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Exposure of Non-Applicator Personnel and Adjacent Areas to Aerially Applied Propanil

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Rice production in Arkansas has shown a steady increase in acreage since the early 1970's with over 600,000 hectares planted in 1981. It is estimated that over 30% of the rice grown in Arkansas receives multiple applications of herbicides, many of which are aerially applied. Propanil (Stam) is extensively used for postemergence control of grasses, especially barnyardgrass (Echinochloa crus-galli) and broadleaf weeds in rice (Smith 1961 and 1983). Propanil is used at a rate of 3.36 to 6.7 kg/ha. Its use increases both yield and quality (Bode et al. 1977 and Eastin 1979). An associated problem with the use of propanil is the drift into susceptible crops, such as soybeans and vegetables, and aerial applicators must exercise caution when applying this herbicide.

Propanil is classified in the amide family of herbicides. Laboratory experimentation with rats indicates oral LD_{50} of 2200 mg/kg, a dermal LD_{50} of 3500 mg/kg in rabbits and an LC_{50} of 4.8 mg/L/h was found with rats.[1] Propanil is not classified as a highly toxic pesticide.

The primary objectives of this study were (1) to measure the residual concentrations and phytotoxicity of the drift which occurs to fields adjacent to the sprayed area and (2) to estimate potential hazards that exposure to these concentrations would produce for spinner plates with a #10 orifice.

MATERIALS AND METHODS

The study was conducted in Dumas, Arkansas, on five rice fields ranging from 24.0 to 36.0 ha. Table 1 lists time, date, rate of applications, temperature, and wind speed and direction. The plane ordinarily flew perpendicular to the wind direction and the monitoring equipment was placed on the downwind side of the field.

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[1]Personal Communication with E. N. Irwin, Stam Research and Development Product Manager, Rohm & Haas, Independence Mall, Philadelphia, PA 19105.

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Airplane speed was approximately 160 to 168 kph at an altitude of 6.0 to 8.0 m above the field. The spray nozzles used were #46 humans near spray sites.

Table 1. Date and weather conditions at the time of propanil applications (1985).

Field #	Temp.	Propanil Application			Wind	
		Date	Time	Rate	Speed	Direction
	(°C)			(kg ai/ha)	(kph)	
1	24	5/13	6:00 am	4.5	9.6	S.E.
2	24	5/14	6:10 am	4.5	<3.2	S
3	18	5/15	6:30 am	4.5	11.2	W
4	28	5/15	7:30 pm	3.4	8.0	W
5	18	5/16	5:50 am	3.4	12.8	S

Denim-gauze patches and air monitors were used to measure the amount of potential dermal and inhalation exposure which could conceivably occur during and after aerial application. The denim gauze patches are comparable to a worker's trousers and were used to collect droplets of propanil and any airborne particles that would adhere to the material. The denim patches were 10 cm x 10 cm attached to a paper backing supported by a 60 cm x 60 cm pressed board. The air samplers were designed to collect only vapors or airborne particles. Air was sampled with Bendix (Baltimore, MD) model BDX 60, Dupont (Wilmington, DE) model 400 air monitor, and Dupont (Wilmington, DE) model Alpha 1 battery-operated pumps. A cartridge containing about 300 mg (primary) and 150 mg (breakthrough) of 20 to 60 mesh Amberlite® XAD-2 polystyrene resin (Rohm and Haas, Philadelphia, PA) was attached to each air sampler. Pump flow rates ranged from 2.6 to 6.0 L/min.

Plants sensitive to propanil were used to estimate injury to crops and home gardens. Sweetcorn (Zea mays var. Royal Gold), tomatoes (Lycopersicon esculentum var. Big Boy), and soybeans (Glycine max var. Jeff) were cultured to parallel the growth stages of plants grown in the area at the dates in which the study was conducted. Plants were grown outdoors in plastic pots, 10 cm in diameter and 10 cm in depth. They were transported to each application site, and after exposure to drift for 3 h, the plants were removed from the pots and transplanted into a centrally located untreated soil to grow. Plant heights were taken on each application date and 3 weeks thereafter.

The denim patches and air samplers were placed 10 m (-10 m) within the border of the field in which the herbicide was applied, and 10, 50, 100, 500, and 1000 m downwind from the application site (Figure 1). At each distance, three monitoring sites were

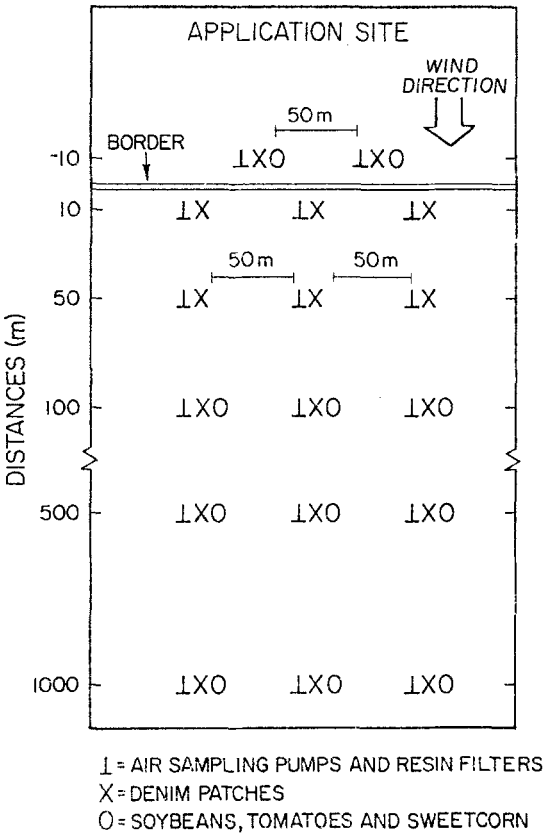

Figure 1. Sampling station arrangement at each application site.

established in a row parallel to the sprayed field. Within each row, the sites consisting of two denim patches and an air monitor, were set 50 m apart. Air monitoring for drift was conducted for 0 to 60 min at sites 10 m within the field and 10, 50, and 100 m from the field. After the first hour, the resins were changed and monitoring continued for the next 2 h, i.e., 60 to 180 min after application. Upon completion of monitoring, resins were removed, placed in airtight containers, and stored under cool conditions until analysis. Immediately prior to the aerial propanil application, the bioassay plants were placed at the application sites. At each site there were six soybeans, five sweetcorn, and two tomato plants of uniform size and height.

Propanil residues were extracted from the denim patches using 100 ml of an acetone:hexane (1:1) mixture. The patches and solvent were placed in plastic bottles and shaken for 15 min. A 3-ml aliquot was removed and evaporated to dryness under a stream of nitrogen. The resulting residue was redissolved in 3 ml of methanol. Extraction efficiency was found to be 98%. The samples were analyzed with a Waters Associates (Milford, MA) high performance liquid chromatographic system consisting of WISP® 710A auto-

sampler, a Radial-Pak® C_{18} cartridge contained in a RCM-100® radial compression module, a model 440 Data Module®, for recording and integrating. The mobile phase was 40% acetonitrile in water pumped at 2.0 ml/min. The injection volume was 25 ml, and the retention time was 16.2 min. The limit of detection was 0.003 ug/ml.

Propanil residues were extracted from the XAD-2 resins with 4 ml of an acetone:hexane (1:1) mixture. A 2-ml aliquot was evaporated to dryness under a stream of nitrogen and redissolved in 2 ml of 50% methanol/water. The 2-ml aliquot was then cleaned-up with a Baker-10™ Extraction System (J. T. Baker, Phillipsburg, NJ) with a 3-ml C_{18} disposable chromatographic column. The columns were conditioned by passing 2 ml of methanol through each, followed by 4 ml of 60% methanol/water. The 2-ml sample was then passed through, followed by 2 ml of 60% methanol/water; both fractions were discarded. Then 4 ml of 70% methanol/water was passed through the column and saved. The 4-ml fraction was evaporated to 3 ml under a stream of nitrogen and analyzed by the high performance liquid chromatography system previously described. Recovery of propanil residues including extraction from the resins and purification was 95%.

The data from the five individual fields were subjected to separate analysis of variance procedures because the variances were not homogeneous from field to field. Means were compared by LSD values computed at the 5% level of significance.

RESULTS AND DISCUSSION

Denim patch data from each field (Table 2) show that the highest concentrations of propanil were found in the field, i.e. at the

Table 2. Propanil concentration in denim patches after application in fields 1 through 5.

	Propanil measurement					
	Denim patches[a]					
	Sampling distance (m)					
Field	-10	10	50	100	500	1000
	(ug/100 cm^2)					
1	1333 a	374 b	102 c	46 cd	30 cd	26 d
2	532 a	0 b	0 b	0 b	0 b	0 b
3	5233 a	372 b	0 b	17 b	4 b	5 b
4	4895 a	1386 b	193 c	179 c	60 c	52 c
5	1864 a	849 b	67 c	29 c	0 c	0 c

[a]Means within rows followed by the same letter are not significantly different (P = 0.05).

-10 m distance; deposition on the patches decreased significantly from the -10 to 10 m. The variability in the concentrations of propanil detected on denim patches and in air sampling resins from field to field probably results from different herbicide rates used or to varied wind speeds or shifts during monitoring or result from flying patterns used by the individual aerial applicators. In fields 1, 4, and 5, deposition of propanil decreased significantly at the sites located -10 to 50 m. The data from fields 3, 4, and 5 show that the concentration of propanil on denim patches at 50 m and beyond remained insignificant at near 0. Propanil residues beyond -10 m in field 2 were no longer detectable. The air monitor data confirm those findings. Since wind direction did not shift during the monitoring period, the lack of residues at 10 m and beyond is attributed to low wind speeds. In field 5, changes in propanil concentration were not significantly different at any distance from -10 to 1000 m.

Data on air monitors from fields 1, 2, and 5 (Table 3) show that 0 to 1 h after application propanil concentration was not significantly decreased as distance increased from 10 to 500 m. In fields 2, 3, and 4, propanil residues were no longer detectable at 500 m and beyond. Propanil residues were no longer detectable in the resins 60 to 180 min after application at any given site.

Table 3. Propanil concentration in air sampling resins after application in fields 1 through 5.

	Propanil measurement					
	Air sampling resins[a]					
	Sampling distance (m)					
Field	-10	10	50	100	500	1000
	(ug/L/h)					
1	17.7 a	10.7 ab	21.7 a	21.2 a	10.2 ab	4.7 b
2	4.6 a	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b
3	1.6 a	1.5 a	0.0 b	0.0 b	0.0 b	0.0 b
4	2.2 a	2.2 a	1.2 ab	0.0 b	0.0 b	0.0 b
5	4.0 a	3.0 a	2 ab	1.0 a	0.0 a	0.0 a

[a]Means within rows followed by the same letter are not significantly different (P = 0.05).

The data from fields 1, 2, 3, and 5 show that growth of tomato, sweetcorn, and soybean plants that had been placed at -10 m growth was significantly reduced when compared to plants at other distances (Table 4). Three weeks after application heights of tomato and sweetcorn plants used in field 1 and 3 increased as distance increased from -10 to 100 m, but a significant decrease in phytotoxicity was not evident between 100 and 500 m. Heights of toma-

The amount of propanil drift decreased as distance from the field increased. Wind velocity appears to be important to propanil drift because at speeds of 2 mph or less, deposition on denim patches and air filters outside the field was not detectable. The concentration of propanil remaining suspended in the air was not detectable 60 min after application at wind speeds of 12.8 kph or less. Apparently, larger droplets remained suspended for shorter periods and were deposited in larger amounts near the treated site.

To estimate potential human hazards that may result from dermal or inhalation exposure, values from the five fields were averaged and compared to results obtained from animal feeding studies. The amount of propanil in the air and that deposited on denim patches at the 10-m collection sites were used for these estimations. These amounts were compared with LD_{50} and LC_{50} values in rat and rabbit studies, respectively. In order for a rat to receive an inhaled dose comparable to an LC_{50} of 4.8 mg/L/h, the rat would have to inhale more than 1,000,000 times as much propanil in an hour as was detected in the air while the herbicide was applied to an individual field. If we assume that a 150 lb man has 1620 cm^2 of non-covered dermal surface (Lavy et al. 1983) and that he receives exposure comparable to the deposition on the denim patches at 10 m, in order to attain an amount equivalent to the LD_{50} (dermal) of 3,500 mg/kg in rabbits, the patch concentration would need to be 24,000 times greater than was present in this study.

The results of this study show that non-applicator personnel are exposed to low concentrations of propanil during an aerial application of the herbicide to a single rice field. However, the concentrations detected were found to be injurious to crop plants at distances of up to 1000 m from the application site. Therefore, aerial applicators must exercise caution when applying propanil to rice fields in areas near other sensitive crops, such as tomatoes, sweetcorn, and soybean.

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Table 4. Tomato, sweetcorn, and soybean response to propanil drift.

Crop[a]	Field	Heights[b] 3 weeks after application Sampling distance (m) -10	100	500	1000	Control
		(cm)				
Tomato	1	16.2 a	25.3 b	28.4 bc	29.9 c	37.5 d
	2	24.4 a	27.6 a	28.4 a	27.4 a	37.5 b
	3	13.2 a	19.1 b	28.2 c	28.3 c	37.5 d
	4	15.5 a	26.0 a	27.5 a	26.2 a	37.5 b
	5	16.8 a	26.1 b	26.5 b	26.2 b	37.5 c
Sweetcorn	1	41.1 a	56.1 b	55.9 b	64.8 c	76.3 d
	2	36.1 a	62.2 b	63.6 b	64.3 b	76.3 c
	3	28.2 a	45.7 b	62.5 c	64.3 c	76.3 d
	4	49.0 a	60.6 a	58.8 a	57.4 a	76.3 b
	5	25.8 a	66.5 b	63.3 b	68.1 b	76.3 c
Soybeans	1	0.0 a	22.8 b	30.6 c	40.8 d	46.5 d
	2	7.8 a	43.8 b	43.3 b	45.0 b	46.5 b
	3	0.0 a	27.9 b	42.1 c	45.3 cd	46.5 d
	4	0.0 a	13.8 b	17.5 b	37.3 c	46.5 c
	5	0.0 a	29.8 b	31.7 b	37.6 c	46.5 d

[a]Data presented are means of two (tomato), five (sweetcorn), and six (soybeans) replications.
[b]Means within rows followed by the same letter are not significantly different (P = 0.05).

toes and sweetcorn placed at 100 and 500 m from fields 2, 4, and 5 were not significantly increased. In field 4, tomato and sweetcorn plant heights were not significantly increased as their distance from the application site during treatment increased. The data from fields 2 and 3 show that significant differences in height responses were no longer apparent after 500 m for any of the plants studied. An increase in the height of sweetcorn was noted between 500 and 1000 m in field 1, and a similar increase in the height of soybeans was observed in fields 1, 4, and 5. Height response of soybeans that had been placed between 100 and 500 m in fields 2, 4, and 5 was not significantly affected.

Soybean plants were found to be the least tolerant to propanil drift, followed by tomato and sweetcorn, respectively. In general, phytotoxicity decreased as distance from the field increased but recovery from injury by treated plants, as compared to controls, was reduced at all distances. These data indicate that at wind speeds of 12.8 kph, some injury may occur to susceptible crops at distances up to 1000 m from the application site.

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