	0.82	0.08	0.70	0.02	0.01
1.65	0.13	0.08	ND	ND	ND
	ND	ND	ND	ND	ND
	0.01	ND	ND	ND	ND
	ND	ND	0.02	ND	ND
		Averages ($\bar{X}$)			
1.80	0.21	0.04	0.13	ND	ND

*Values below 0.01 mg/pad were below detection limits (ND).

Although wind speed was nearly negligible at the time of the spraying, some drift is indicated. The first three analyses listed in Table 2 at all distances were all lying to the leeward side of the helicopter. The last 3 analyses were on the windward side. Only two of the twelve samples taken beyond 320 feet of the spray path showed trace levels of 2,4,5-T. All other samples were below the 10-microgram detection level.

These data indicate that workers applying 2,4,5-T are receiving much less than the 20 mg/kg levels of 2,4,5-T reported to have caused fetotoxicity in mice (ROLL, 1971). This information in conjunction with the 2,4,5-T excretion studies (GEHRING et al., 1973) and a recent human exposure study conducted by LAVY in November, 1978, indicates that 2,4,5-T quantities received by applicators should be below any known possible health hazard levels.

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