ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ENFORCEMENT

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Pesticide Use Observations In Kent County, Delaware June 2-7, 1976

ENFORCEMENT INVESTIGATIONS CENTER
DENVER, COLORADO

OCTOBER 1976

Environmental Protection Agency
Office of Enforcement

PESTICIDE USE OBSERVATIONS
IN
KENT COUNTY, DELAWARE

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National Enforcement Investigations Center
Denver, Colorado

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I. INTRODUCTION

The Environmental Protection Agency (EPA) is involved in the development and implementation of a national pesticdes use observation program. The initial site selected for study was in the northeastern United States (EPA Region III), a potato field near Magnolia, Delaware. The study site consisted of 16 hectares (39.6 acres) bordered by soybeans, barley, woodlands and human habitations. Scientists from the National Enforcement Investigations Center (NEIC) conducted on-site audits of pre-application, application, and post-application operations. The audits were conducted with the following objectives:

1. Thoroughly investigate storage, handling, application and disposal of pesticides by observing operations on a typical Delaware potato-producing farm.

2. Assess methods and transfer technology and establish criteria needed to scientifically document environmental hazards associated with the use of pesticides.

3. Determine the most appropriate type of Agency action which should be initiated to minimize risks to human health and the environment.

A six-day pesticide observation study began June 2, 1976 and the potato field pesticide application began on June 4, 1976. The study included sampling of air, water, sediment, soil and biota, which were analyzed in the event of a major misuse condition. A dye tracer technique along with spray droplet impaction devices were used to determine the drift characteristics of the aerially applied pesticide. In addition, observations were conducted on-site to determine if the pesticide users read and understood the labels on the products; followed the directions and precautions on the label; properly cleaned the application and protective equipment and maintained it in good working order; properly stored pesticides; and properly disposed of excess pesticides and containers so as to create minimal impact on the environment.

II. SUMMARY AND CONCLUSIONS

In June 1976, University of Delaware entomologists recommended aerial application of Dithane (M-45®)* to prevent blight, and Guthion 2-S** to control a Colorado potato beetle infestation in a potato field in Kent County, Delaware.

A field investigation was conducted June 2-7, 1976 to evaluate the operations and methods of an aerial applicator prior to, during, and after treatment of a Delaware potato field with guthion and dithane for control of the Colorado potato beetle and prevention of blight, respectively.

GENERAL CONCLUSIONS

1. The use observation study in Delaware revealed exemplary pesticide storage and application practices. It also revealed operational deficiencies during the handling and disposal of pesticides.

2. Of the twelve sampling and observational techniques used to document environmental effects caused by pesticide use, the most valuable were: on-site observations by trained observers, tracer dye studies, and droplet-size characterization.

3. Study results indicated an immediate need for the EPA and State officials to:

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* *Rohm and Haas, EPA Reg. No. 707-78-AA.*
** *Chemagro, EPA Reg. No. 3125-123-ZA.*

(a) enforce the use of protective equipment and apparel during all pesticide handling and use operations, and

(b) establish environmentally safe dump sites designed for the proper disposal of highly toxic compounds and used chemical containers.

SPECIFIC CONCLUSIONS

1. An observation tour of the applicator's premises showed that pesticides were properly and securely stored and spraying equipment was in excellent maintenance.

2. During pre-application pesticide handling activities, a human health hazard was observed because safety apparel was not worn by all personnel. Specifically, non-Company personnel were allowed in the mixing area without protective clothing.

3. Weather instruments were not available to assist the applicator in determining local micrometeorological conditions before insecticide application. Ideally, wind speed and direction and temperature should be measured near the target field. However, this may create certain logistical problems for the applicator.

4. Observations and dye tracer studies conducted by the EPA during the aerial applications indicated that no pesticide misuse or environmental harm occurred. Pesticide drift off the target field was the result of occasional overspraying and atmospheric transport of minute spray particles. Dye tracer studies indicated that most of the drifting spray settled within 40 feet on adjacent fields.

5. Good weather conditions, the use of relatively large spray droplets (up to 335 μm), and excellent pilot judgment during the aerial application were major factors in minimizing pesticide drift.

6. Although the applicator followed all precautions for the proper disposal of used pesticide containers, accumulations of used containers were observed on the study farm. This haphazard disposal practice by unknown persons constituted a hazard to environmental quality and human health. Furthermore, such disposal is a violation of EPA Regulations (Federal Register Vol. 39, No. 85, May 1, 1974), a condition augmented by the fact that the State of Delaware has no Class I dump sites.

7. Personnel monitors and Greenburg-Smith impinger devices were used to semi-quantitatively monitor the atmospheric transport of guthion. Their value in documenting specific amounts of airborne pesticides was limited because of variable temperatures, vapor pressures, pesticide concentrations, air movements, and other factors which may have caused erratic trapping efficiency in these sampling devices.

8. A fluorescent dye was added to the guthion and dithane mixture in an attempt to determine pesticide drift patterns. Greenburg-Smith impingers, high-volume air samplers, and mylar sheets were used to collect air samples. Fluorescent analysis of the collected samples showed the dye concentrations used were often undetectable because of trapping inefficiency in the impingers or excess dirt (dust) in the impactors. The mylar sheet technique was successful in collecting measurable amounts of dye used to trace the pesticide drift.

9. Tracing pesticide drift patterns by visible spot deposits on oil-sensitive photographic papers (Kromecote cards) placed in and around the potato field was unsuccessful. Subsequent evaluation of

this technique indicated two possible reasons for the lack of success: (1) cards were underexposed to ultraviolet light, thus preventing development of the visible spots, and (2) spray droplets contained insufficient oil-based ingredients to chemically react with the photographic paper.

10. Drift patterns were documented by examining particles impinged upon glass slides coated with magnesium oxide. Droplet sizes, derived from microscopic examination of the slides, ranged from 126 to 289 μm for a drift potential of 5 to 11.5 meters. Although complete drift control is not achievable, it is concluded that the D7-45 nozzle used would produce droplets greater than approximately 125 μm and minimize potential drift.

11. Efficacy of the guthion treatment, 88.5% as determined by the average kill, was considered to be about the average for the geographic area studied.

III. DESCRIPTION OF STUDY AREA

Field studies were conducted on a potato-producing farm near Magnolia, Delaware. The cooperating farmer was engaged in general farming practices with principal crops being potatoes and soybeans.

The study site was a 34.6 hectare (85.5 acre) field in which 16 hectares (39.6 acres) were planted in potatoes and the remaining acreage in soybeans. Private residences, county roads, an unoccupied migrant labor camp, a commercial chicken farm, grainfields, woodlands and a small unnamed creek bordered the study site [Fig. 1].

Twenty-three sampling stations were established for the study: nine stations on the potato field; twelve stations off the field and two stations in the creek. Samples of air were collected from the potato field and surrounding land for pesticide drift analyses. Additionally, water and sediment were collected from the two creek stations for pesticide residue analyses.

The pesticide was applied by a local aerial applicator. The flying service facility, about a half mile east of the study farm [Fig. 1], included a warehouse for pesticide storage, a mixing and loading area, an aircraft maintenance area and hangar space for three Grumman Ag-Cat aircraft. Immediately behind the warehouse was a fenced enclosure where used pesticide containers were stored. Corporate offices were located near the hangar.

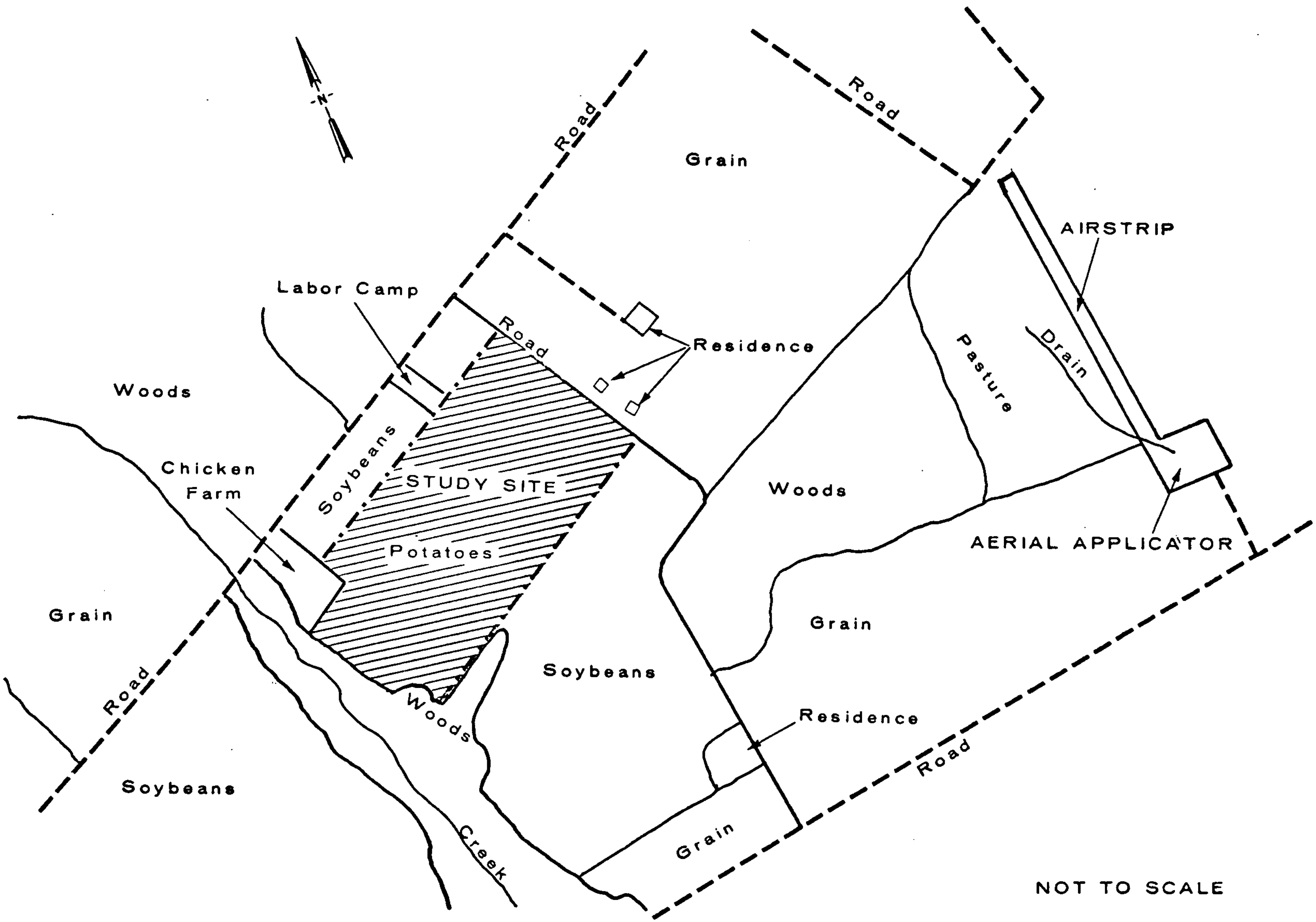

Figure 1. Location of Potato Field Study Site, Kent County, Delaware

IV. USE OBSERVATIONS

PRE-APPLICATION

Insect Infestation Assessment

Prior to pesticide treatment of a crop it is necessary to: (1) identify the pest or disease, (2) determine the extent of the infestation, and (3) select the appropriate control methods or materials.

On June 1, 1976, University of Delaware entomologists examined the potato field. In their survey, a random sampling of four areas within the field, they walked fifty paces along a plant row into the field, made insect counts on 10 plants, then walked across 12 to 13 rows and counted insects on an additional 10 plants. Finally, they walked back to the field border and made insect counts on 10 plants at the edge of the field.

Results revealed large numbers of Colorado potato beetles (*Leptinotarsa decimlineata* [Say]). The insect counts averaged from 2.1 to 22.8 beetles per potato plant. According to the University of Delaware entomologists this exceeded the population density of two insects per linear foot of each planted row, which constitutes a serious infestation. As a result, chemical control using a mixture of Guthion 2-S and Dithane (M-45) was recommended. The guthion, a non-systemic organophosphate insecticide, was predicted to kill 80 to 90% of the potato beetles. The dithane, a fungicide, was recommended to prevent the development of potato blight.

Aerial Applicator - Preparation and Evaluation

Prior to the June 4, 1976 application of guthion and dithane to the study site, NEIC and Region III personnel observed the operational procedure of the aerial applicator in preparing the pesticide material.

Standard procedure consisted of pre-mixing the pesticides with water prior to loading them into the aircraft. Pre-mixing was accomplished by use of a specially designed 1,135.5-liter (300-gallon) circular fiberglass tank, with a built-in agitation system. Other features included a bottom draw device with the necessary pumps and hoses for filling the aircraft, a quick disconnect or shut-off system for the hose, and exterior markings which graduated the tank into 19-liter (5-gallon) segments [Fig. 2].

Mixing the material used in this study consisted of putting about 75 liters (20 gallons) of water in the tank and starting the agitator. After about five minutes, a pre-weighed amount (27 kg) of 80% dithane and additional water were added to the tank. From rubber buckets, containing 38 liters (10 gallons) of 22% guthion were added to the tank and the mixture was diluted with water. Then, empty dithane bags, guthion cans and the rubber buckets were triple rinsed, and the rinse water was added to the tank. At this time, the Rhodamine WT dye used for tracer studies was added.

The material was agitated for 15 minutes before pumping it into the aircraft. After the tank was drained, an additional 75 liters (20 gallons) of water was added, agitated for five minutes (to wash the tank of guthion and dithane residues) and pumped into the aircraft. The final volume was 908 liters (240 gallons) of diluted material.

This mixture provided for an application rate of 22.7 liters/hectare (6 gallons/acre), with an actual active ingredient of 0.47 liter (1 pint) of guthion and 0.54 kg (1.2 lb) of dithane per acre as specified on the product labels.

Figure 2. Mixing pesticide materials prior to application.

Company policy of the aerial applicator dictated that employees involved in the mixing and loading operations wear safety clothing consisting of hats, rubber aprons, trousers, boots, gloves, goggles and canister-type respirators. The mode of dress worn by EPA personnel is shown in Figure 3. Aircraft pilots were not permitted to participate in the loading and mixing operation. Company employees did not have routine acetylcholin-esterase (AChE) evaluations, which would demonstrate damage to nervous functions induced by organo-phosphate, pesticide exposure. In view of the fact that many compounds used by this applicator are AChE-inhibiting agents, such medical checks should be routinely performed.

While not directly related to the mixing operation, observations were made of the pesticide storage area. Pesticide materials were arranged according to basic types of compounds (herbicides, insecticides, etc.) and further segregated into specific types and brands. Bags, cans and drums were properly organized, with well-defined passageways available to provide adequate working space.

The warehouse was kept under security conditions. All doors were plaingly marked to indicate the contents, with abundant signs for "No Smoking" and "Authorized Personnel Only." The applicator indicated he was making every effort to comply with all pertinent Operational Safety and Health Administration (OSHA) requirements.

During the pre-application phase, only one area of concern was noted: the applicator allowed non-Company individuals without safety gear to be present during mixing operations. While not in violation of EPA regulations, this practice can lead to exposure of these individuals to toxic materials.

Prior to pesticide application, water and sediment samples were collected from two stations in the creek [Fig. 4], while samples of the undiluted and diluted pesticides were obtained during the mixing operation.

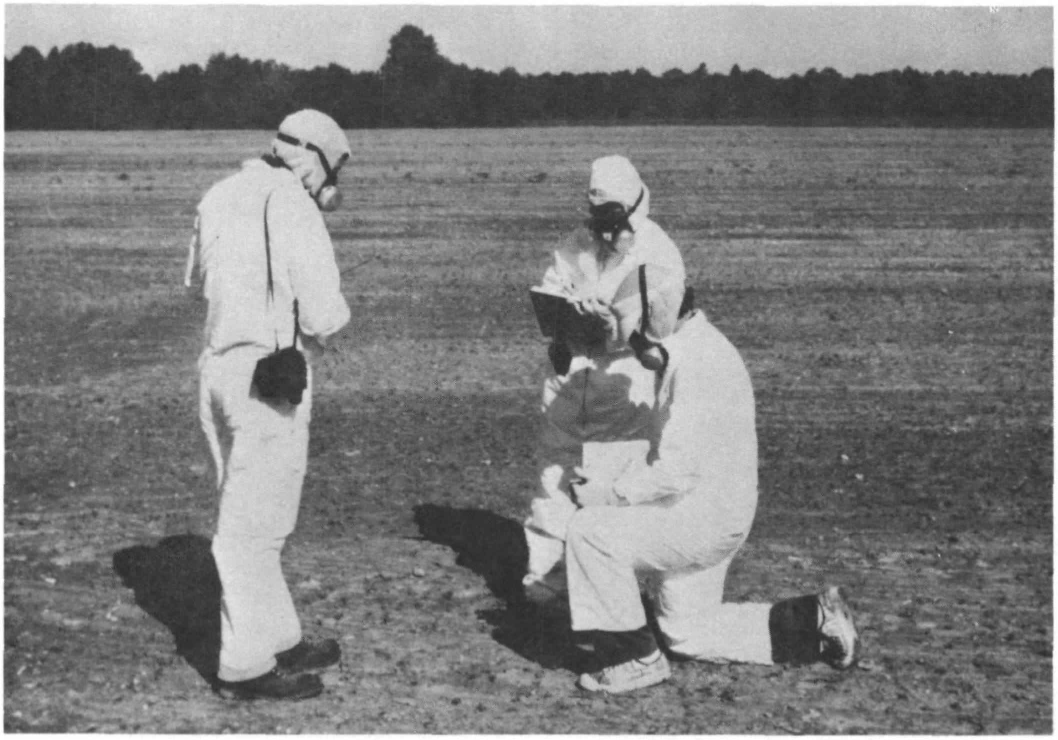

Figure 3. Safety clothing worn by EPA personnel (foot and lower leg covering not shown).

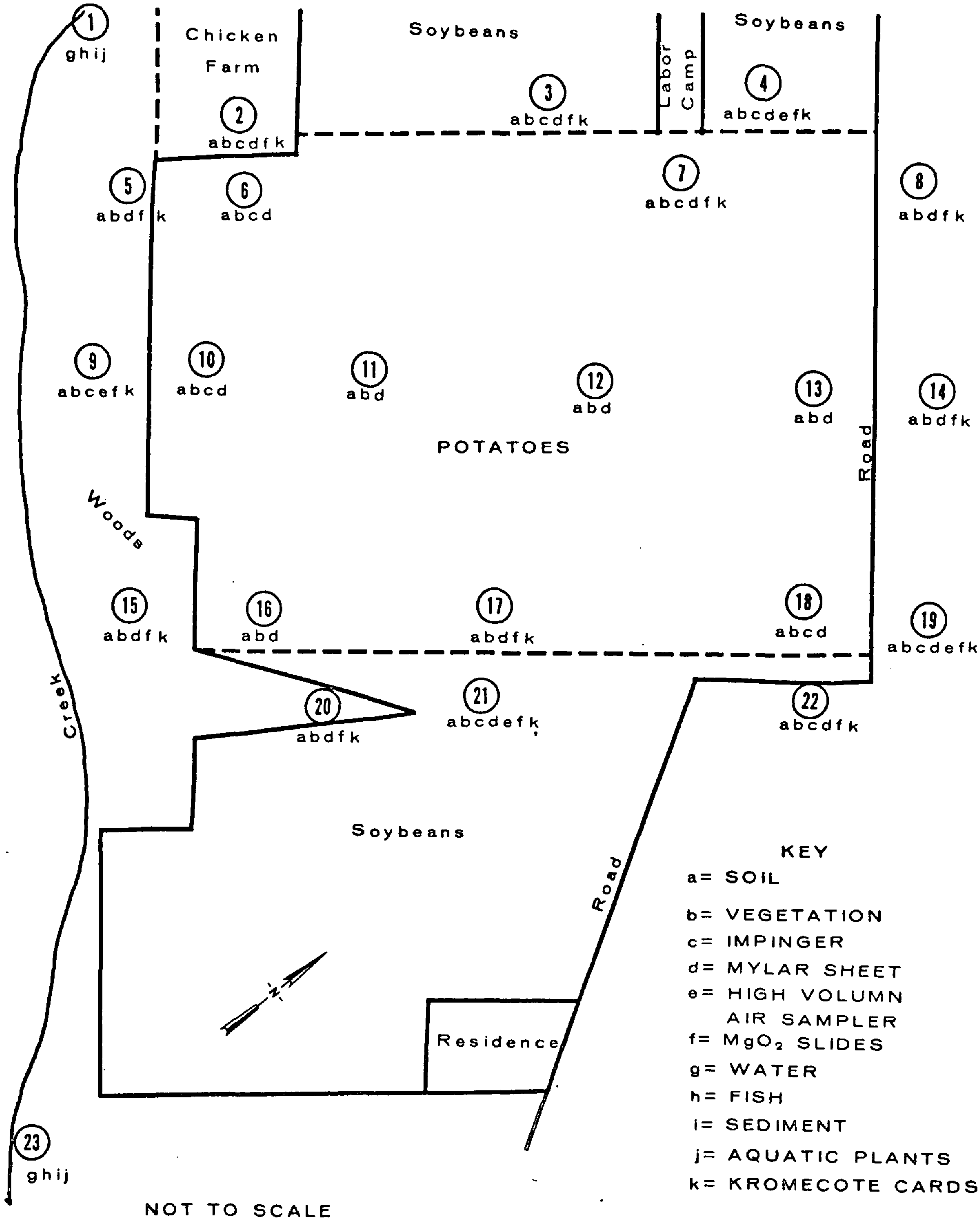

Figure 4. Sampling Locations, Delaware Potato Field, Kent County, Delaware

To evaluate spray drift characteristics, five types of sampling gear were placed in and around the field: a device using the Greenburg-Smith impinger system [Fig. 5]; a high-volume air sampler [Fig. 6]; mylar sheets, Kromecote cards and glass slides coated with magnesium oxide [Fig. 7]. Additionally, each member of the EPA team carried a small, portable, monitoring device designed to determine personal exposure to airborne pesticides. Each system is described in detail in the Appendix.

Impinger units were placed at four stations on the field and seven stations off the field [Fig. 4]. High-volume air samplers shared four of the off-field locations. Tracer dye sheets of mylar were placed at all stations except 1, 9 and 23. Magnesium oxide slides and Kromecote cards were placed at 15 stations.

Station selection for assessing spray drift characteristics was governed by prevailing wind direction and adequate coverage in the event of variable wind direction.

APPLICATION

Observations

Chemical treatment of the study field occurred during the early morning hours on June 4 and 5, 1976. The second day of spraying was required when the wind velocity of June 4 increased to unacceptable velocities and the pilot discontinued spraying.

Weather conditions were recorded 7.2 kilometers (4.5 miles) from the study site at Dover Air Force Base. At 6:54 a.m. (EDT) on June 4 the report was: scattered clouds at 7,010 meters (23,000 feet), air temperature of 13.4°C, dew point 10.5°C, winds at 12.9 km/hr (8 mph) from the NNE, barometric pressure 30.23 mm Hg, and a relative humidity of 83%.

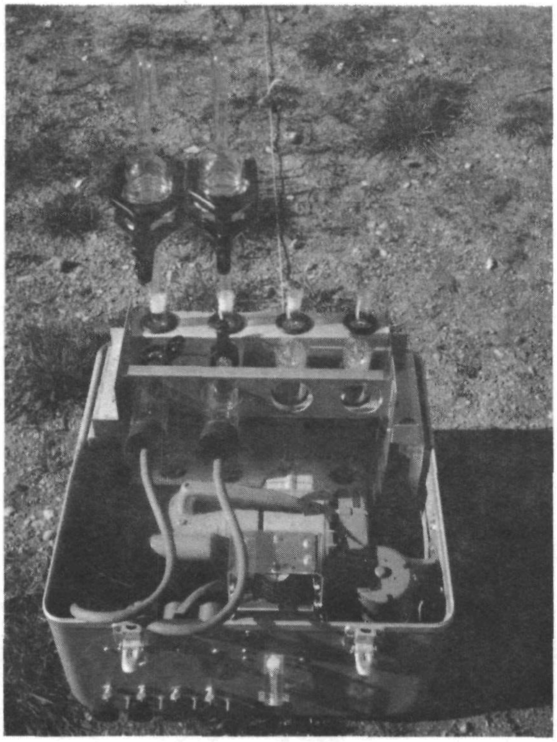

Figure 5. Air sampling device using Greenburg-Smith impinger system.

Figure 6. High-volume air sampling device.

Figure 7. To evaluate spray drift characteristics, a Kromecote card is surrounded by magnesium oxide slides and a mylar sheet is placed on the ground.

An aircraft equipped with a 36-nozzle spray boom was used to apply the guthion and dithane mixture on the potato field [Fig. 8]. The cone-type spray nozzles (D7-45; i.e. 7/64-inch orifice diameter and a number 45 whirl-plate) were directed with the air stream. Boom pressure was set at 4.2 kg/cm^2 (60 psi). To treat the 16 hectare (39.6 acre) field, a total of 908 liters (240 gallons) of the pesticide mixture was pumped into the spray tank of the aircraft.

Aerial spraying began at 6:45 a.m. (EDT) on June 4, 1976. The aircraft approached the south edge of the potato field and the pilot leveled the aircraft so the spray boom height was approximately 2.4 meters (8 feet) above the field. Passes were made in a west-to-east and east-to-west direction, parallel to the potato rows. At the completion of each pass, a tissue paper streamer was released from the aircraft to visually mark the swath completed. This marker was used by the pilot as a reference point for the beginning of the next pass [Fig. 9]. During each pass, pesticide in a swath about 12 meters (40 feet) wide was sprayed over the potato crop.

The wind velocity noticeably increased about 7 a.m., at which time the pilot lowered his flight path to a boom height of about 2 meters (6 feet) above the ground to minimize spray drift. Later, during an interview with the pilot, the EPA observers learned that the pilot lowered his flight path in order to spray as much of the field as possible, with minimum spray drift, before weather conditions forced the aerial application to be discontinued.

Spraying continued at the 2-meter boom height until 7:05 a.m. when increasing wind velocities required cessation of operations. Approximately two-thirds of the field had been treated during the 18 passes made before the spraying oepration was discontinued.

The application was evaluated by 2-man teams of EPA observers. The teams were situated at the corners of the potato field. Each member

Figure 8. A Grumman Ag-Cat airplane applying pesticides at low level for the control of Colorado potato beetles.

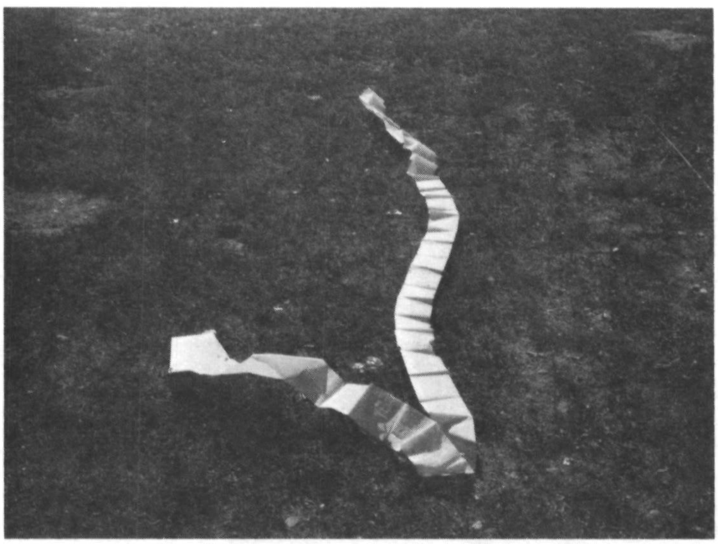

Figure 9. Streamer used to mark the completion of one spray pass and the initiation of another.

used an observation checklist to record the spraying activities. Two teams were equipped with telephoto cameras. Photographs were taken for subsequent analyses and verificaiton of aircraft flight patterns and a record of visible spray cloud patterns [Fig. 10].

During this operation three instances of visible drift were observed by the EPA teams. The first drift was recorded while an east-to-west pass was flown between stations 10 and 16 [Fig. 4]. The drift cloud was observed passing into the woods. Observers reported this occurred when the aircraft was rotated upward at a severe angle to miss the trees. The second drift occurred at the north end of the field, again as the aircraft rotated upward at the completion of a pass. A light mist drifted 3 to 4.5 meters into an adjacent soybean field. The third off-field drift pattern was at the southeast corner of the field. As the aircraft swerved to miss a power pole, a light drift cloud crossed the roadway.

The following day at 6:14 a.m. (EDT) the aerial applicator resumed spraying the potato field. Weather conditions recorded at the Dover Air Force Base at 5:55 a.m. (EDT) on June 5 were: clear sky, 16 km (10 mi) visibility, air temperature 11.6°C, dew point 7.2°C, wind from the N at 8 km/hr (5 mph), barometric pressure 30.34 mm Hg, and a relative humidity of 74%.

Spray passes were made north-to-south and south-to-north. No visible drift off the field was observed during the eleven passes made to treat and trim the remaining two-thirds of the potato field.

Evaluations

Observations by EPA of the 2-day application led to the following conclusions: pesticides released during aerial application were subject

Figure 10. Aerial pesticide application at the 2.5 meter flight level showing the aircraft wingtip vortices.

to drift from the potato field as a direct result of aircraft turbulence (wingtip vortices) and aerial transport by atmospheric movement. Meteorological conditions which most affect drift are wind direction and velocity, turbulence, relative humidity, air temperature, and atmospheric stability. Additionally, the size and nature of spray droplets are directly related to drift potential. Each of these factors is examined below.

Wind Direction and Velocity

The direction the wind is blowing determines the direction of drift. Wind speed varies as atmospheric stability conditions change, thus causing the lateral movement of spray particles in the air.[1] In these studies the low average wind speeds were important in minimizing drift; however, when the wind speed increased to 12.9 km/hr the morning of June 4, the potential for drift increased.

Turbulence

Turbulence is a series of horizontal and vertical gusts and lulls, and random eddy movements of the air. It is dependent upon ground roughness, mean wind speed, thermal stability of the air, and aircraft movement.[1] Turbulence is considered one of the most important factors affecting drift. Airborne pesticide droplets are reported to be transported the greatest distances by the combined forces of gravity, wind speed, and turbulence.

Relative Humidity and Air Temperatures

Relative humidity from 74 to 83% combined with moderate air temperatures of 11.6 to 13.4°C were measured during the application. These combined factors would reduce the evaporation rates of the water-based pesticide droplets and the drift potential.[1] The average volume median diameter (VMD)* of the droplets sprayed on the potato field was 148.2 μm. (Drift potential for these droplets will be discussed under *Spray Droplet Characteristics*.)

Atmospheric Stability

The morning of June 4, the atmospheric stability** was calculated to be 0.19 (based on data obtained from the Dover Air Force weather station). In character the conditions were variable. Initially, winds were of low velocity, and velocity gradients and vertical turbulence would have been minimized.[1] During the spraying, the atmospheric stability changed to a a lapse or unstable condition. Wind speed increased and the spraying operation was discontinued.

On June 5, the atmospheric conditions were reported by the Dover Air Force Base weather bureau to be stable. Atmospheric stability was calculated to be 0.82. This condition was characterized by low wind speed, minor changes in the velocity gradient, and mild vertical turbulence. Spray drift would be minimized by these favorable weather conditions.

Spray Droplet Characteristics

Of greatest importance to controlling drift are the size and nature of the spray droplet.[1] The principal factor affecting drift appears to be the number of drops smaller than 125 μm (micrometers). If droplets were restricted to 125 μm or larger, pesticide applications would be effective and drift would be minimized. On-site observations and sampling

* *VMD is that volume which divides the droplet diameter into two equal parts, one-half above and one-half below the median or 50% cumulative point.*

** *Stability is mathematically given as:* very stable *>1.2,* stable *0.1 to 1.2,* neutral *-0.1 to 0.1 and* unstable *less than -0.1.*

revealed that the water-base spray evaporated rapidly, usually within an hour. Small particles of the spray, consisting of active chemical plus solvents, emulsifiers and carriers, drifted downwind. The drops below 50 μm could have been carried for many miles, especially on June 4 when the brisk air currents began. This was prevented, however, when the pilot postponed the remainder of the spraying until the next morning.

Because both days of spraying were conducted during good meteorological conditions, the drifting spray cloud did not appear to dilute vertically. It remained low and close to the ground, permitting slowly settling drops to concentrate on the potato crop.

The aircraft's cone-type nozzles (D7-45) produced a medium-to-coarse spray. The VMD of the droplets produced ranged from 300 to 400 μm. With drops this size, an estimated 70 to 90% of the pesticide mixture should settle to the ground within a distance of 378 meters downwind.[1] Therefore, 10 to 30% of the chemical applied to the downwind edge of the field theoretically would not deposit within the field, but would move to nearby fields and to greater distances even under ideal meteorological conditions. Data generated by this study indicate that only minor drift passed beyond the field borders.

From this pesticide use observation study and an associated literature search, it has become evident that complete drift control (no loss beyond treated field) cannot be achieved with any device, additive or system commercially available. However, drift can be minimized by using coarse sprays. When a fixed wing aircraft uses large orifices, and whirl plate cone nozzles which are directed with the airstream, coarse sprays can be achieved. Apparently, maintaining the pesticide application volume at a minimum of 9.2 liters/hectare (6 gallons/acre) will also reduce drift.

Weather conditions must be considered during spraying operations when no wind is blowing or when an inversion occurs close to the ground. Drift is minimized when coarse sprays are applied under mildly ventilating conditions; calm inversion-type weather will lead to increased drift.[1]

POST-APPLICATION

Aerial Applicator - Clean-up and Disposal

Procedures for the clean-up of used containers, as practiced by the applicator, followed closely the recommended EPA guidelines: all containers (bags, cans, drums, etc.) were triple-rinsed (with the rinse water being added to the spray material), punctured, and stored in a fenced, security area near the warehouse.

Used containers are temporarily stored on-site. When a sufficient number of containers has been collected to justify the cost, they are hauled to a local landfill site to be buried. Unused, undiluted material (e.g., a partially used 5-gallon can of an insecticide) frequently is recapped and returned to the warehouse for future use.

Disposal of containers and unused, undiluted and diluted pesticides poses a problem in Delaware. The State does not have a dump site especially designed for the disposal of highly toxic or environmentally damaging compounds or containers, referred to as a Class I dump site by other States. It is recommended that such a site be established.

Container disposal presented a problem for both the applicator and the cooperating farmer. Numerous empty pesticide containers (cans, drums and bags) were observed to have been previously disposed of in an open dump along the creek near the potato field study site [Fig. 11].

Storage and disposal of diluted material by the applicator also presented a problem. Since weather conditions prevented spraying the study field in a single day, the applicator returned to the airstrip with about 378 liters (100 gallons) of material still aboard. To prevent the mix from settling and possibly clogging the spray nozzles, the material was pumped from the aircraft back into the mixing tank for storage. The following day the mixture was reintroduced into the aircraft

Figure 11. Used pesticide containers found at uncontrolled dump site on study farm.

to finish spraying. However, problems arise when conditions prevent complete use of the diluted material and the mixing tank is needed to prepare a different compound.

Pesticide residue in the aircraft spray tank posed another disposal problem. About 19 liters of material remained in the spray tank, booms and nozzles. The applicator drained as much as possible from the plane and added about 76 liters of water to the spray tank, turned on the spray system, with only enough pressure to force the water through the booms and nozzles, and allowed this water to flush and clean the system. The water flowed into a grate-covered drain at the loading area which extends about 91 meters into an unused pasture [Fig. 1], terminating in a specially prepared limestone-filled leach field. Another technique occasionally used by the applicator is to put 76 to 95 liters of water in the tank and spray this solution over the field treated with the parent mix. However, distance from the airstrip to the field, costs and time, as well as the possibility of exceeding the recommended treatment level, often prevents the use of this technique.

EPA Post-Application Sampling

Post-application sampling consisted of obtaining additional soil and vegetation samples from 21 stations in and around the study field [Fig. 4], along with additional samples of fish, water, sediment and aquatic vegetation from the stations in the creek. These samples were collected for analyses in the event of an accident, spill, or major drift losses from the field. Also, at this time, the sampling systems used to evaluate drift characteristics were removed from their field locations.

Analyses of drift deposits are presented in Table 1, for water and sediment samples from the creek, and for air samples collected in the

Table 1

IMPINGER, PERSONNEL MONITOR, WATER AND SEDIMENT ANALYTICAL DATA (GUTHION)
June 1976

Station	Sample Type	Concentration µg
23	Water	15 µg/l
23	Sediment	N.D.†
	Ethylene glycol (impinger)	µg/ml
2		1.2
3		1.7
4		1.5
6		2.1
7		2.3
9		1.5
10		3.7
18		1.1
19		2.3
21		1.9
22		1.3
Tube No.	Charcoal tube (Personnel monitor)	µg
1		F†† <1
		B††† <1
2		F <1
		B <1
3		F 1.0
		B 2.0
7		F <1.0
		B <1.0
11		F <1.0
		B 1.0
12		F <1.0
		B <1.0
15		F <1.0
		B <1.0
16		F <1.0
		B 1.4
17		F <1.0
		B <1.0
18		F <1.0
		B 2.0

† *N.D. = Not detected*
†† *Front section*
††† *Back section*

impinger system and the personnel monitors. Table 2 presents data on the magnesium oxide slides, with Table 3 showing results obtained with mylar sheets and the high-volume air sampler.

No guthion was found in water or sediment samples from the creek, indicating that no drift had penetrated the woods that deeply. At on-field locations the impinger system collected a range of 1.1 μg guthion/ml of ethylene glycol at Station 18 to 3.7 μg guthion/ml of ethylene glycol at Station 10. Off-field locations were generally lower, with 1.2 μg guthion/ml of ethylene glycol at Station 2 and ranged upward to 2.3 μg guthion/ml of ethylene glycol at Station 19. The off-field values are due primarily to overspray and turbulence. Minor amounts of drift were observed also.

Personnel monitors worn by the EPA team collected a maximum of 2 μg of guthion and ranged downward to <1 μg (minimum detection limits). Highest concentrations were found in the monitors worn by the EPA Consumer Safety Officer during the mixing operations and by a team member retrieving sampling equipment from the field two to three hours after spraying. Other detectable values, 1.0 μg and 1.4 μg of guthion, were recorded eight hours after treatment, again by EPA personnel who entered the treated field. All EPA personnel who entered the study site during the first 24 hours after treatment wore complete safety gear, consisting of hats, respirators, rubber gloves, long-sleeved coveralls and plastic foot coverings. Label requirements for guthion prohibit re-entry within 24 hours without safety clothing.

To evaluate drift characteristics, a Rhodamine WT dye solution was added to the guthion and dithane mix to provide a final dye concentration of 100 μg/l. Three types of equipment were used to monitor the dye, the Greenburg-Smith impinger systems, a high-volume air sampler, and mylar sheets. The dye was used in a qualitative manner, the interest being only in the presence or absence of the dye. The numbers used have no absolute meaning; the differences between numbers are indicative of greater or lesser amounts of dye at one location as compared to another.

Table 2

RESULTS OF MAGNESIUM OXIDE SLIDES
Kent County, Delaware
June 1976

Station	VMD[†] µm	Calculated Drift Distance[††] m
2	159	7
3	No drops present	
4	98	23
5	103	15.5
7	126	11.5
8	No drops present	
9	61	43
14	24	305
15	335	4
17	289	5
19	No drops present	
20	115	12
21	172	6
22	No drops present	

† *VMD = volume median diameter: that value which divides the droplet diameter into two equal parts, one-half above and one-half below the median or 50% cumulative point.*

†† *Rumker, et al., 1975 (Ref. 1)*

Table 3

DYE ANALYSIS OF MYLAR SHEETS AND CASCADE IMPACTORS
Kent County, Delaware
June 1976

Station	Type	Value† Fluorescent Units
	Mylar Sheet	
2		14.5
3		17.0
4		14.5
5		17.5
6		23.5
7		17.5
8		14.0
10		72.5
11		20.5
12		18.0
13		48.5
14		19.0
15		33.0
16		48.5
17		32.5
18		14.0
19		18.0
20		16.0
21		15.0
22		30.0
4	High-volume air sampler	68.0
9		80.5
19		59.5
21		56.5

† *These values have no absolute meaning, only the differences between numbers are indicative of greater or lesser amounts of dye at one location as compared to another location.*

The Greenburg-Smith impingers collected generally higher dye concentrations at the north end of the field than at the south end. Values at Stations 2, 3 and 4 were 28.5, 35.0 and 51.0 fluorescent units, respectively; Stations 19, 21 and 22 had values of 20.0, 26.5 and 39.0 units, respectively. These differences were due primarily to sampler placement about the field and reflect the effect of turbulence more than drift.

The high-volume air sampler proved to be of little value in evaluating drift of dye, primarily because the instrument is designed to collect particulate matter (dust, etc.). During this study, the volume of dust collected masked the identification of the dye residue.

Mylar sheets, placed horizontally on the ground, showed minimal drift off the field except at two locations [Table 3]. Station 15 had a high value (33.0 fluorescent units) because the aircraft spraying system was not turned off quickly enough at the completion of the pass and the material drifted into the woods. The higher value at Station 22 (30.0 units) occurred during the field trimming operation and resulted when the aircraft pulled up at the completion of the pass and the spray cloud, released at a slightly higher elevation, drifted off the field.

To fully evaluate the drift characteristics in the spray discharge of the aircraft, it was necessary to sample the airborne drops. Two sampling devices were used: magnesium oxide (MgO) coated microscope slides and Kromecote cards.

Four slides, held in vertical positions and facing the four cardinal directions [Fig. 7], were placed at ~~13~~ 14 stations around the field. The airborne drops impinged on the MgO coating, leaving a crater after evaporation of the liquid. In this study, the method devised by Rathburn[2] was used to calculate droplet diameters and the volume mean diameter. These values also served to determine the theoretical distance that spray droplets measured in this study would drift.[1]

Ten of the fifteen MgO slide sites had positive hits by spray drops [Table 2]. The largest drop sizes occurred on the field, with Station 17 showing a VMD of 289 μm. The smallest drops were recorded at Station 14. For undetermined reasons, the average VMD of the south end of the field was about 2.3 times that of the north end. The droplets on the field traveled from 5 meters (VMD of 289 μm at Station 17) to 11.5 meters (VMD of 126 μm at Station 7). The smaller droplets falling off-field (VMD of 24 μm at Station 14) were estimated to drift a maximum distance of 305 meters.

These values indicated the nozzles of the applicator's aircraft were of sufficient size (D7-45 nozzles with 7/64-inch orifices) to prevent major drift, when combined with the weather conditions and flight characteristics described in this report.

Kromecote cards were placed at all stations, except 1 and 23, with the intent of catching and retaining spray droplets for later measurement. However, no drops were observed on the cards after the completion of spraying operations. Subsequent evaluation indicated two probable reasons for the lack of success: (1) the cards were underexposed to ultraviolet light, preventing development of the visible spots, and (2) spray droplets contained too little oil-based active ingredients to chemically react with the photographic paper.

Pesticide Efficacy

To determine the efficacy of the guthion treatment, the field was inspected three days after treatment by a University of Delaware Extension Service entomologist. The following tabulation of insect counts from four randomly selected sites illustrates the results.

June 1, 1976 Pre-application	June 8, 1976 Post-application	Kill %
21	2	91
49	0	100
182	36	81
228	43	82

The average kill was 88.5%, considered by the entomologist to be about average in that geographic area.

No data were collected on the efficacy of the dithane treatment.

EVALUATION OF OBSERVATION METHODS

An objective of this study was to assess methods to scientifically document the environmental hazards associated with the use of pesticides. To achieve that objective, several methods and sampling systems were tested. Those which proved most useful were: (1) observers equipped with cameras; (2) mylar sheets to collect tracer dye; and (3) magnesium oxide slides to determine drift of spray droplets.

The application program was visually observed and areas of concern were noted. Drift was recorded through the use of dye tracers and spray droplet size, and hence the drift distances were determined with a minimum use of time and manpower. Formulation testing was important because it provided the analysis of the undiluted and diluted material for comparison with labeling and other applicable regulations.

The impinger devices had limited value. The principal problem was the variable trapping efficiency. The devices were aslo affected by temperature and the concentration and partial pressures of the pesticides. However, impingers are one of the few tools available for semi-quantitative sampling of airborne pesticides.

The high-volume air samplers were considered a good tool for sampling airborne particles, but in this study the dust masked the tracer dye, thus limiting their usefulness. Kromecote cards proved to be unsuitable under the weather conditions and with the type of pesticides applied during this study.

Minimal drift observed during this study precluded residue analysis of the soil and vegetation samples. However, if drift was greater or an accident had occurred, analyses of soil and vegetation samples would enable the EPA to more effectively assess the environmental effects.

REFERENCES

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2. C. B. Rathburn, 1970. Methods of assessing droplet size of insecticidal sprays and fogs. Mosquito News, 30(4): 501-513.

Appendix

Description of Sampling Devices and Methods

DESCRIPTION OF SAMPLING DEVICES AND METHODS

A variety of techniques were used to evaluate spray drift characteristics during this study. Principal emphasis was placed on the use of Rhodamine WT dye as a tracer compound, mixed with the sprayed material.

The selection of the tracer material was based on the following desirable characteristics:

1. High sensitivity, measurements down to 0.01 microgram (μg)
2. Rapid analysis available
3. Soluble in spray mixture with minimum physical effect on atomization and droplet evaporation
4. Distinctive property to differentiate from background or naturally occurring substances
5. Stable or predictable concentration relationships under environments encountered
6. Moderate cost
7. Non-toxic

Rapid analysis of micro-concentrations of fluorescent solutions was attained with a Turner model 111 fluorometer. This instrument has a primary filter to select the excitation wavelength from an ultraviolet lamp source (GE No. F4T4/BL or G4T4/1). The secondary filter and photomultiplier tube are mounted at right angles to the primary source. The secondary filter was selected to absorb any stray ultraviolet light and, furthermore, to restrict any background fluorescent response that occurs at a wavelength different from the fluorescent sample. The photomultiplier tube, type 931A, has an S-4 response which is sensitive to wavelengths from 300 to 700 μm (micrometers). All dye study analyses were performed in a field laboratory.

One system used to collect the insecticide and dye mixture was mylar sheets (a type of plastic commonly used by draftsmen), 4 x 12 in. x 5 mils thick, placed horizontally on the ground. The dye retained on these sheets was evidence of spray drift.

Relatively rapid processing techniques were developed for preparing the samples for analysis. To wash each mylar sample, 100 ml of 95% ethyl alcohol was used. Approximately 25 ml of each solution was subsampled, and a 5 ml sample was poured into matched cuvettes and in turn placed in the Turner fluorometer for measuring the fluorescent response. Previous tests verified that nearly all of the dye was recovered from the mylar sheets with the above laboratory procedure.

A second system used, the high-volume air sampler, uses a fiberglass filter, 20 x 25.4 cm, on which airborne particles are trapped. In this study, the filters were used to trap the spray droplets, retaining the dye while the liquid phase evaporated. In use, about 0.99 m^3 (35 ft^3)/min of air was pulled through the filter. The system was operated for about 1 hour before spraying to about 4 hours after spraying. A total of about 297 m^3 (10,500 ft^3) of air passed through each filter. Processing of the filters followed the same procedure as the mylar sheets.

The third system used for dye studies, the Greenburg-Smith impinger, also served as a means of semi-quantitating pesticide levels in the drift. This system contains a pump that draws air through a sampling train and auxiliary equipment to control and measure air flow, switching the flow from one sampling train to another after a pre-set interval.

(a) Sampling train - Each sampling train contains an impinger containing 100 ml of ethylene glycol to trap particulates and gases and an absorption tube packed with a plug of glass wool to remove any splashover or water condensation.

(b) Flow control and pump - After the air has been pulled through the sampling train, it passes through a solenoid valve controlled by a timer, through a control valve by which the air flow in the sampling train may be set at the desired rate as shown on a flowmeter, through the flowmeter, and finally through the vacuum pump. A momentary contact switch may be closed to switch the air flow to a particular sampling train so that its flow may be adjusted to read any time.

Each unit was given a station number and was used only at that station. The impingers were filled with approximately 100 ml of ethylene glycol. Flow rates were set for 0.9 standard ft^3/min. Pesticide-free aluminum foil was used to cover the air intake tubes while transporting the units to their sampling locations in the fields.

The sampling units shut off automatically after 48 hours. The units were then transported to the servicing area and disassembled. The ethylene glycol was removed from the sampling trains and transferred to 250 ml screw-cap glass bottles. Impingers were rinsed with approximately 25 ml ethylene glycol which was added to the samples. The bottles were appropriately labeled and stored in an ice chest for transportation to the field laboratory where a 25 ml aliquot was removed and analyzed for dye concentrations. The remaining sample was shipped to the Denver NEIC laboratory for further chemical analysis.

The final two devices used, magnesium oxide coated microscope slides, and Kromecote cards did not sample the dye but rather the droplet itself.

The slide is prepared by burning strip magnesium beneath the slide to form a white powdery coating, which was slightly deeper than the largest droplet diameter. Upon impaction with the stationary slide the airborne droplets make a crater, leaving visible evidence even after evaporation.

Craters, caused by the droplets, were measured to the nearest micron by use of a microscope, measuring 200 craters on each slide used. These data were then used to compute the VMD and allow estimates to be made of drift distance.[1]

Kromecote cards, consisting of a special white oil-sensitive coating, 4 x 5 in., were used in a manner similar to MgO slides. The spray droplets impinge on the card, leaving a discolored area approximately the size of the spray droplet. Had the cards been successful, they too would have allowed the computation of a VMD to confirm and support data derived from MgO slides.

Personnel monitors contained a glass capsule filled with activated charcoal and lightly capped with fiberglass. Analysis of the contents was used to assess the degree of pesticide exposure to the observers.

Environmental samples (soil, vegetation and aquatic life) were collected by standard methods.