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RESEARCH PROGRESS REPORT

Phase I

DISTRIBUTION PATTERNS OF SELECTED HERBICIDES APPLIED USING AERIAL EQUIPMENT

July 1968 – June 1969

by

Wayne G. McCully

and

Charles W. Robinson

Contract No. DAAA13-68-C00176

Fort Detrick
Frederick, Maryland 21701
June 1969

Research Report No. 1
Texas Agricultural Experiment Station
Texas A&M University
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ABSTRACT

Bromacil and Tandex were applied to one-acre plots as granules and as sprays using rotary-wing aircraft, and as granules using fixed-wing aircraft. Granular materials were applied at rates ranging from 11 to 200 lbs/A. Spray volumes ranged from 10 to 40 gal/A.

The spray volumes dispensed did not differ more than five percent from scheduled amounts, but the output of granular materials was more variable. The greatest difficulty in delivery was encountered with granules formed on a sand core. Individual sand grains interferred with the proper operation of gates in the rotary-wing distributors. Also, the variation between scheduled and measured delivery of granules from rotary-wing equipment was greatest when less than 25 lb/A was applied, indicating a need for a less sensitive gate design.

Distribution of applied materials was measured by collecting samples of granules for weighing or samples of dyed spray for colorimetric determination. Generally, the distribution patterns were satisfactory.

The characteristics of each type of aircraft and the different forms of materials are discussed as they would apply to a military operation.

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DISTRIBUTION PATTERNS OF SELECTED HERBICIDES APPLIED USING AERIAL EQUIPMENT

Wayne G. McCully and Charles W. Robinson

Aerial equipment can be fitted with distributors for applying herbicides having a wide range of physical characteristics. Liquid sprays, as well as dry materials fashioned into granules or pellets of varying size and configuration, have been distributed from aircraft in flight. The widespread use of various types of aircraft in military operations offers a ready source of transport for applying herbicides to a target vegetation.

Perhaps the greatest advantage of aircraft over ground equipment for distributing herbicides is the facility with which large areas can be treated relatively quickly. This rapid dissemination of material does not lessen the need for accurate placement of herbicide over the area being treated. The response of target vegetation to the applied herbicide may vary considerably with seemingly small variations in amount of material intercepted. The relatively high herbicidal activity of materials presently in use, compared with older materials, demands precise application for most efficient control of vegetation.

This project, "Aerial Test Evaluation of Soil-Applied Herbicides," was activated 1968 July 1. The objective of this phase of the study was to assess the depositional patterns of liquid and granule/pellet formulations in aerial applications by available dissemination systems used in the test program. Subsequent work will evaluate plant response to the applied herbicides, determine the rate of dissipation for the herbicides, and assess the relative effectiveness of liquid and granule/pellet formulations.

PROCEDURE

This study was organized to compare the relative effectiveness of two herbicides, bromacil and Tandex,* for controlling perennial grasses and associated woody and herbaceous plants. The herbicides were applied in liquid and dry form using both fixed- and rotary-wing aircraft. Phase I of this study consisted of securing and organizing the experimental area, and applying specified herbicides.

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* See Table 1 for approved names of herbicides used.

TABLE 1. Schedule of treatments applied during fall 1968 and spring 1969 near Cuero, Texas. Each formulation was applied at 10 and 20 lb/A (ai) using the equipment indicated.

Method of Application	Herbicide Formulation* Bromacil	Tandex
Spray (Rotary-wing only)	Urox B - Emulsifiable concentrate containing 4 lb/gal ai.	Tandex 80WP - Wettable powder containing 80% ai.
	Urox 379 WP - Wettable powder containing 25% bromacil and 25% HCA (1,1,1,3,3,3-hexachloro-2-propanone.) Applied as 50% ai.	
Granule/pellet (Rotary and fixed-wing)	Hyvar X Granular - extruded clay pellets containing 10% ai.	Tandex 10G - coated sand- or clay-core granules containing 10% ai.
	Synule - clay granular material furnished by Fort Detrick containing 85% ai.	

* Bromacil = 5-bromo-3-*sec*-butyl-6-methyluracil.

Tandex = m-(3,3-dimethylureido)phenyl *tert*-butylcarbamate.

Formulations are indicated by appropriate commercial designations, where appropriate, only as an aid to identification.

Experimental location.

The study area consists of 169.6 acres of leased land located approximately 10 miles east of Cuero in DeWitt County, Texas. Livestock are excluded from the study location by a three-strand barbed wire, suspension-type fence with gates located on opposing corners (Appendix A).

According to the U. S. Soil Conservation Service the study area is a sandy prairie site having soils in the Fordtran, Katy and Edna series (Appendix B). The principal grasses include brownseed paspalum (Paspalum plicatulum Michx.), little bluestem (Schizachyrium scoparium Michx.) and knotroot bristlegrass (Setaria geniculata (Lam.) Beauv.), with scattered areas containing red lovegrass (Eragrostis oxylepis (Torr.) Torr.), rattail smutgrass (Sporobolis poiretii (Roem. and Schult.) Hitchc.) and some colonies of Indiangrass (Sorghastrum spp). The most prevalent broadleaf herbaceous plant is sneezeweed (Helenium amarum (Raf.) H. Rock). Sprout regrowth of liveoak (Quercus virginiana Mill) and yaupon (Ilex vomitoria Ait.) up to five feet tall together with scattered trees or sprouts of blackjack oak (Quercus marilandica Muench) compose the overstory vegetation (Figure 1).

Climatological records for the twenty-year period ending in 1968 showed an average rainfall of 32.52 inches for the Cuero area. Rainfall amounts ranged from a low of 13.92 inches in 1956 to a high of 49.05 inches in 1960 (U. S. Weather Bureau, 1968).

Herbicide applications.

During late summer 1968, 80 one-acre plots, 544.5 ft x 80.0 ft, were permanently staked in the study location. Individual plots were oriented with the long side parallel to the east-west axis (Appendix A), and isolated inside a border 30 feet wide. Within each of the plots, 30 points located at random were permanently marked for vegetation inventory using the point-center quarter method. The field plots were organized as a randomized complete block design with two replications.

A stationary rain gauge, U. S. Weather Bureau type, was placed in open terrain on the south central portion of the experimental area.

The herbicide materials listed in Table 1 were applied during the fall 1968 and spring 1969 using the type of aircraft indicated. The fixed-wing aircraft was a Snow, Model S2, fitted with a Swathmaster distributor (Figure 2), furnished by the Gulf Coast Aerial Spray Service, Inc. of Tivoli, Texas. The rotary-wing equipment for the fall application was provided by Allied Helicopter Service Inc. of Tulsa, Oklahoma. The aircraft for the spring application was furnished by Boyl's Aviation of Sinton, Texas.

Both rotary-wing contractors used Bell, Model 47D1, helicopters. The Allied unit was fitted with a granular distribution system fabricated in their own shop (Figure 3). In this system granular material was fed from both straddle tanks through pre-set gates into the center of a centrifugal spreader. This spreader consisted of upper and lower plates separated by curved vanes.

The distributor for the spring application was a Sling-King unit furnished by Transland Aircraft Inc. of Harbor City, California. This unit was suspended beneath the helicopter furnished by Boyl using a hook and sling arrangement (Figure 4). It consisted of an open fiberglass hopper with an internal adjustable gate arrangement which dumped directly onto a spinning disc fitted with four vanes.

The granule/pellet materials were applied with fixed-wing aircraft on October 29-30, 1968 and on April 1, 1969. The distribution patterns and swath widths for the various materials were checked at College Station, Texas prior to the actual application. Releasing the material 30 feet above the ground with the ship traveling at 80 mph ground speed gave a swath approximately 40 feet wide. The gate opening was established during application. The initial spacing was based on the experience of the operator with materials having particles of similar size and density, and was adjusted during the operation. The Cuero Airport, ten miles west of the experimental location, was used for landing and loading the fixed-wing aircraft.

The fall treatments using rotary-wing equipment were made October 30-31, 1968, except the Tandex 10G material on a sand-core. Individual sand grains interferred with the proper operation of the release gate assembly, and the treatment was applied December 4, 1968 using a clay granule. Spring treatments were applied April 18-19, 1969.

The flow rate for each granular material was established on the ground by adjusting the gate opening to deliver a specified amount of material during a prescribed time interval (Figure 3). The pilot for Allied, by flying at an altitude of 20 ft, a ground speed of 40 mph, and turning the spreader at 750 rpm, applied the lower rate of each material to an effective swath of 40 feet. Higher rates were achieved by flying each swath twice.

The Transland distributor (Figure 4) was powered by an auxilary 3 HP gasoline motor. A radio signal in the aircraft accelerated the auxilary motor, which in turn actuated a centrifugal clutch to raise the covering sleeve on the gate a pre-set distance. A swath 80 ft wide was achieved by releasing the material at an altitude of 30 ft and a ground speed of 30 mph with the plate spinning at 1750 rpm.

The rotary-wing aircraft also were used to apply spray materials (Figure 5). Fall spray applications were scheduled at volumes of 10 and 20 gal/A (1 gal/1 lb ai), and the spring treatments inadvertently were applied at twice these volumes.

The boom on the Allied equipment was suspended behind the power unit at the tail of the skids, with the center nozzle 23 in above the bottom of the skids. Thirty-eight nozzles were spaced according to the contractor's experience to apply a 40-foot swath at the prescribed gallonage. All applications were flown at a ground speed of 55 mph using K-5 Floodjets (Spraying Systems, Inc.) to apply 10 gal/A and K-15 Floodjets to apply 20 gal/A.

The Boyl equipment was fitted with a 28-nozzle boom mounted on the toe of the skids. Twenty-four Teejet 8015 nozzles (Spraying Systems, Inc.) supplemented by 4 Teejet 8-45 nozzles just to left of center were spaced 9 in apart, except the drops directly in front of the skids were left plugged. The application was flown using swaths 40 ft wide at a ground speed of 30 mph with a nozzle pressure of 12 psi and a release height of 30 ft. Rotary-wing aircraft were loaded adjacent to the experimental location.

The aircraft was guided during application by cloth flags at either end of the swath. Flag locations were marked with colored tape prior to treatment. The amount of material dispensed was measured at the loading point. Distribution of granules was determined by collecting and weighing material retained on cloth panels suspended within a wire frame two feet square (Figure 6) and spaced 5 ft center to center. Distribution of the spray material across the plot was determined from dye intercepted by mylar sample plates, four inches square, distributed transversely to the line of flight and spaced 5 ft center to center. Ten grams of carmine pontacyl dye (duPont) were added to each gallon of spray mixture. The dye retained on each plate was dissolved in 20 ml of 1:1 water: propanol (v/v). The dye solution was analyzed using a Klett-Summerson photoelectric colorimeter, and the colorimetric readings were converted to gallons per acre by comparing them with readings from standard solutions (Deonier et al, 1963).

RESULTS AND DISCUSSION

Monitoring the application with sample devices was conceived initially to aid in interpreting plant response, but it was installed later as a distinct phase of this study. These data are subject only to generalization; engineering controls were not used to measure such variables as deviation of the vehicle from the flight line, height of release of the applied material, or the precise wind vectors. Despite these limitations, the distribution patterns measured indicate the capabilities of the equipment used.

Two parameters are needed to physically evaluate an application. These are (1) the actual delivery relative to the amount scheduled, and (2) a profile of the distribution transverse to the line of flight.

In this study the volumes of spray applied were much more consistent and closer to the scheduled volume than were granular applications (Tables 2-7). Since the spray materials were delivered with the rotary-wing aircraft, this may reflect in part a greater familiarity of the operator with spray application. In no case did the measured delivery differ from the scheduled delivery by more than 5%.

TABLE 2. Scheduled delivery, measured delivery and percent intercepted for spray applications applied using rotary-wing aircraft, Fall 1968.

	Scheduled Application			
Herbicide	Active Ingredient lb/A	Material gal/A	Material Delivered gal/A	% Intercepted (Sample plates)
Urox B EC	10	10	10	37
Urox B EC	10	10	10	44
Urox B EC	20	20	19	39
Urox B EC	20	20	19	51
Urox 379 50WP	10	10	10	53
Urox 379 50WP	10	10	10	39
Urox 379 50WP	20	20	19	41
Urox 379 50WP	20	20	19	41
Tandex 80WP	10	10	10.5	58
Tandex 80WP	10	10	10.5	58
Tandex 80WP	20	20	20	80
Tandex 80WP	20	20	20	67

TABLE 3. Scheduled delivery, measured delivery and percent intercepted for spray applications applied using rotary-wing aircraft, Spring 1969.

Herbicide	Scheduled Application: Active Ingredient lb/A	Scheduled Application: Material gal/A	Material Delivered gal/A	% Intercepted (Sample plates)
Urox B EC	10	20	21	32
Urox B EC	10	20	21	23
Urox B EC	20	40	40	17
Urox B EC	20	40	42	39
Urox 379 50WP	10	20	19	47
Urox 379 50WP	10	20	19	43
Urox 379 50WP	20	40	42	16
Urox 379 50WP	20	40	40	53
Tandex 80WP	10	20	20.5	46
Tandex 80WP	10	20	20.5	44
Tandex 80WP	20	40	41.5	52
Tandex 80WP	20	40	41.0	13

TABLE 4. Scheduled delivery, measured delivery and percent intercepted for granular materials applied using fixed-wing aircraft, Fall 1968.

Herbicide	Lb/A Scheduled Active Ingredient	Lb/A Scheduled Material	Material Delivered lb/A	% Intercepted (Sample panels)
Bromacil 85G	10	11.75	14.0	13
Bromacil 85G	10	11.75	14.0	48
Bromacil 85G	20	23.5	22.5	24
Bromacil 85G	20	23.5	22.5	30
Bromacil 10G	10	100	115	31
Bromacil 10G	10	100	118	14
Bromacil 10G	20	200	236	22
Bromacil 10G	20	200	236	18
Tandex 10G	10	100	118	65
Tandex 10G	10	100	116	28
Tandex 10G	20	200	294	39
Tandex 10G	20	200	205	65

TABLE 5. Scheduled delivery, measured delivery and percent intercepted for granular materials applied using fixed-wing aircraft, Spring 1969.

Herbicide	lb/A Scheduled Active Ingredient	lb/A Scheduled Material	Material Delivered lb/A	% Intercepted (Sample panels)
Bromacil 85G	10	11.75	11.1	
Bromacil 85G	10	11.75	11.1	
Bromacil 85G	20	23.5	22.2	
Bromacil 85G	20	23.5	22.2	
Bromacil 10G	10	100	92.0	(No samples collected)
Bromacil 10G	10	100	92.0	
Bromacil 10G	20	200	184	
Bromacil 10G	20	200	184	
Tandex 10G	10	100	75	
Tandex 10G	10	100	75	
Tandex 10G	20	200	150	
Tandex 10G	20	200	150	

TABLE 6. Scheduled delivery, measured delivery and percent intercepted for granular materials applied using rotary-wing aircraft, Fall 1968.

Herbicide	Lb/A Scheduled Active Ingredient	Lb/A Scheduled Material	Material Delivered lb/A	% Intercepted (Sample panels)
Bromacil 85G	10	11.75	16	22
Bromacil 85G	10	11.75	16	63
Bromacil 85G	20	23.5	32	9
Bromacil 85G	20	23.5	32	28
Bromacil 10G	10	100	112.5	23
Bromacil 10G	10	100	112.5	25
Bromacil 10G	20	200	204	17
Bromacil 10G	20	200	182	20
Tandex 10G	10	100	144	74
Tandex 10G	10	100	103	60
Tandex 10G	20	200	211	56
Tandex 10G	20	200	200	63

TABLE 7. Scheduled delivery, measured delivery and percent intercepted for granular materials applied using rotary-wing aircraft, Spring 1969.

Herbicide	Lb/A Scheduled Active Ingredient	Lb/A Scheduled Material	Material Delivered lb/A	% Intercepted (Sample panels)
Bromacil 85G	10	11.75	17.5	31
Bromacil 85G	10	11.75	17.5	26
Bromacil 85G	20	23.5	34.2	16
Bromacil 85G	20	23.5	25.4	41
Bromacil 10G	10	100	99	15
Bromacil 10G	10	100	99	29
Bromacil 10G	20	200	173	16
Bromacil 10G	20	200	221	17
Tandex 10G	10	100	116.5	24
Tandex 10G	10	100	116.5	35
Tandex 10G	20	200	210	75
Tandex 10G	20	200	158	86

The pattern of spray distribution across any particular application was quite similar along the two collection lines (Appendix C-10 to C-15). An expected lateral displacement of the spray pattern was found with a crosswind, particularly at velocities greater than 3 mph. Some irregularities were found in distribution, but these were not consistent for either aircraft. The amount of dye which was recovered varied from 37 to 80 percent for the fall application and from 13 to 50 percent for the spring application (Tables 2-3).

Recovery of a smaller amount of the tracer dye from the spring application compared with that from the previous fall treatment may have been due in part to the extremely heavy dew which formed on and ran off the collection plates prior to treatment. Failure to recover a large proportion of spray material released from aircraft is not unusual; most engineering studies expect to recover only 40-60 percent of the released material.

Gate openings on the Swathmaster for each material are shown in Figure 7. The delivered rate of granular material varied from the scheduled rate less than 10 percent in nearly one-half of the applications (Tables 4-7). In only two cases, both involving Tandex 10G granules, was the variance greater than 44 percent. In the case of the fall application using the fixed-wing aircraft, the plot receiving the extreme overdose of Tandex 10G (Table 4) was the first load of material flown.

The extreme overrun with Tandex 10G on the fall application using rotary-wing aircraft probably reflects the difficulty encountered in the gate mechanism with the sand-core material. There may have been some pneumatic (venturi) influence on small granules with the Allied distributor. Further adjustment of the gate setting was needed after the first flight with finer but not with coarser material. The remaining Tandex treatments for the fall application were applied using clay granules supplied by the manufacturer (Figure 8).

The greatest problem in delivery seemed to be the metering of the synules by the two distributors used with the rotary-wing aircraft, although the fixed-wing ship had no problem. This is seen as a mechanical problem requiring the installation of a saw-tooth baffle or other critical metering mechanism to render the gate adjustment less sensitive. Flying at a faster speed so long as the distribution pattern is not affected adversely is another alternative.

The amount of granular material recovered relative to the amount delivered varied widely and was considerably below the standards set by Chamberlin and Young (1956). Using sample collectors having vertical sides 3 inches high they were able to account for more than 90 percent of the known discharge. The muslin panels (Figure 6) used in these applications to sample granule distribution were taut enough in most cases that some of the granules bounced off on impact.

Crosswinds having a velocity of 5 mph or greater appeared to displace the distribution pattern laterally (Appendix C-3, C-5, C-9). Some distortion of the pattern occurred when the aircraft traveled into and with the wind in applying a light rate of Tandex G, but this distortion was not so evident at the higher rate of application (Appendix C-6).

Some comparisons can be made of the distribution patterns obtained with the Transland distributor used in the spring helicopter applications down a single flight line (Appendix C-8; C-9) with the other granular applications where two flight lines were utilized (Appendix C-1 to C-6). The distribution patterns for the bromacil synules and the Tandex 10G granules using the Transland unit approached the ideal trapezoidal form for a single swath. However, the sharply vertical sides may pose some problem in swathing.

The Transland unit on loan was radio controlled; the manufacturer has installed a direct electrical connection through the hook on later models. Pilot training will be essential in using these units since there is a lag of approximately 0.8 seconds between activation and the opening and closing of the gate. Also, lighter materials such as Tandex and synules tend to swirl in the fiberglass basket and spilled over the edge in flight. This has been corrected in later models by installing a cover.

The granular materials used varied widely in their physical characteristics (Table 8). For soil-applied materials such as these, the absorbing plant root must intercept the herbicide in the soil solution. The soil area each particle must service (Table 8) varies from 0.05 sq in for Tandex to 6.03 sq in for bromacil 10G. Further judgements in this regard should be based upon the responses of the treated vegetation.

TABLE 8. Some selected physical characteristics of three granular materials.

Characteristic	Material Bromacil 10G	 Bromacil Synule	 Tandex 10G
No particles/gm	229	346	2,725
No particles/sq ft (10 lb/A ai)	23.9	42.5	2,840

The clay granules did not cause any of the problems which were encountered in Allied and Transland equipment with the Tandex on a sand-core. The fall application of Tandex on a coated clay granule generated considerable dust at the point of release (Figure 8). Delivery of Tandex from the Swathmaster varied more from the prescribed rate than did other materials. Although many herbicides are applied on clay granules, representatives of Niagara maintain that a clay granule will endanger the viability of the Tandex material.

SUMMARY AND RECOMMENDATIONS

Precision in the placement of an herbicide is necessary for efficient biological action of the applied material. Too little material gives disappointing results, and too much may not only be wasteful but generate undesirable side effects. Both rotary- and fixed-wing aircraft have been used to dispense herbicides in agricultural operations. Since both of these types of aircraft are commonly used in military operations they could easily be fitted to distribute biological agents.

Within limits, the pattern of distribution for either a single or multiple swath obtained with material distributed from aircraft depends upon the height of release above the target surface, the density of the individual particles, the aircraft velocity, mechanical characteristics of the herbicide distributor and certain atomspheric conditions such as wind direction and velocity. Some distance between the aircraft and the target surface is desirable for safety and to take advantage of aerodynamic factors in distributing the herbicide particles, but the risk of particle displacement increases with greater height.

Liquid and granular forms of bromacil and Tandex were applied using fixed- and rotary-wing aircraft to an area of mixed grass-brush vegetation near Cuero, Texas. Duplicate 1-acre plots were treated during fall 1968 and spring 1969 using 10 and 20 pounds of material (ai) per acre. The amount of material dispensed was measured at the landing site, and distribution within the treated plots was determined on two lines transverse to the direction of flight. Dye added to the spray mixture was determined colorimetrically from material intercepted on mylar plates; granules deposited on cloth panels attached to wire frames were collected and weighed.

The fixed-wing aircraft featured an internal tank and a standard Swathmaster distributor mounted directly under the wing. The granular distributors on the rotary-wing aircraft offered a comparison of an internally-contained unit with one suspended beneath the ship. Detachable distributors, such as Transland, offer greater flexibility in the use of assigned aircraft. An internally-contained unit, such as Allied used, produces a minimum amount of drag compared with external distributors employed by the other contractors. This increased drag may increase power requirements with a possible reduction in speed and maneuverability. Spray systems are available which do not require outside mounting, or which produce a minimum of drag.

The amounts of spray dispensed were much more precise than were the granular materials. Each of the three types of granular distributors applied the various materials in a satisfactory pattern over the target area. If granules are to be dispensed at rates less than 25 lb/A from aircraft flying at a ground speed of 40 mph, a more sensitive metering design than a rectangular gate opening should be employed.

The volume of granular material used is a function of the rate applied and the active ingredient content. Tandex and bromacil applied as sprays of wettable powders (WP) required a volume of 1 gal of water per lb (ai) of herbicide. Emulsifiable concentrate (EC) forms applied undiluted would treat four times the area/load than would WP, using the materials in this test.

The only real problem involved granular Tandex coated on a sand core. Individual sand grains rendered the Allied sliding gate inoperable. They prevented the covering sleeve on the Transland unit from closing completely, causing it to leak material. This material also was the most erratic of the three distributed through the Swathmaster unit. Also, units accommodating the sand-core material would be subject to accelerated wear from sand abrasion.

It may be concluded from this study that soil-applied herbicides may be distributed either dry or as sprays. Distribution systems for either type of material are available, but some additional engineering studies involving granular distributors probably are warranted.

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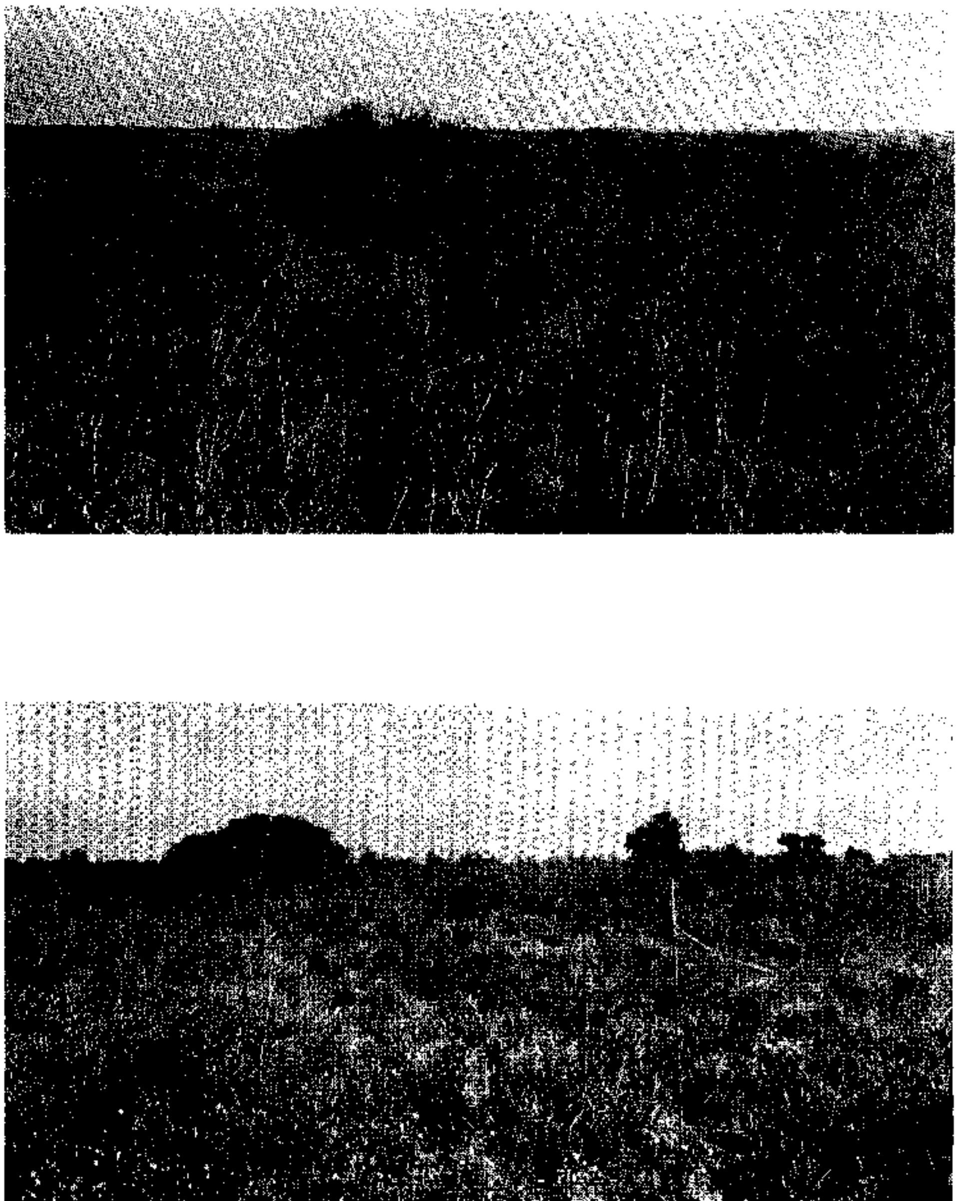


Figure 1. The vegetative cover was a mixture of perennial grasses, other herbaceous plants, woody sprout growth and an occasional tree. Iron poles (bottom) marked plot corners.

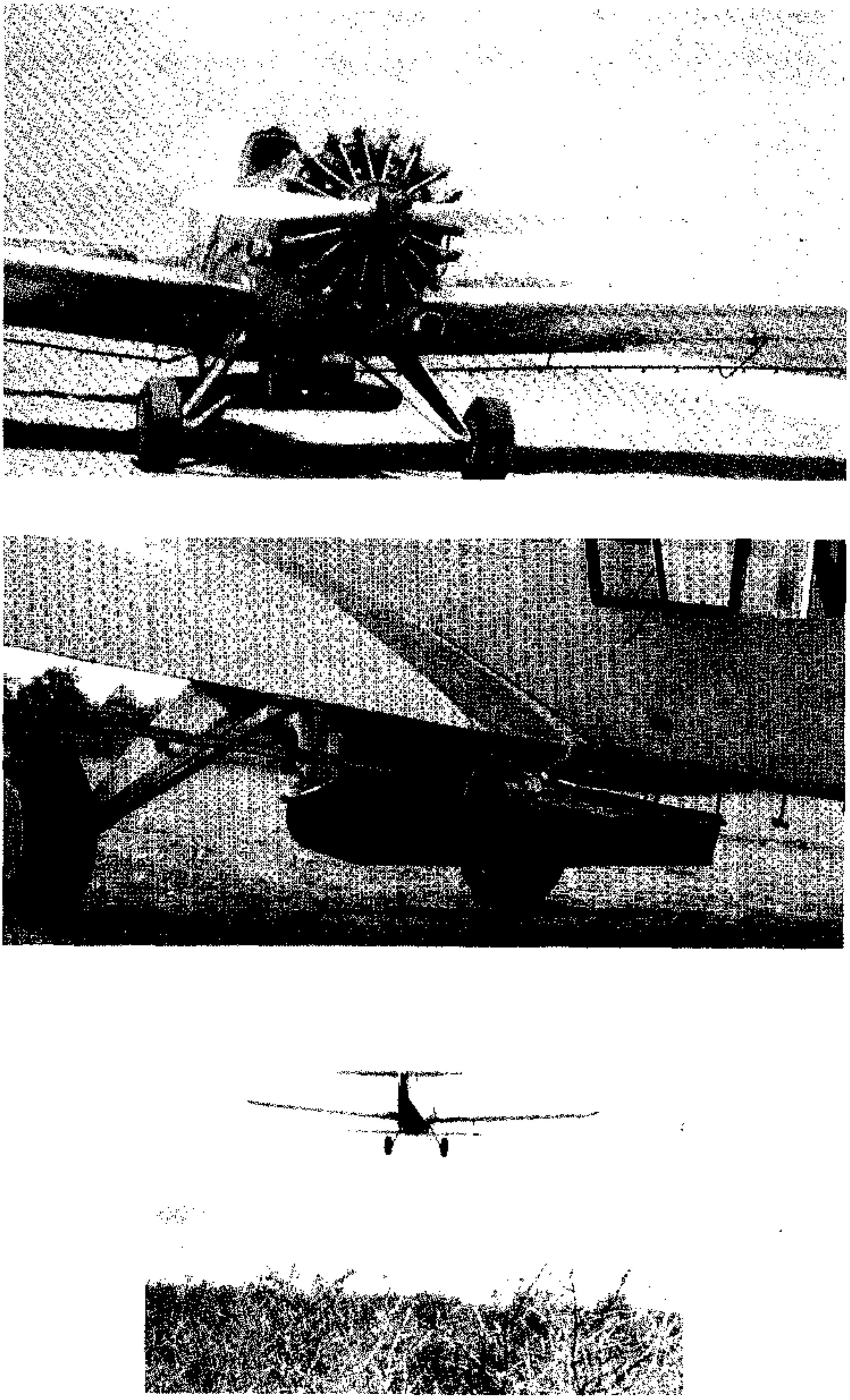
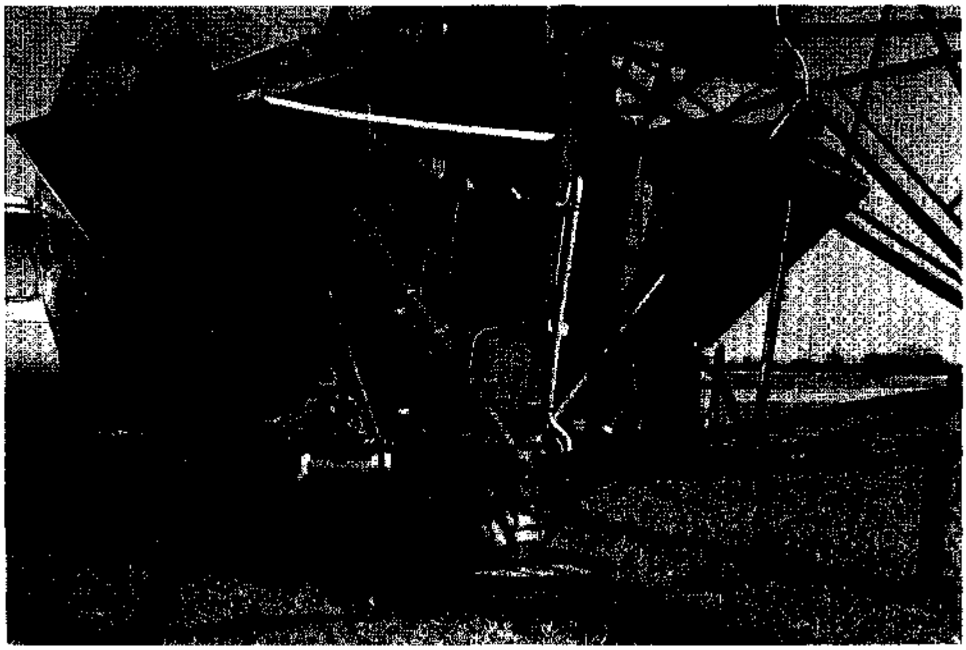


Figure 2. Fore and aft views (top and center) of the Swathmaster granular distributor mounted on a Snow Model 2 airplane, and (bottom) the same unit in operation.



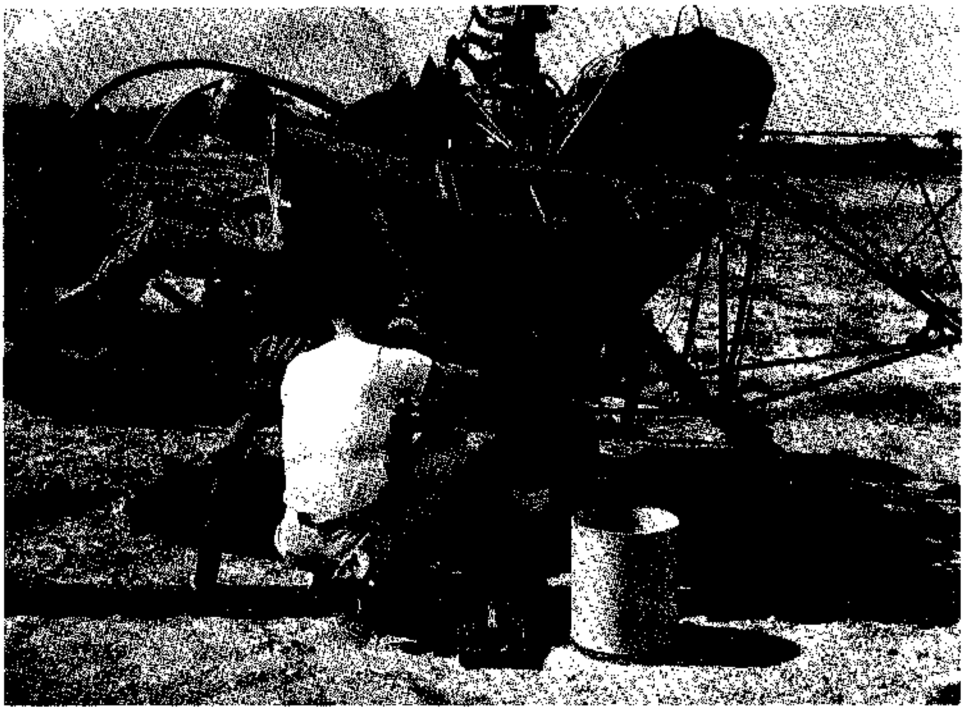


Figure 3. In the equipment furnished by Allied, herbicide granules were metered through an adjustable gate (bottom) at the base of each straddle tank and traveled through a flexible hose into the center of the spreader. During operation in flight the spreader was dropped to a position just below the level of the skids.

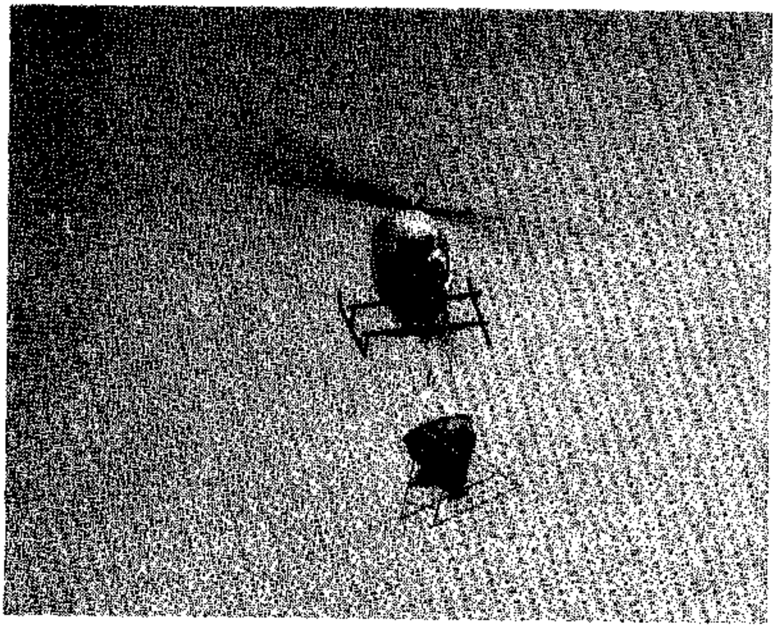


Figure 4. The Transland Sling-King was picked up and released by the helicopter in flight.

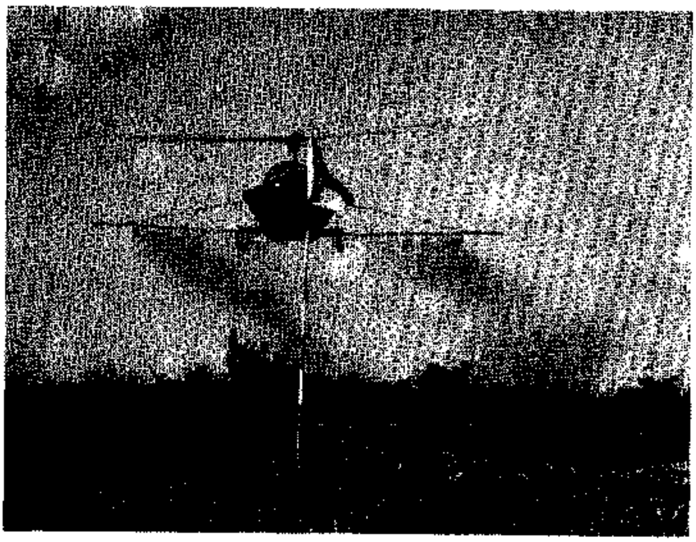


Figure 5. Even a slight wind displaced spray released at a low altitude.

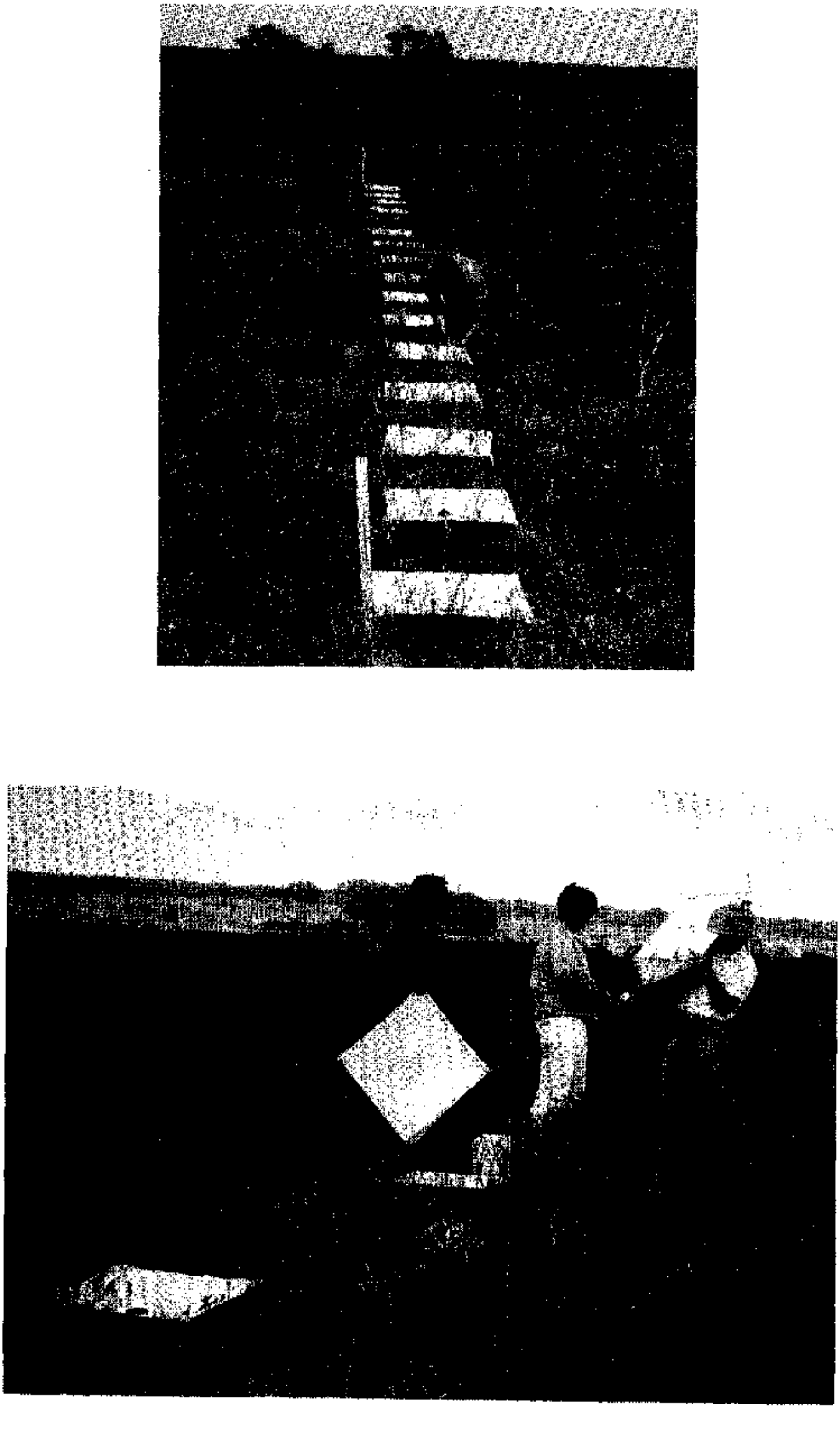


Figure 6. Granules were intercepted on cloth panels and collected into paper bags for weighing.

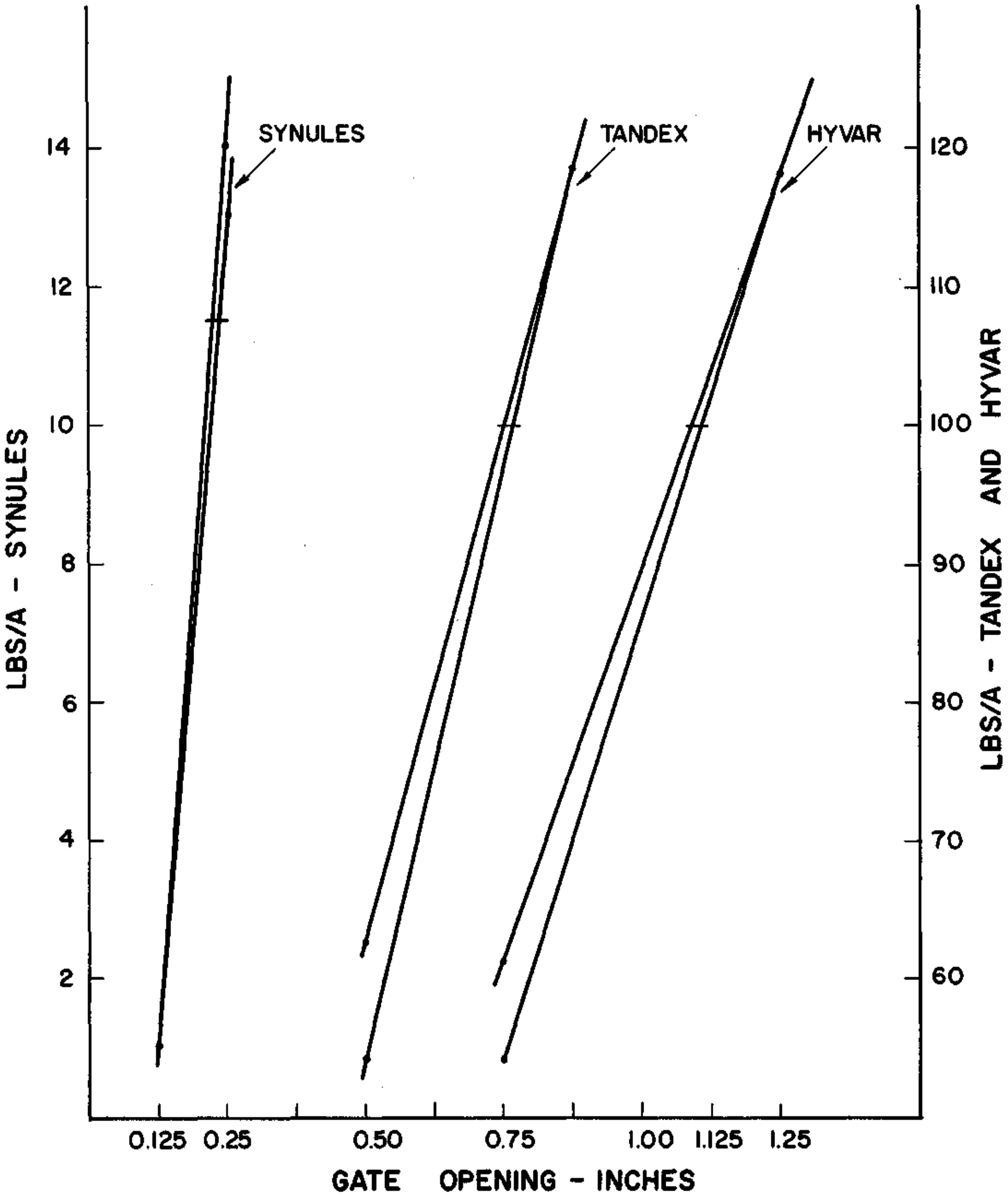
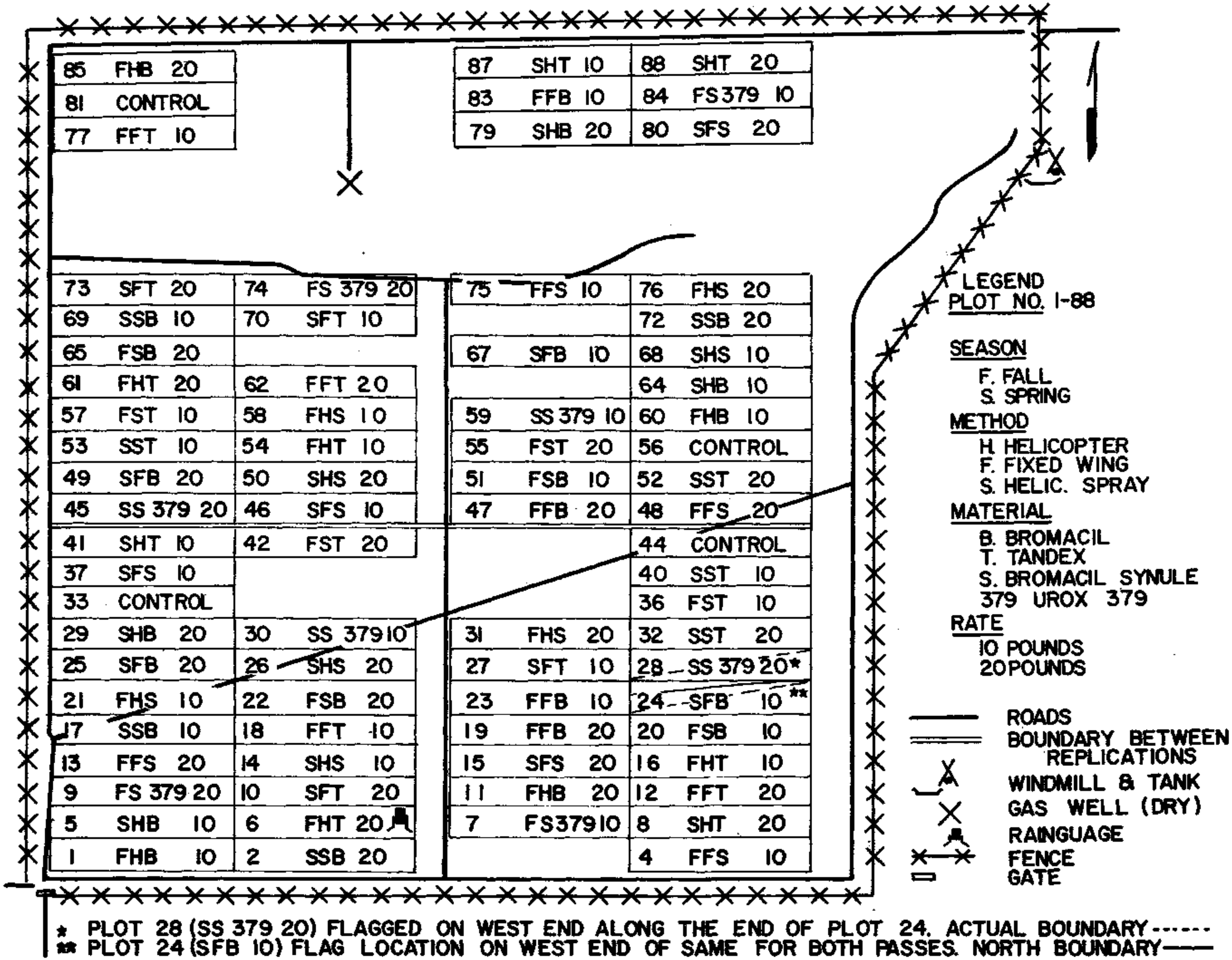
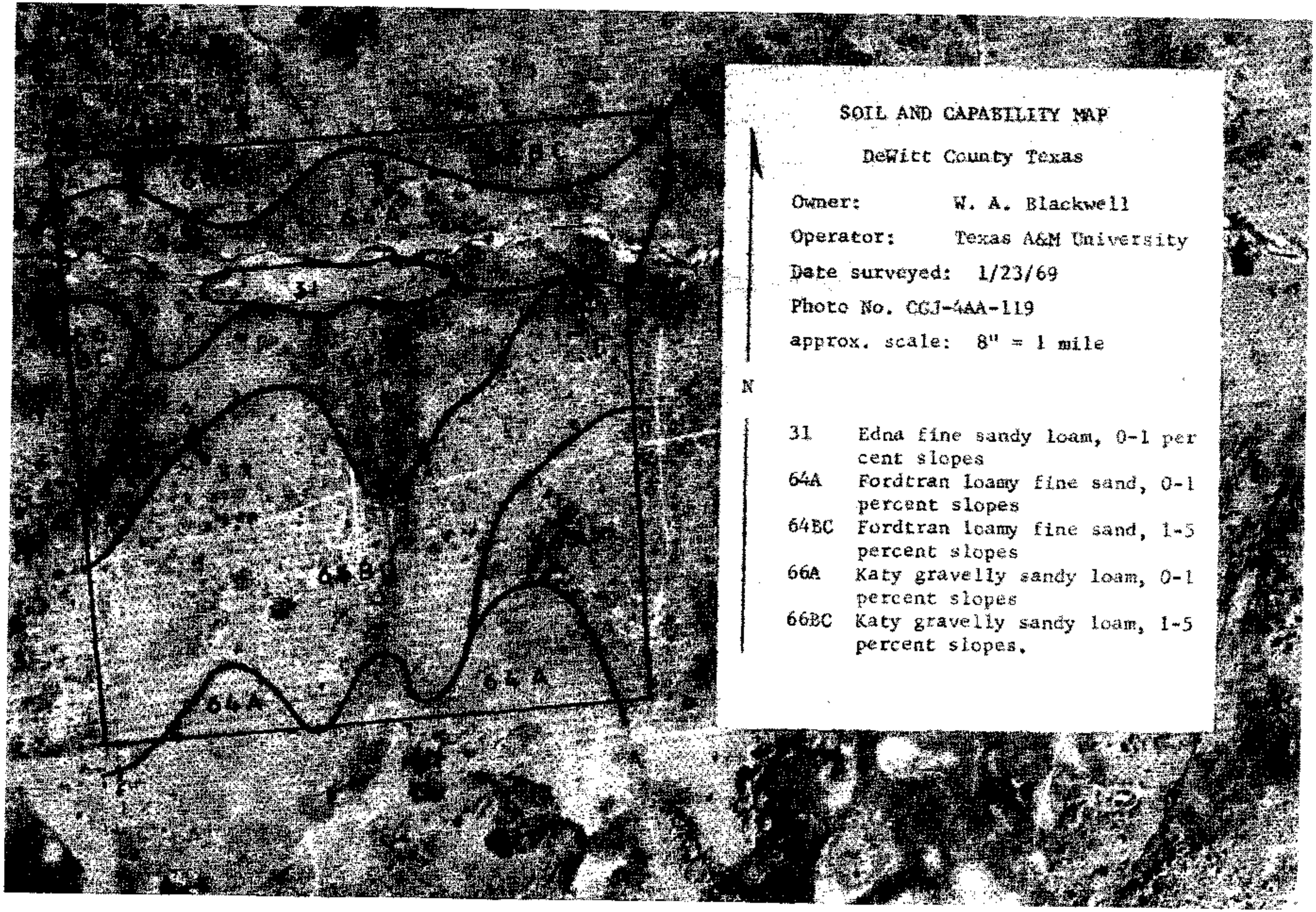


Figure 7. Flow rates through the Swathmaster distributor for the three granular herbicides used.

Figure 8. Tandex clay granules were quite dusty, probably indicating poor binding of the herbicide to the clay core.



Appendix A. Organization and some physical features of the experimental location.



Appendix B1. An aerial view of the experimental location showing the soil types present (for descriptions see Appendix B2-4).

Appendix B2. Description of a typical profile of Edna fine sandy loam.

(31) Edna Fine Sandy Loam

This soil is a member of the fine, montmorillonitic, thermic family of Vertic Albaqualfs. It has a thin, gray, crusty fine sandy loam A horizon and dark gray clay Bt horizons.

A representative profile (moist) is:

A1	0 to 6 inches, gray fine sandy loam with weak granular structure; few fine roots; slightly acid; abrupt boundary.
B2t	6 to 38 inches, dark gray clay; weak to moderate coarse blocky structure; continuous clay films on peds; few fine roots, mostly between the peds; slightly acid; gradual boundary.
B3t	38 to 51 inches, grayish brown sandy clay with common fine faint yellowish brown mottles; weak blocky soil structure; slightly acid; patchy clay skins on peds; gradual boundary.
C	51 to 84 inches, light brownish gray sandy clay with common medium faint yellowish brown mottles; slightly acid.

This soil occurs in concave positions and in flat drainage ways.

Appendix B3. Fordtran loamy fine sand

(64) Fordtran loamy fine sand

This soil is a member of the clayey, mixed, thermic family of Aernic Albaqualfs. It consists of thick grayish brown loamy fine sand A horizons and mottled sandy clay Bt horizons.

A representative profile (moist) is:

A1	0 to 14 inches, dark grayish brown loamy fine sand; weak granular structure; plentiful fine roots; slightly acid; clear boundary.
A2	14 to 21 inches, grayish brown loamy fine sand without soil structure; contains a few small chert gravel; slightly acid; abrupt wavy boundary.
B21t	21 to 27 inches, dark grayish brown sandy clay with common medium distinct yellowish brown and strong brown mottles; moderate medium blocky soil structure; continuous coatings on natural clods; medium acid; contains a few fine chert gravel; clear boundary.
B22t	27 to 38 inches, light brownish gray sandy clay with many coarse distinct yellowish brown and a few medium strong brown mottles; continuous coating on the natural clods; slightly acid; gradual boundary.
B3t	38 to 62 inches, gray sandy clay with a few, fine strong brown mottles; it has weak blocky structure.
C	62 to 96 inches, dark yellowish brown light sandy clay with a few medium faint light brownish gray mottles; structureless; slightly acid.

Where this soil occurs in the lower valleys, the A horizon is a heavy loamy fine sand and the Bt horizon has less mottling. These areas remain wet longer. During the wet season, a perched water table lays on the Bt horizon and causes it to be boggy.

Native vegetation is brownseed paspalum, some bermudagrass and some scrubby live oak trees.

Appendix B4. Katy gravelly sandy loam.

(66) Katy Gravelly Fine Sand

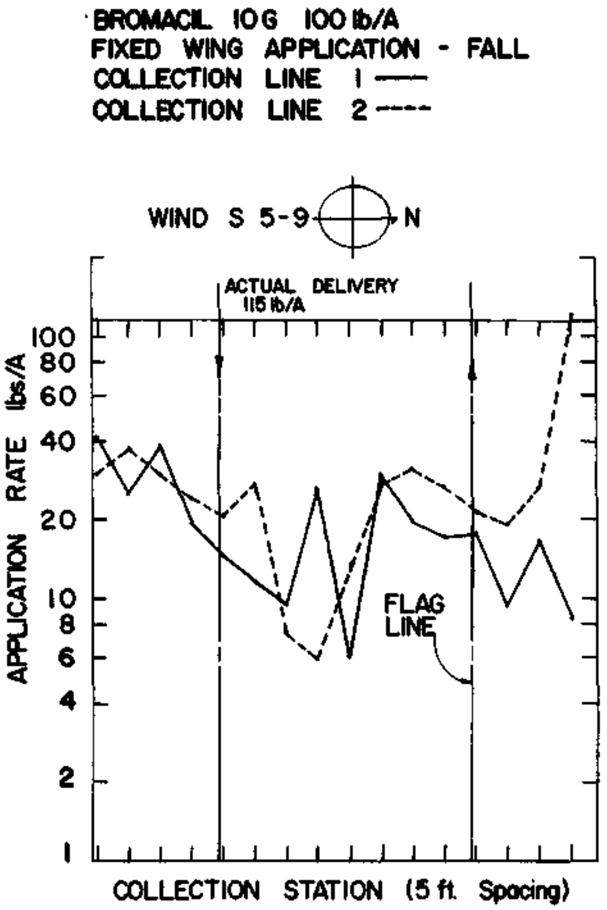
This soil is a member of the sandy-skeletal, mixed, thermic family of Typic Haplustalfs. It consists of thick beds of chert gravel over mottled dark red and light gray acid clay. It has thick vegetative cover of scrubby live oak brush 3 to 12 feet high with bunch grasses of brownseed paspalum in open areas.

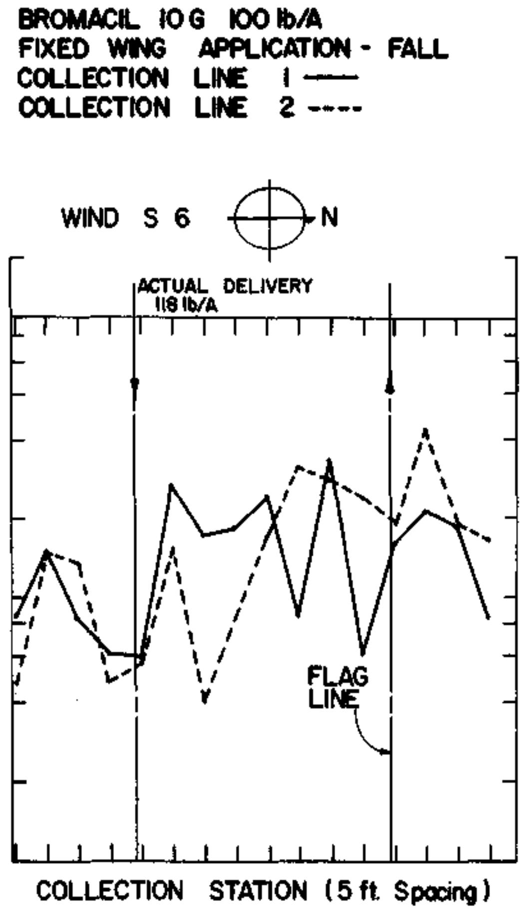
A representative profile (moist) is:

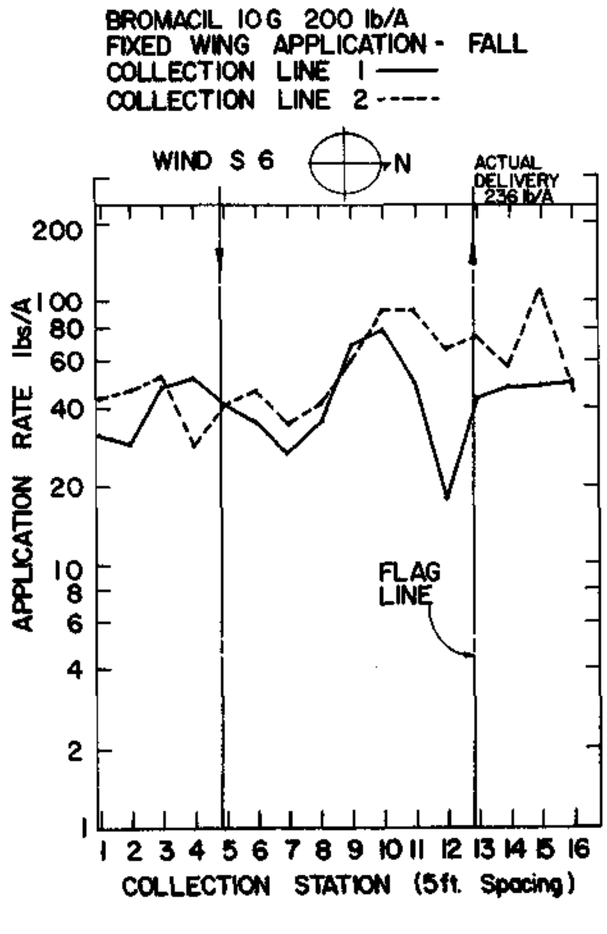
A1	0 to 15 inches, dark grayish brown gravelly fine sand that is strongly acid; the gravel is mostly less than 1 inch in diameter and comprises about 85 percent of the mass, by volume; it includes a few gravel up to 3 inches in diameter; in places there is a surface layer up to 8 inches thick of dark brown fine sandy loam with only a few gravel present, gradual boundary.
A2	15 to 42 inches, brown gravelly fine sand that is strongly acid; the gravel is mostly less than 1 inch in diameter and averages finer than in the surface layer; the gravel comprises about 90 percent of the mass; there are also a few gravel up to 3 inches in diameter; abrupt boundary.
IIC	42 to 54 inches plus, mottled dark red and light gray clay that is without any soil structure; strongly acid; contains a few gravel 1/2 to 1 1/2 inches in diameter.

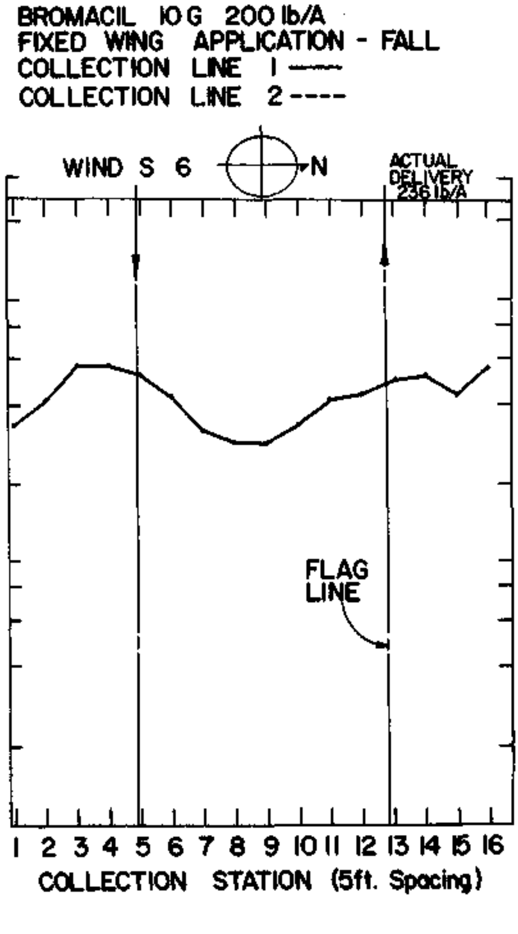
66A	Katy gravelly fine sand, 0 to 1 percent slopes.
66BC	Katy gravelly fine sand, 1 to 5 percent slopes.

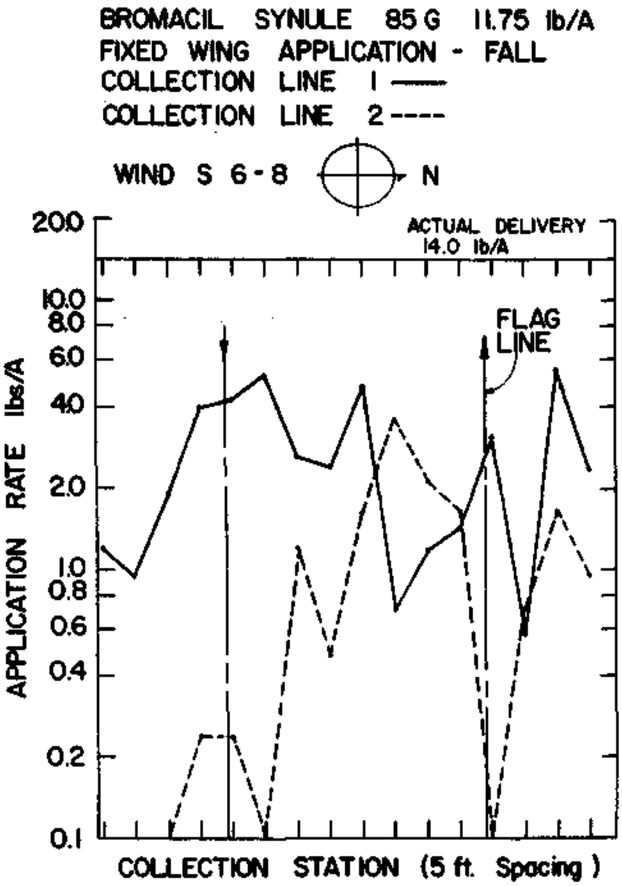
Appendix C1-15. Distribution patterns of spray and granular materials applied with designated aircraft.

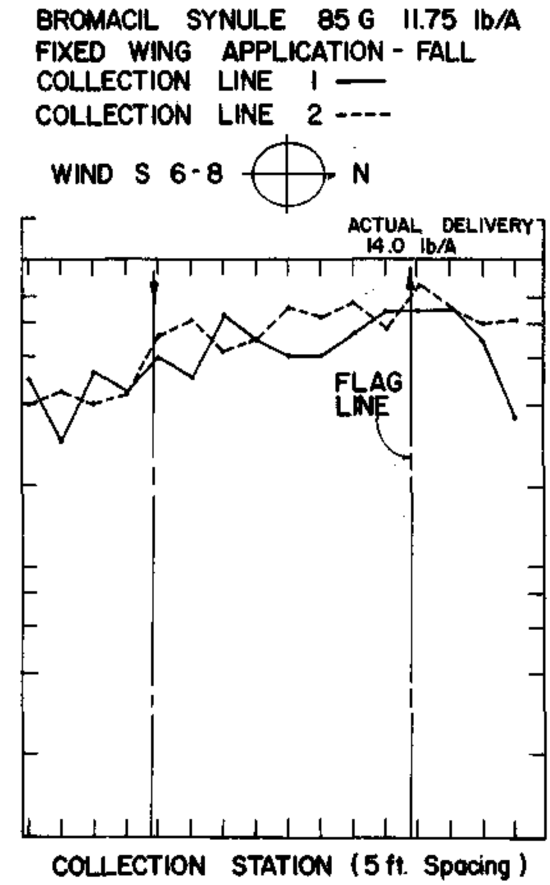

BROMACIL 10G 100 lb/A
FIXED WING APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 5-9
N
ACTUAL DELIVERY 115 lb/A
APPLICATION RATE lbs/A
100
80
60
40
20
10
8
6
4
2
1
FLAG LINE
COLLECTION STATION (5 ft. Spacing)

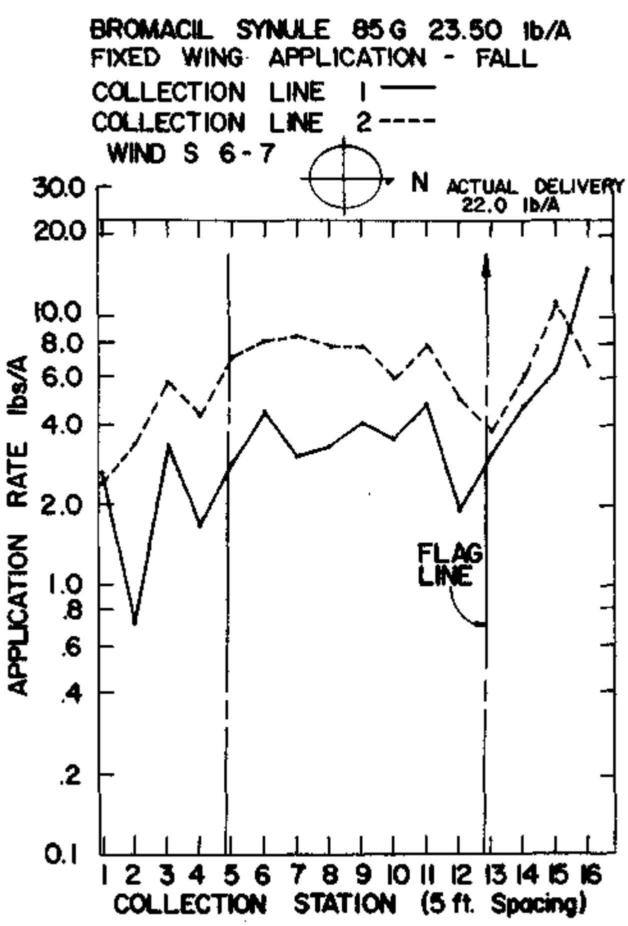

BROMACIL 10G 100 lb/A
FIXED WING APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 6
N
ACTUAL DELIVERY 118 lb/A
FLAG LINE
COLLECTION STATION (5 ft. Spacing)

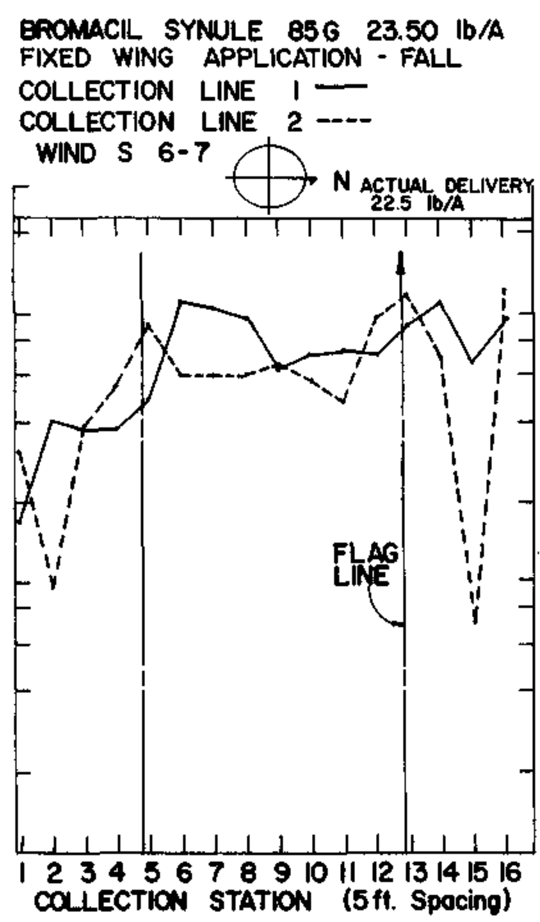

BROMACIL 10G 200 lb/A
FIXED WING APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 -----
WIND S 6
N
ACTUAL DELIVERY 236 lb/A
APPLICATION RATE lbs/A
200
100
80
60
40
20
10
8
6
4
2
1
FLAG LINE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
COLLECTION STATION (5ft. Spacing)


BROMACIL 10G 200 lb/A
FIXED WING APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 6
N
ACTUAL DELIVERY 236 lb/A
FLAG LINE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
COLLECTION STATION (5ft. Spacing)

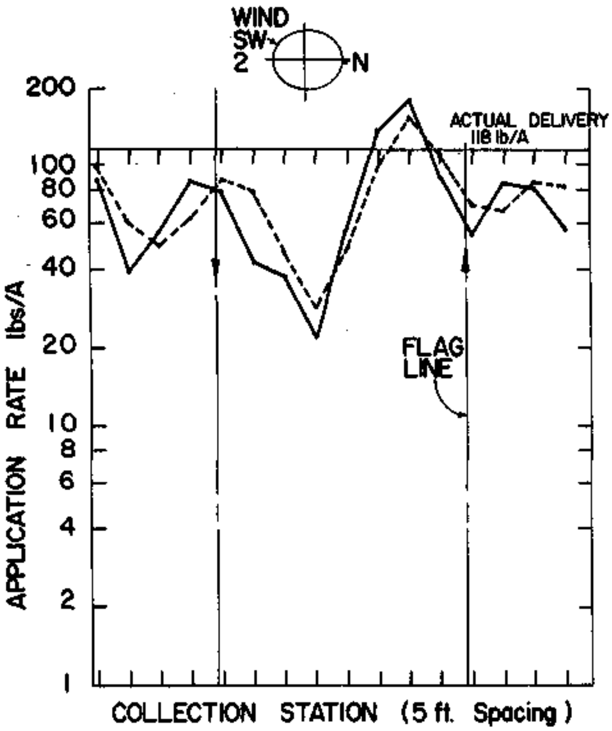

BROMACIL SYNULE 85 G 11.75 lb/A
FIXED WING APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 6-8
N
ACTUAL DELIVERY 14.0 lb/A
FLAG LINE
APPLICATION RATE lbs/A
20.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.2
0.1
COLLECTION STATION (5 ft. Spacing)


BROMACIL SYNULE 85 G 11.75 lb/A
FIXED WING APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 6-8
N
ACTUAL DELIVERY 14.0 lb/A
FLAG LINE
COLLECTION STATION (5 ft. Spacing)

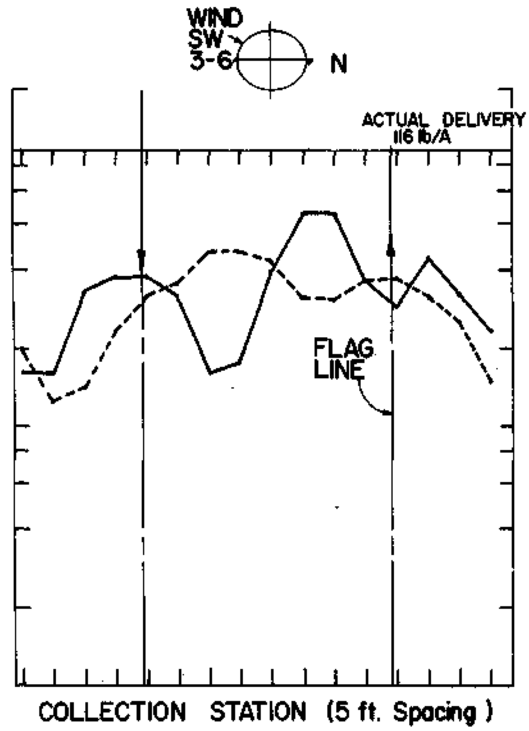

BROMACIL SYNULE 85 G 23.50 lb/A
FIXED WING APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 6-7
N
ACTUAL DELIVERY 22.0 lb/A
FLAG LINE
APPLICATION RATE lbs/A
30.0
20.0
10.0
8.0
6.0
4.0
2.0
1.0
.8
.6
.4
.2
0.1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
COLLECTION STATION (5 ft. Spacing)


BROMACIL SYNULE 85 G 23.50 lb/A
FIXED WING APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 6-7
N
ACTUAL DELIVERY 22.5 lb/A
FLAG LINE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
COLLECTION STATION (5 ft. Spacing)

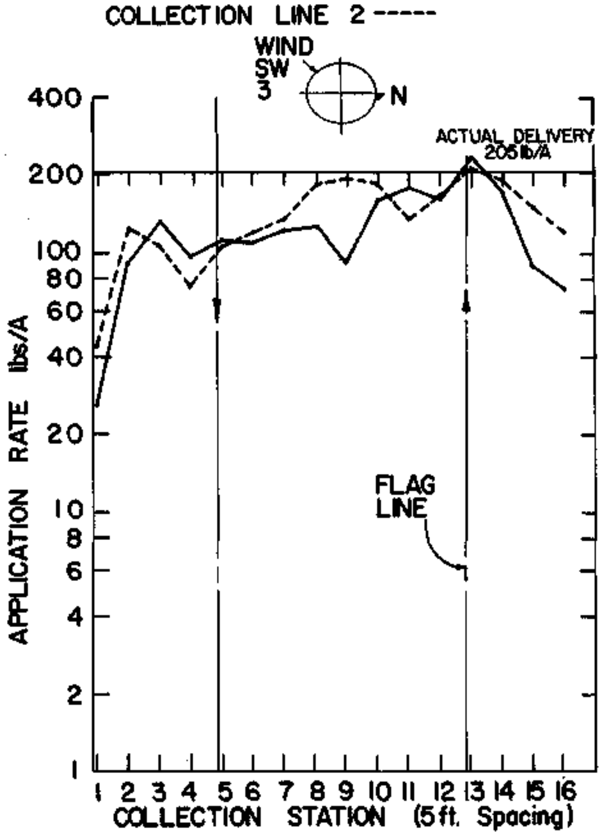
TANDEX 10G 100 lb/A
FIXED WING APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----



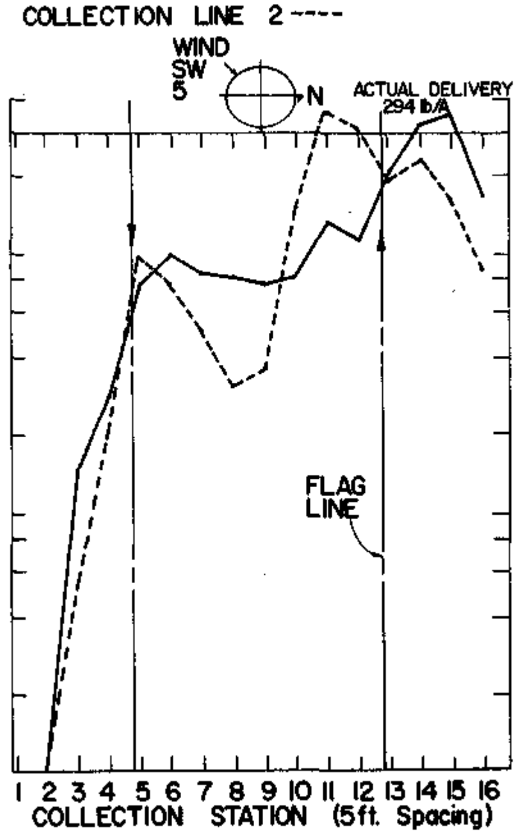
TANDEX 10G 100 lb/A
FIXED WING APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----

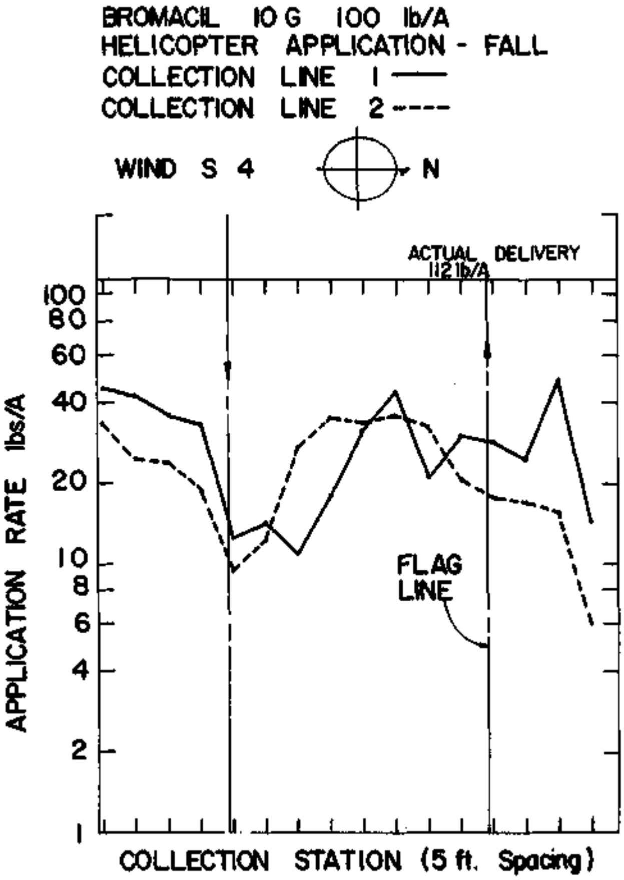


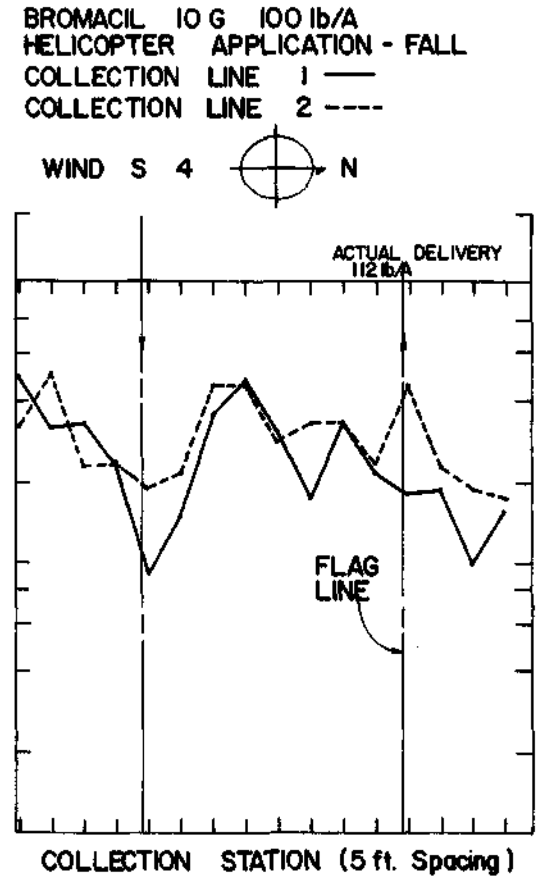
TANDEX 10G 200 lb/A
FIXED WING APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 -----

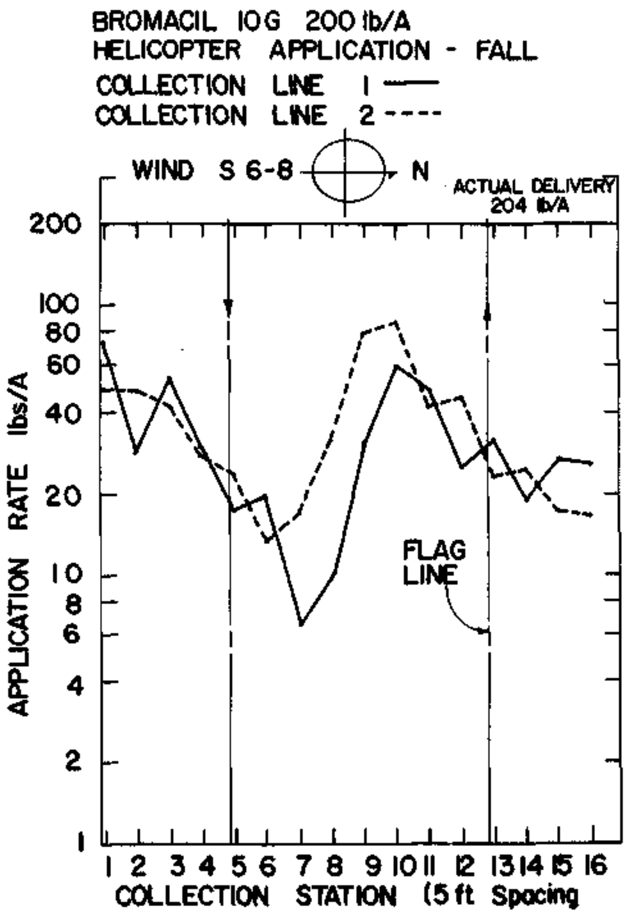


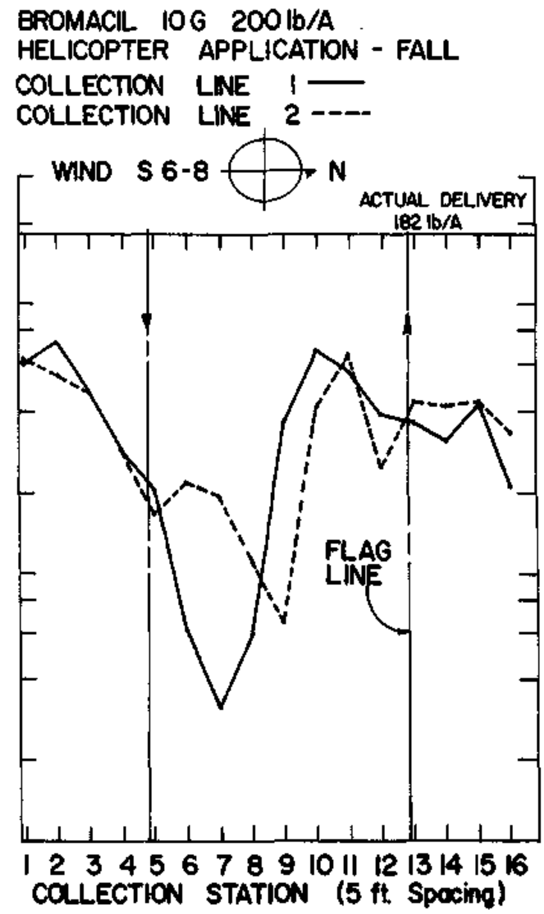
TANDEX 10G 200 lb/A
FIXED WING APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----



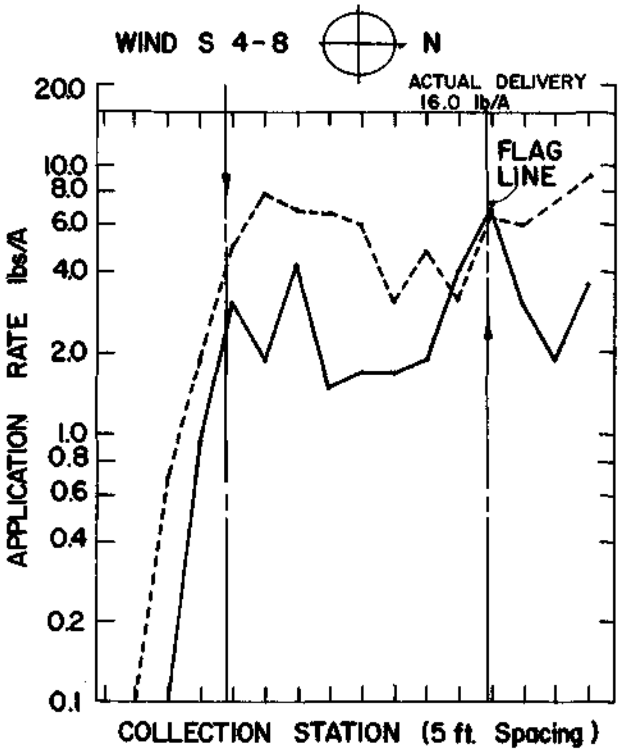

BROMACIL 10 G 100 lb/A
HELICOPTER APPLICATION - FALL
COLLECTION LINE 1
COLLECTION LINE 2
WIND S 4
N
ACTUAL DELIVERY 112 lb/A
FLAG LINE
APPLICATION RATE lbs/A
COLLECTION STATION (5 ft. Spacing)


BROMACIL 10 G 100 lb/A
HELICOPTER APPLICATION - FALL
COLLECTION LINE 1
COLLECTION LINE 2
WIND S 4
N
ACTUAL DELIVERY 112 lb/A
FLAG LINE
COLLECTION STATION (5 ft. Spacing)

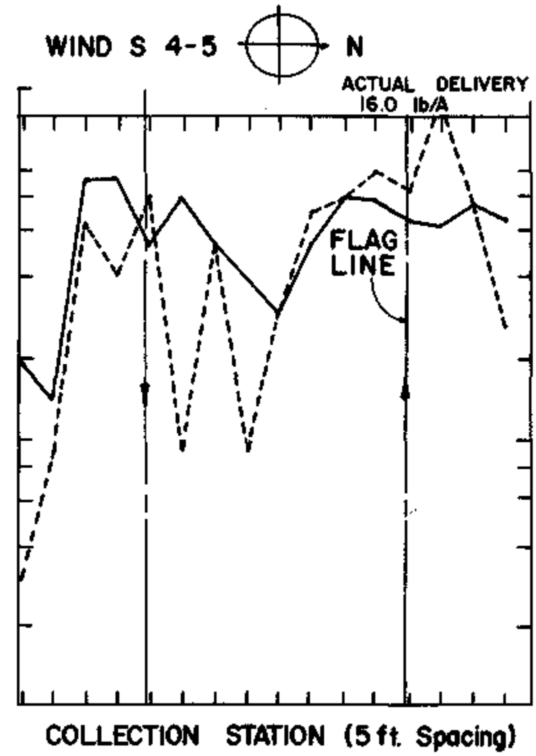

BROMACIL 10G 200 lb/A
HELICOPTER APPLICATION - FALL
COLLECTION LINE 1
COLLECTION LINE 2
WIND S 6-8
N
ACTUAL DELIVERY 204 lb/A
FLAG LINE
APPLICATION RATE lbs/A
COLLECTION STATION (5 ft Spacing


BROMACIL 10G 200 lb/A
HELICOPTER APPLICATION - FALL
COLLECTION LINE 1
COLLECTION LINE 2
WIND S 6-8
N
ACTUAL DELIVERY 182 lb/A
FLAG LINE
COLLECTION STATION (5 ft. Spacing)

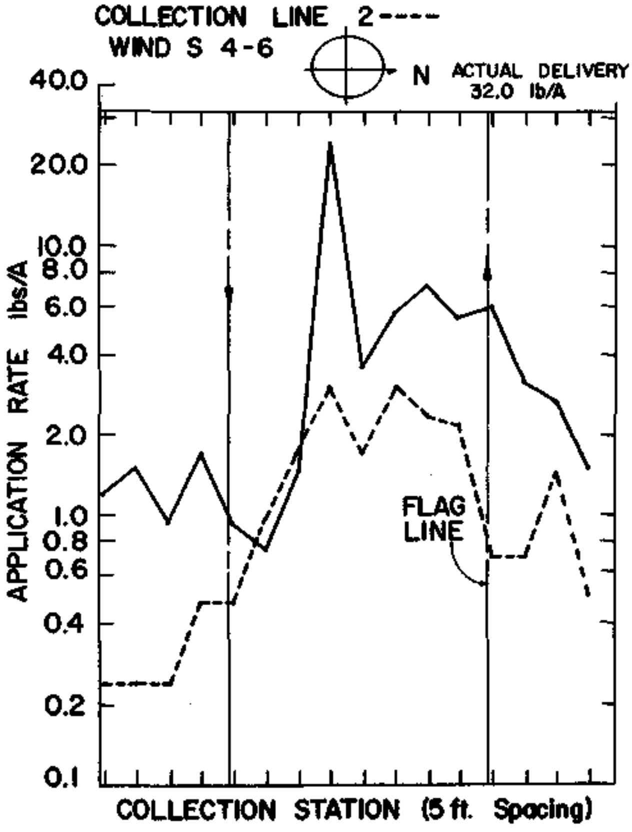
BROMACIL SYNULE 85 G 11.75 lb/A
HELICOPTER APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----



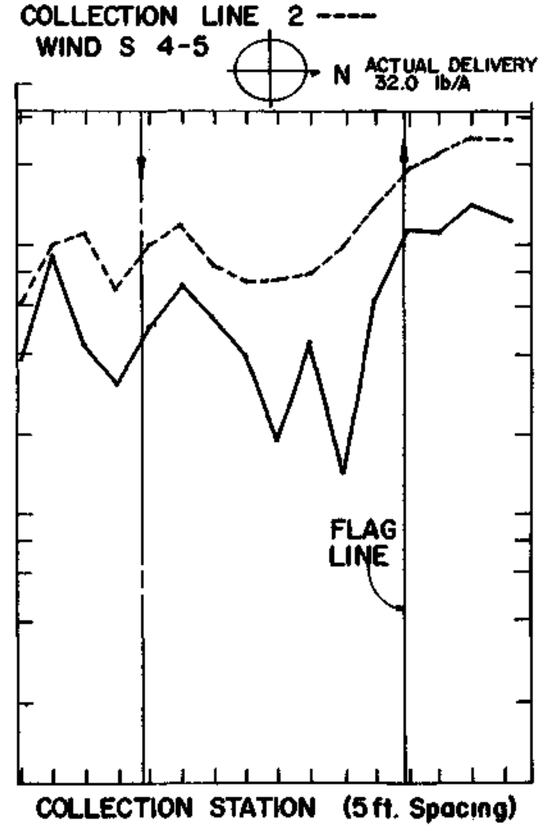
BROMACIL SYNULE 85 G 11.75 lb/A
HELICOPTER APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----



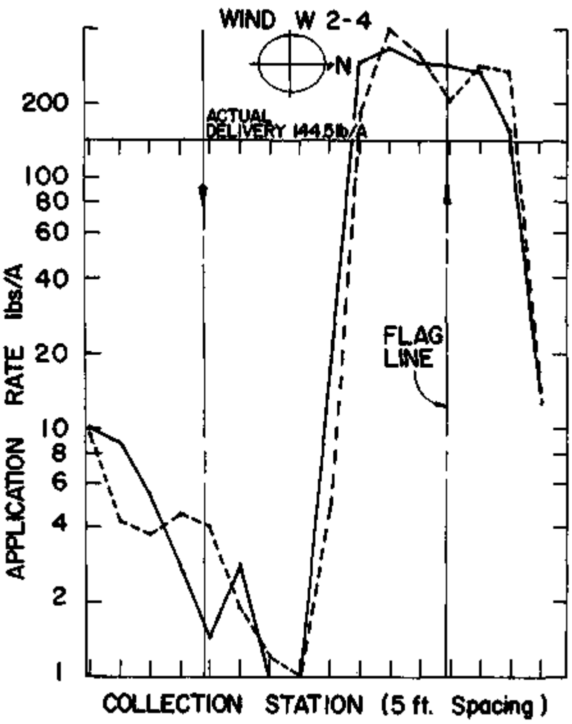
BROMACIL SYNULE 85 G 23.50 lb/A
HELICOPTER APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----



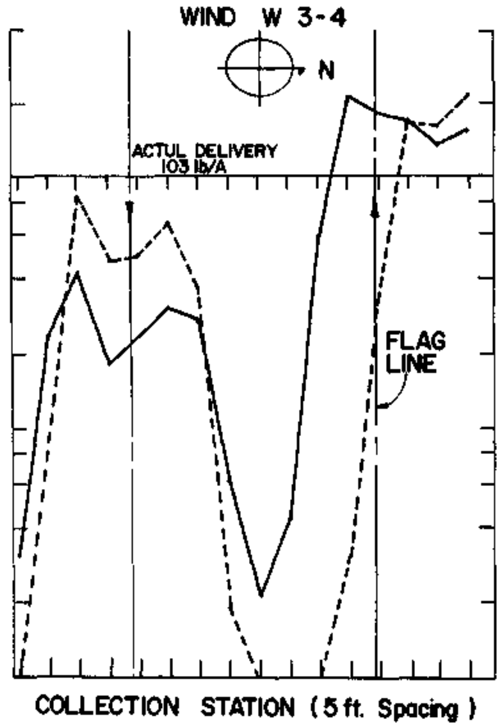
BROMACIL SYNULE 85 G 23.50 lb/A
HELICOPTER APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----



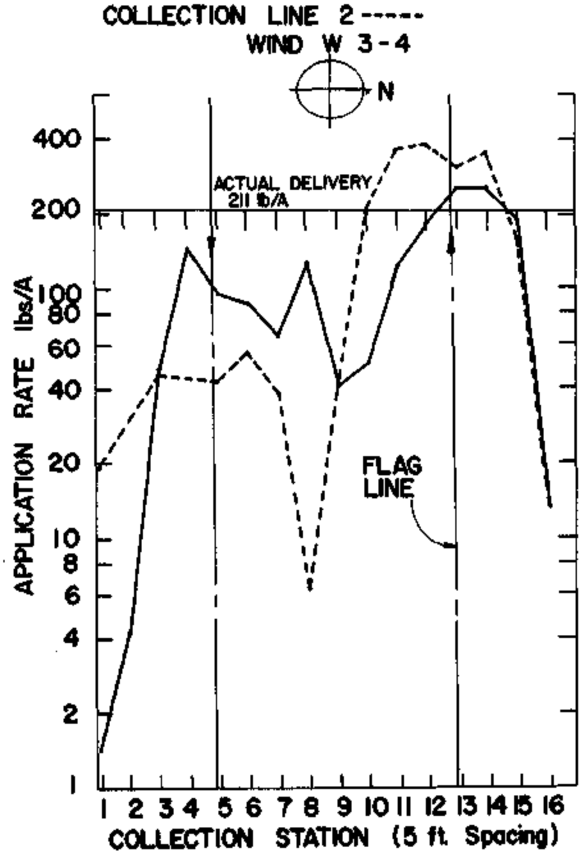
TANDEX 10G 100 lb/A
HELICOPTER APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----



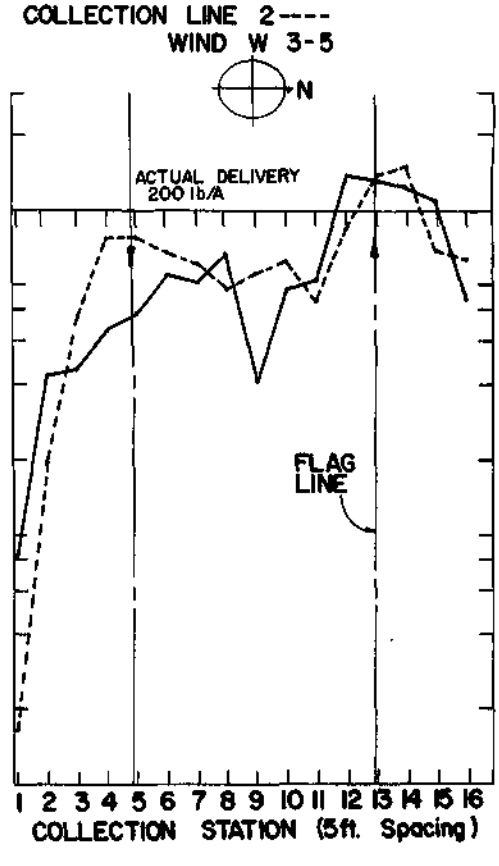
TANDEX 10G 100 lb/A
HELICOPTER APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----

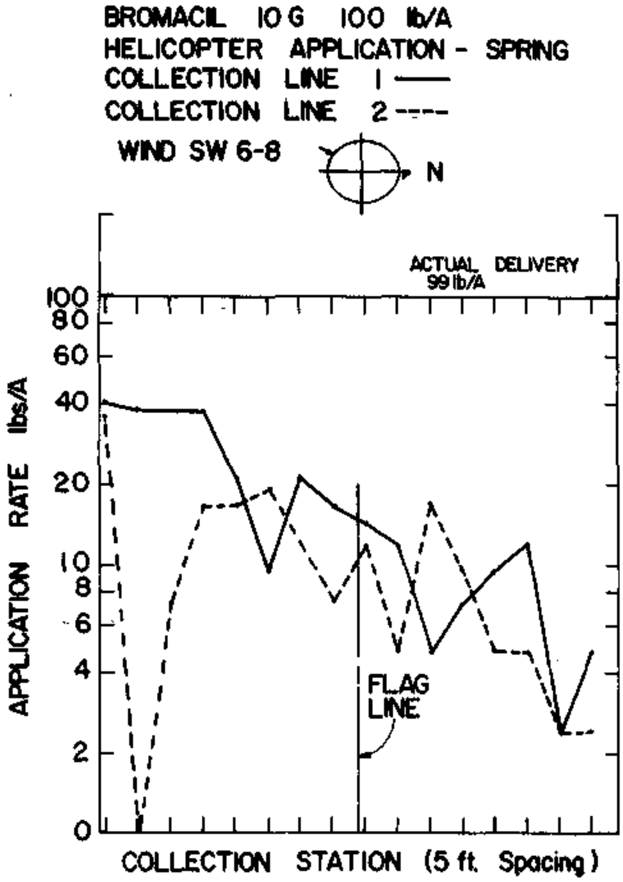


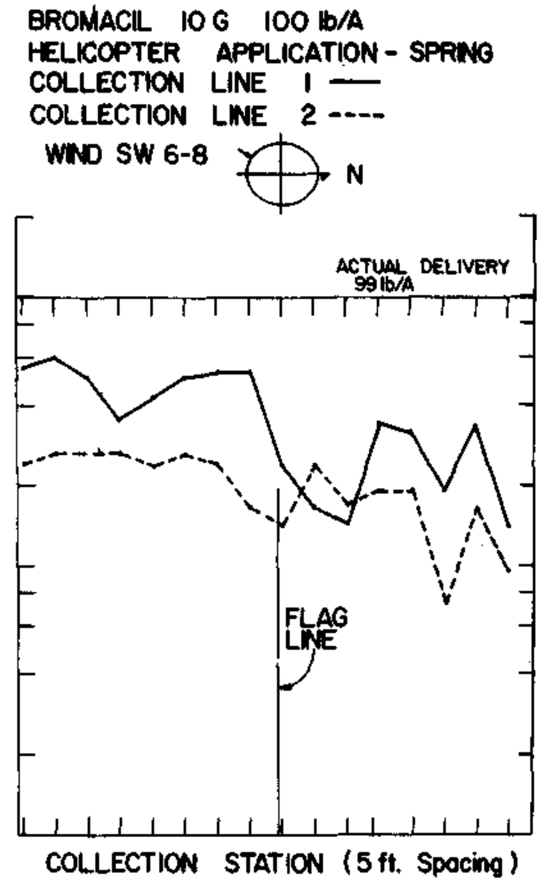
TANDEX 10G 200 lb/A
HELICOPTER APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 -----

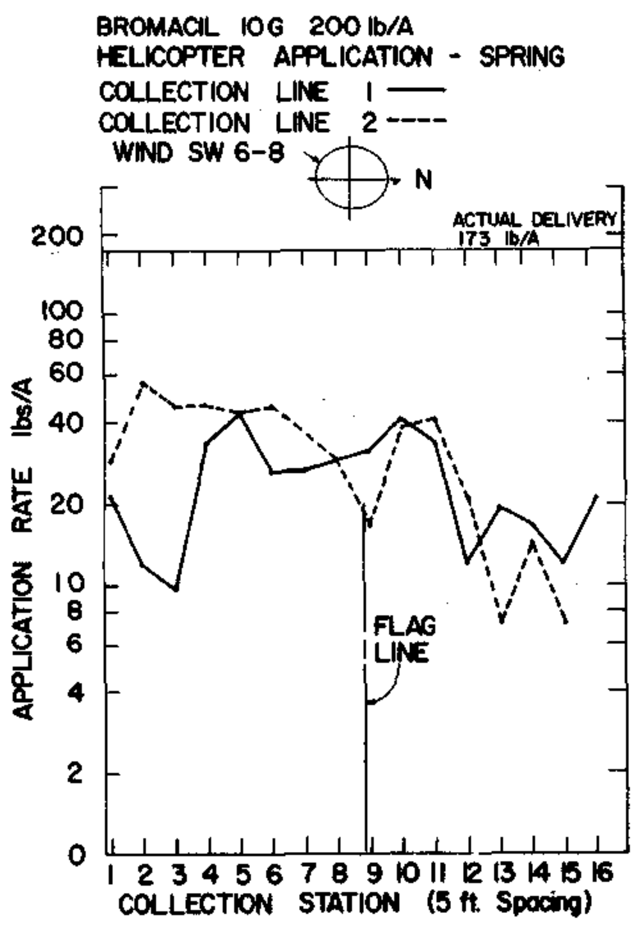


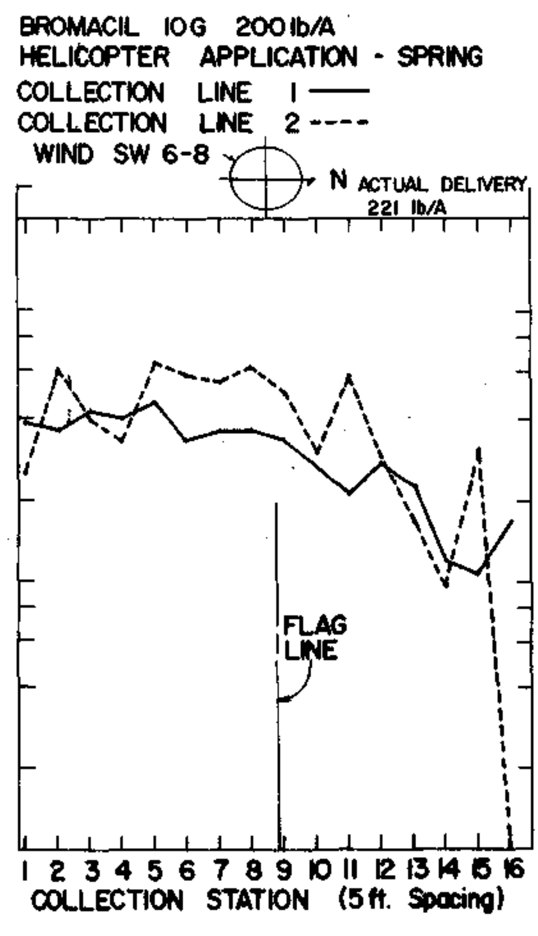
TANDEX 10G 200 lb/A
HELICOPTER APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----



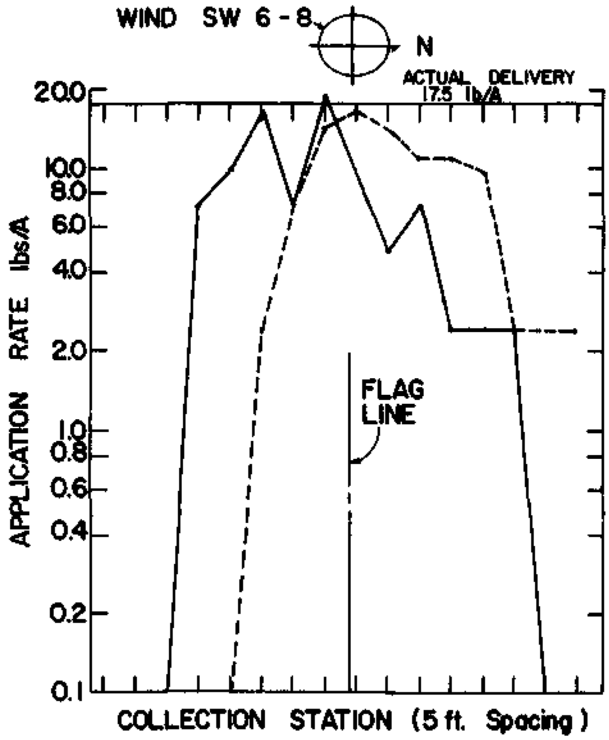

BROMACIL 10 G 100 lb/A
HELICOPTER APPLICATION - SPRING
COLLECTION LINE 1
COLLECTION LINE 2
WIND SW 6-8
N
ACTUAL DELIVERY 99 lb/A
APPLICATION RATE lbs/A
FLAG LINE
COLLECTION STATION (5 ft. Spacing)


BROMACIL 10 G 100 lb/A
HELICOPTER APPLICATION - SPRING
COLLECTION LINE 1
COLLECTION LINE 2
WIND SW 6-8
N
ACTUAL DELIVERY 99 lb/A
FLAG LINE
COLLECTION STATION (5 ft. Spacing)

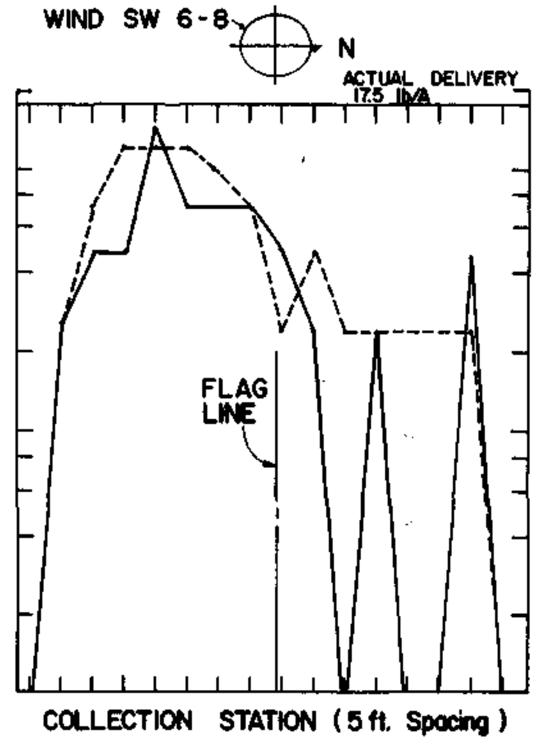

BROMACIL 10G 200 lb/A
HELICOPTER APPLICATION - SPRING
COLLECTION LINE 1
COLLECTION LINE 2
WIND SW 6-8
N
ACTUAL DELIVERY 173 lb/A
APPLICATION RATE lbs/A
FLAG LINE
COLLECTION STATION (5 ft. Spacing)


BROMACIL 10G 200 lb/A
HELICOPTER APPLICATION - SPRING
COLLECTION LINE 1
COLLECTION LINE 2
WIND SW 6-8
N
ACTUAL DELIVERY 221 lb/A
FLAG LINE
COLLECTION STATION (5 ft. Spacing)

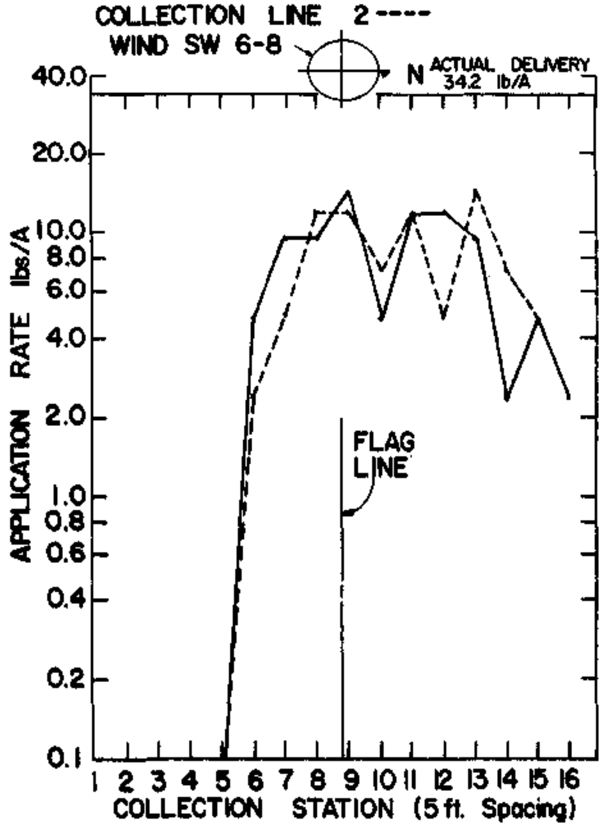
BROMACIL SYNULE 85 G 11.75 lb/A
HELICOPTER APPLICATION - SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----



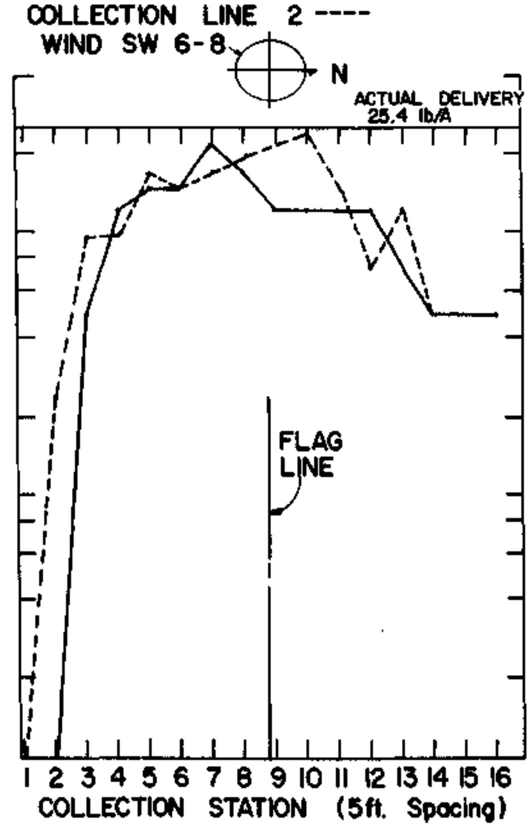
BROMACIL SYNULE 85 G 11.75 lb/A
HELICOPTER APPLICATION - SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----

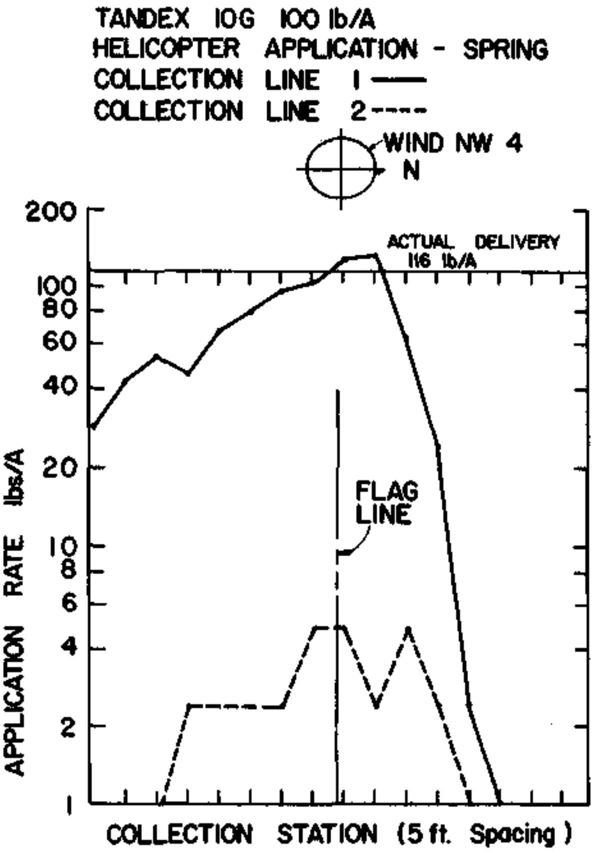


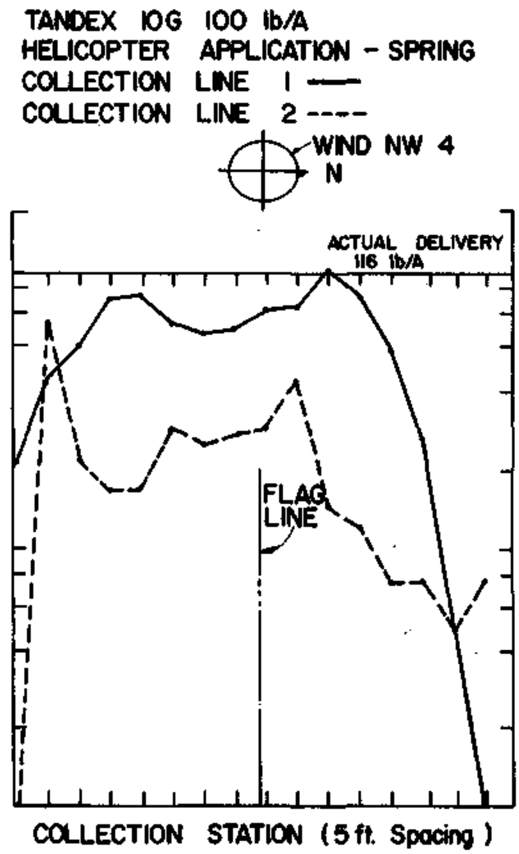
BROMACIL SYNULE 85 G 23.50 lb/A
HELICOPTER APPLICATION - SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----

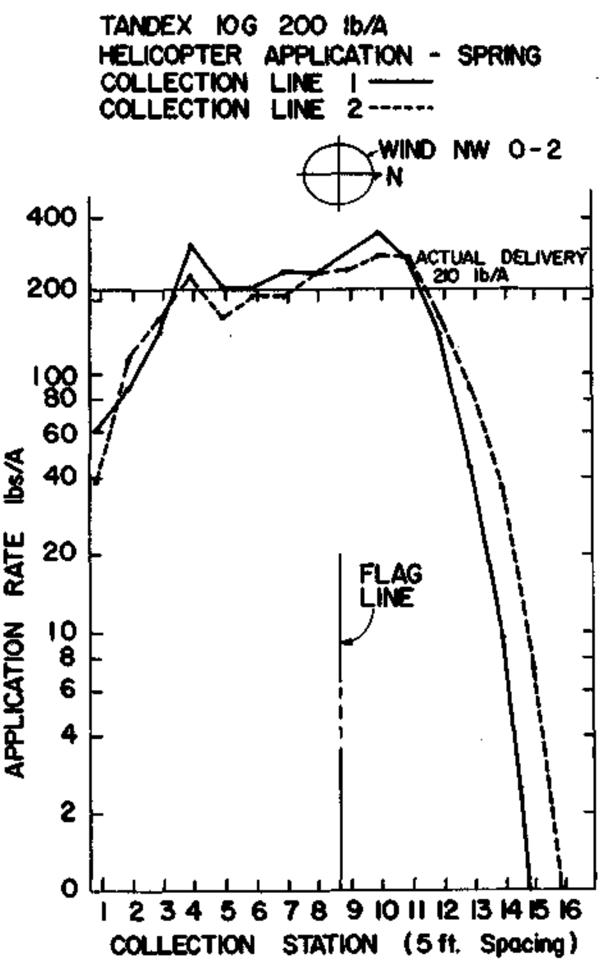


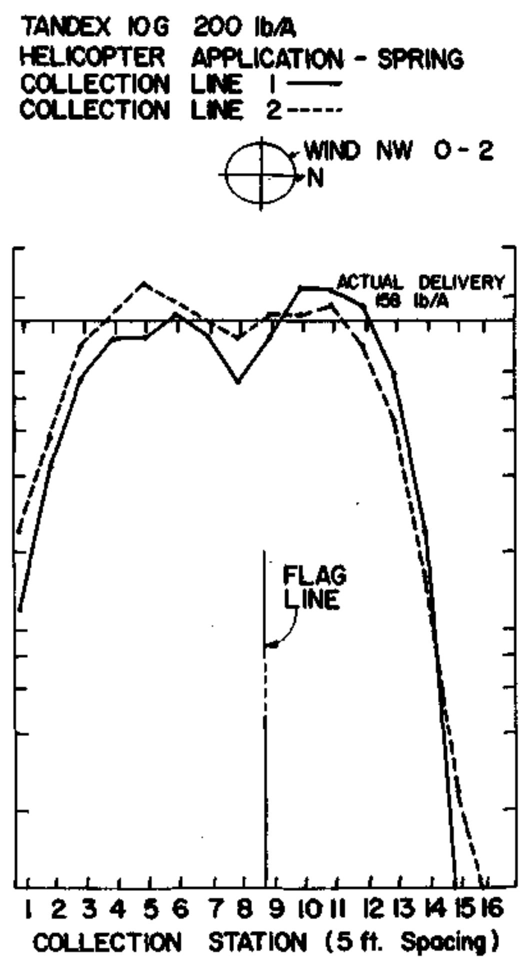
BROMACIL SYNULE 85 G 23.50 lb/A
HELICOPTER APPLICATION - SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----

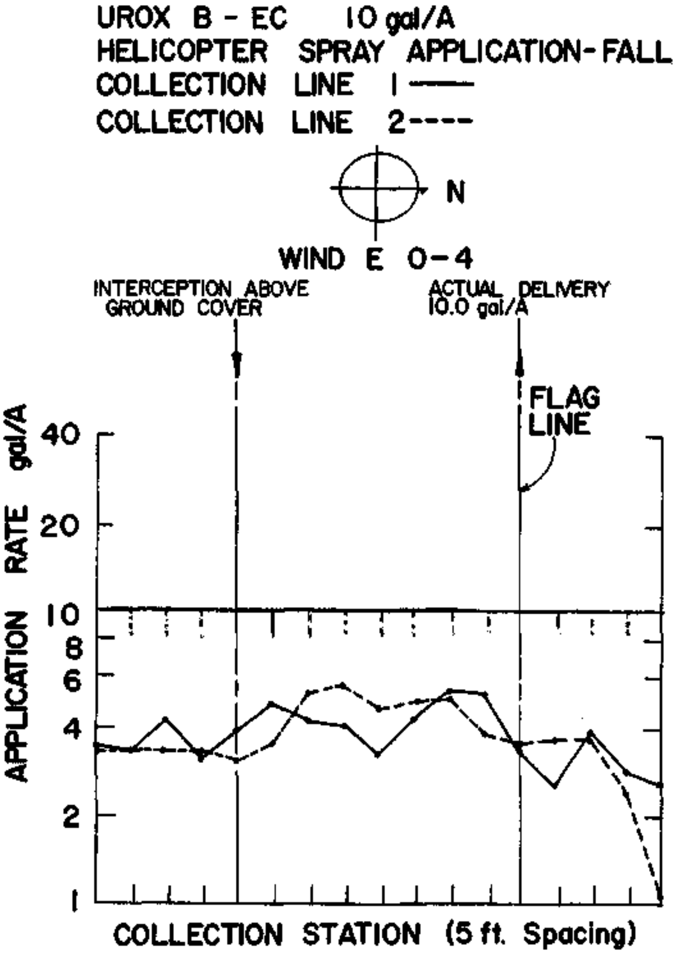


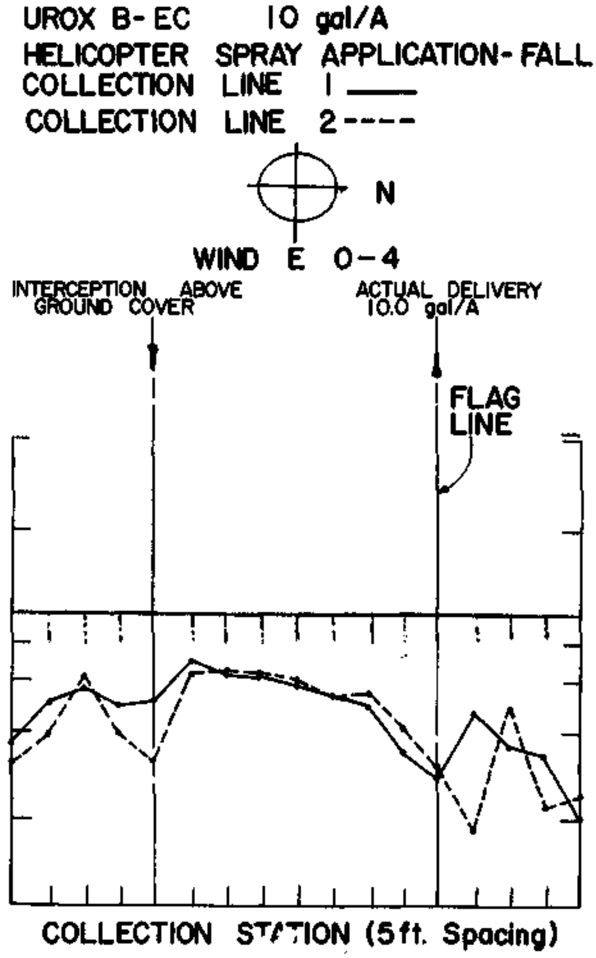

TANDEX 10G 100 lb/A
HELICOPTER APPLICATION - SPRING
COLLECTION LINE 1
COLLECTION LINE 2
WIND NW 4
N
ACTUAL DELIVERY 116 lb/A
FLAG LINE
APPLICATION RATE lbs/A
COLLECTION STATION (5 ft. Spacing)

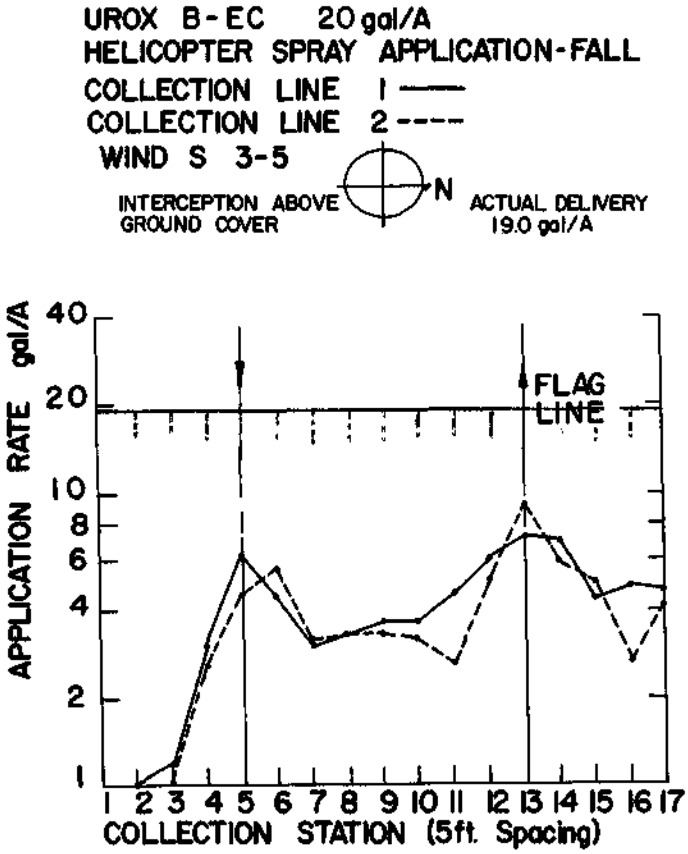

TANDEX 10G 100 lb/A
HELICOPTER APPLICATION - SPRING
COLLECTION LINE 1
COLLECTION LINE 2
WIND NW 4
N
ACTUAL DELIVERY 116 lb/A
FLAG LINE
COLLECTION STATION (5 ft. Spacing)

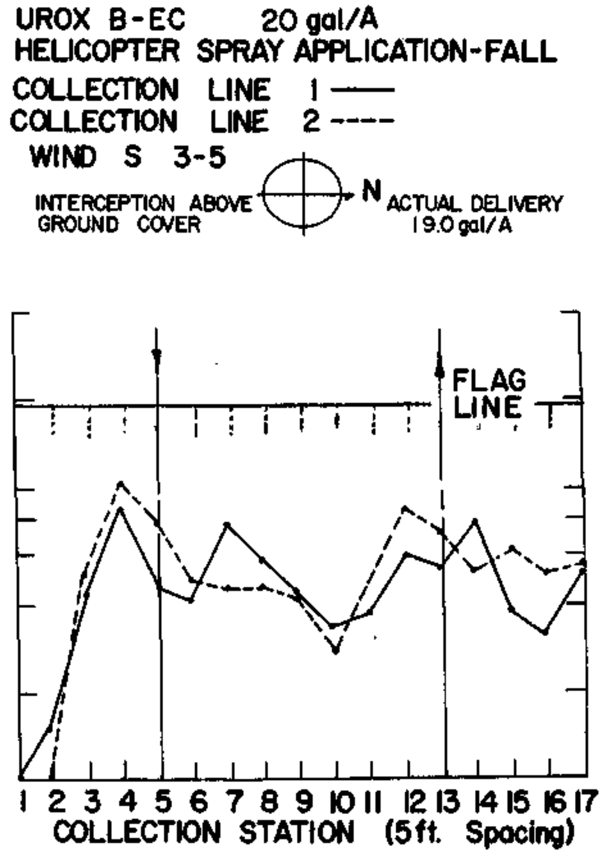

TANDEX 10G 200 lb/A
HELICOPTER APPLICATION - SPRING
COLLECTION LINE 1
COLLECTION LINE 2
WIND NW 0-2
N
ACTUAL DELIVERY 210 lb/A
FLAG LINE
APPLICATION RATE lbs/A
COLLECTION STATION (5 ft. Spacing)


TANDEX 10G 200 lb/A
HELICOPTER APPLICATION - SPRING
COLLECTION LINE 1
COLLECTION LINE 2
WIND NW 0-2
N
ACTUAL DELIVERY 158 lb/A
FLAG LINE
COLLECTION STATION (5 ft. Spacing)


UROX B - EC 10 gal/A
HELICOPTER SPRAY APPLICATION-FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
N
WIND E 0-4
INTERCEPTION ABOVE GROUND COVER
ACTUAL DELIVERY 10.0 gal/A
FLAG LINE
APPLICATION RATE gal/A
40
20
10
8
6
4
2
1
COLLECTION STATION (5 ft. Spacing)


UROX B- EC 10 gal/A
HELICOPTER SPRAY APPLICATION- FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
N
WIND E 0-4
INTERCEPTION ABOVE GROUND COVER
ACTUAL DELIVERY 10.0 gal/A
FLAG LINE
COLLECTION STATION (5 ft. Spacing)


UROX B-EC 20 gal/A
HELICOPTER SPRAY APPLICATION-FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 3-5
N
INTERCEPTION ABOVE GROUND COVER
ACTUAL DELIVERY 19.0 gal/A
FLAG LINE
APPLICATION RATE gal/A
40
20
10
8
6
4
2
1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
COLLECTION STATION (5ft. Spacing)


UROX B-EC 20 gal/A
HELICOPTER SPRAY APPLICATION-FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 3-5
N
INTERCEPTION ABOVE GROUND COVER
ACTUAL DELIVERY 19.0 gal/A
FLAG LINE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
COLLECTION STATION (5ft. Spacing)

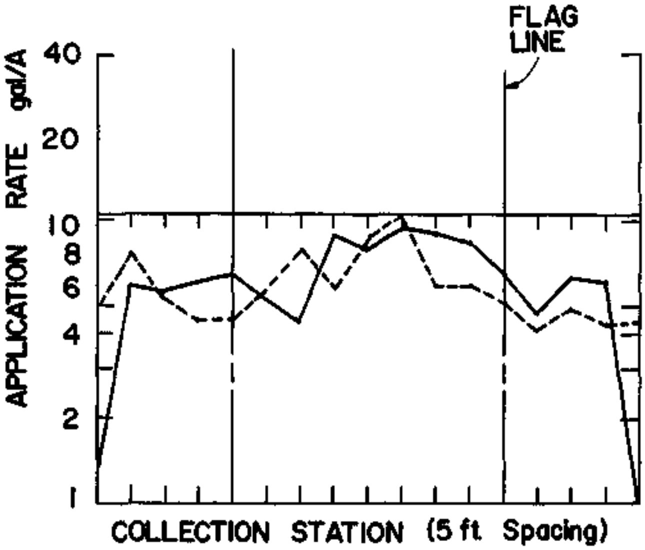
TANDEX 80 WP 10 gal/A
HELICOPTER SPRAY APPLICATION- FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----

N

WIND E 0-2

INTERCEPTION ABOVE GROUND COVER

ACTUAL DELIVERY 10.5 gal/A



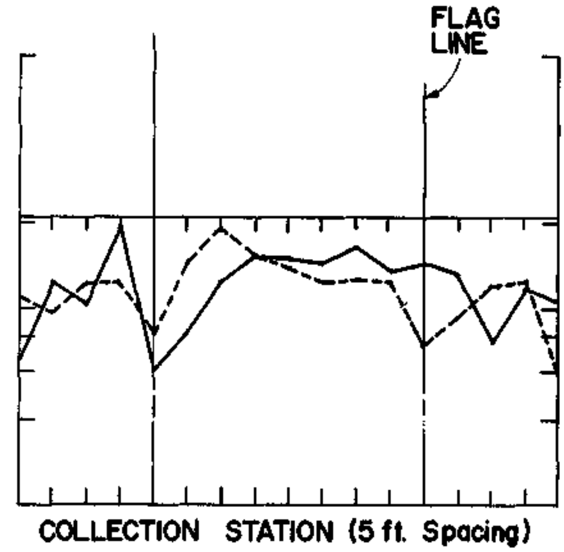
TANDEX 80 WP 10 gal/A
HELICOPTER SPRAY APPLICATION- FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----

N

WIND E 0-2

INTERCEPTION ABOVE GROUND COVER

ACTUAL DELIVERY 10.5 gal/A

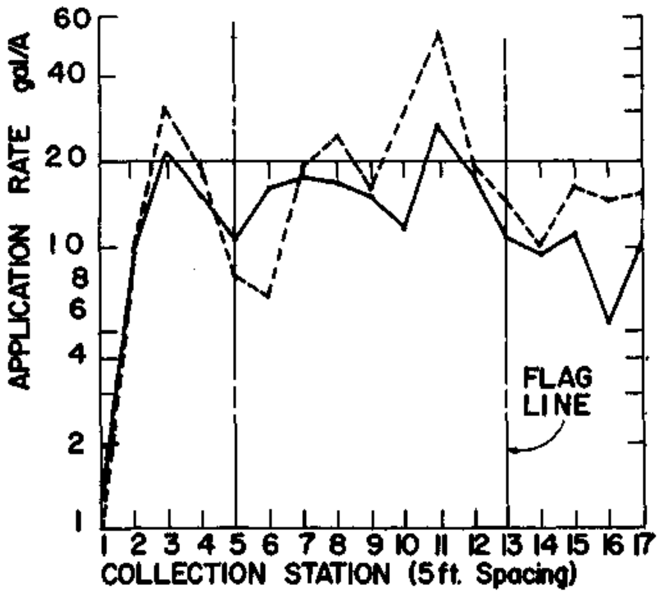


UROX 379 50WP 20gal/A
HELICOPTER SPRAY APPLICATION- FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 4

N

INTERCEPTION ABOVE GROUND COVER

ACTUAL DELIVERY 20.0 gal/A

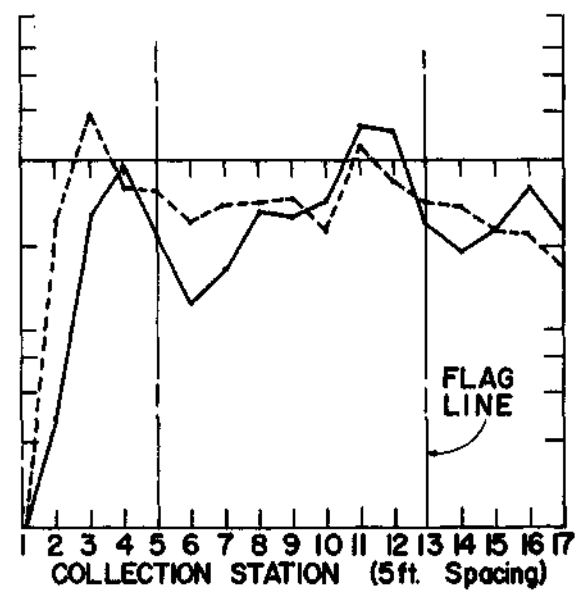


UROX 379 50WP 20gal/A
HELICOPTER SPRAY APPLICATION-FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 4

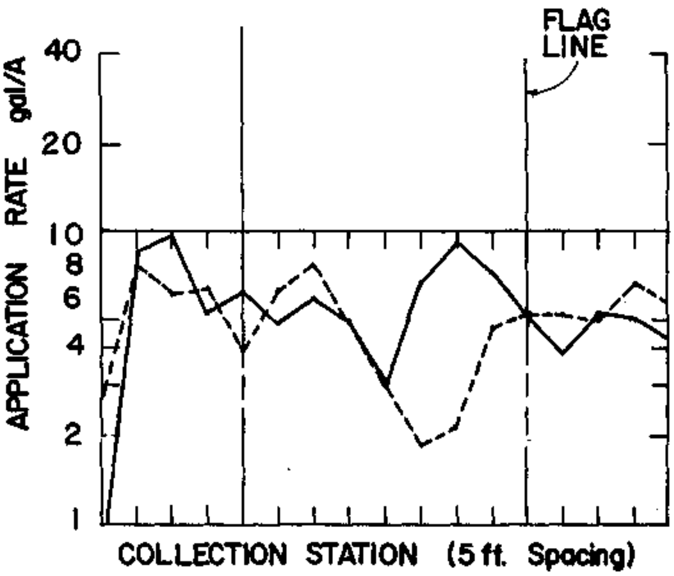
N

INTERCEPTION ABOVE GROUND COVER

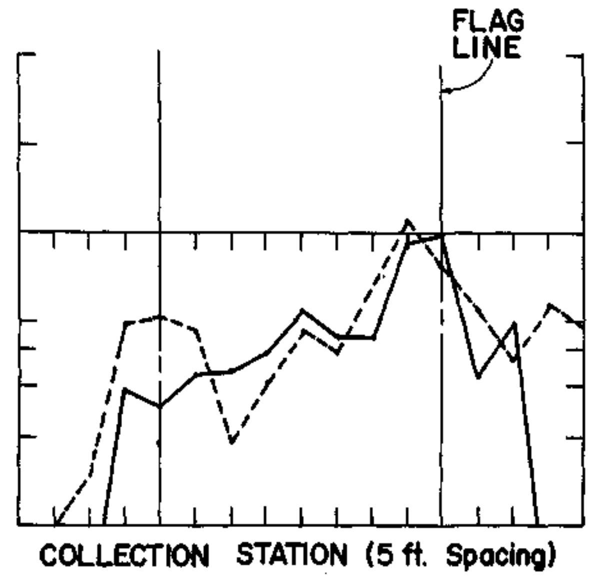
ACTUAL DELIVERY 20.0 gal/A



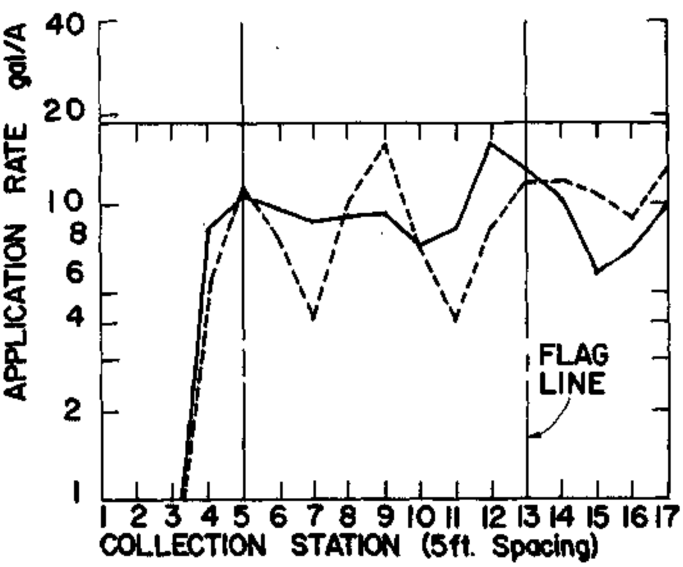
UROX 379 50WP 10 gal/A
HELICOPTER SPRAY APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
N
WIND SE 2-3
INTERCEPTION ABOVE GROUND COVER
ACTUAL DELIVERY 10.0 gal/A



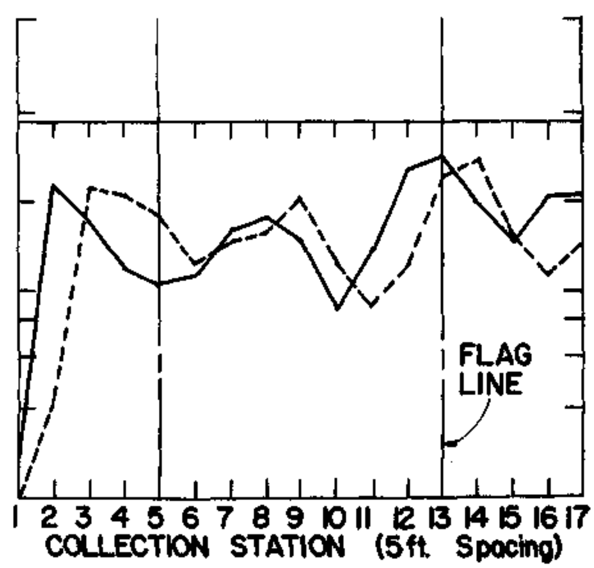
UROX 379 50WP 10 gal/A
HELICOPTER SPRAY APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
N
WIND SE 2-3
INTERCEPTION ABOVE GROUND COVER
ACTUAL DELIVERY 10.0 gal/A



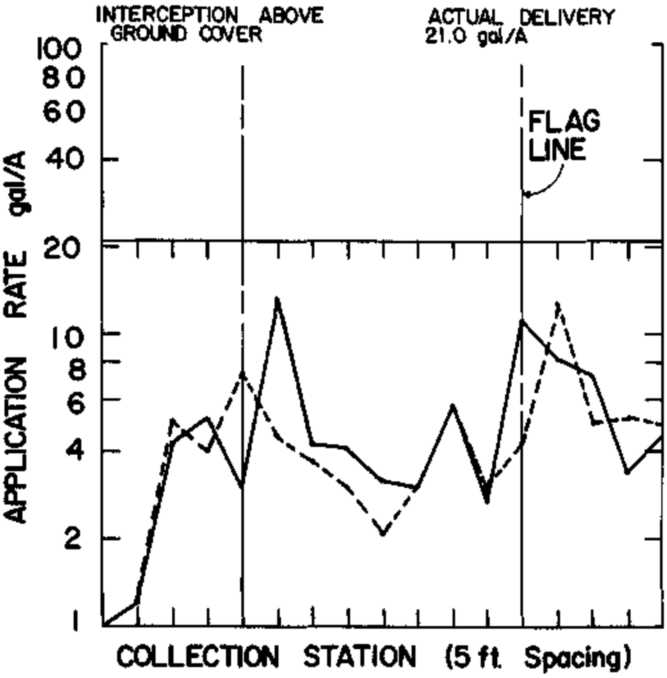
TANDEX 80WP 20 gal/A
HELICOPTER SPRAY APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 5-8
N
INTERCEPTION ABOVE GROUND COVER
ACTUAL DELIVERY 19.0 gal/A



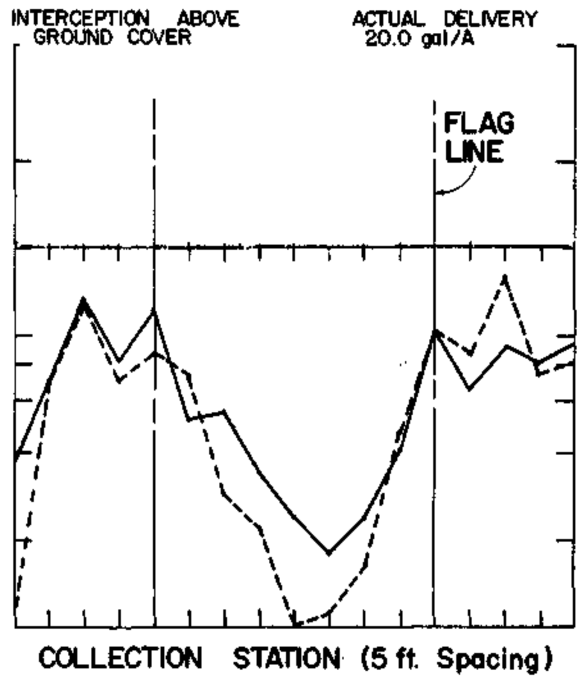
TANDEX 80 WP 20 gal/A
HELICOPTER SPRAY APPLICATION - FALL
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 5-8
N
INTERCEPTION ABOVE GROUND COVER
ACTUAL DELIVERY 19.0 gal/A



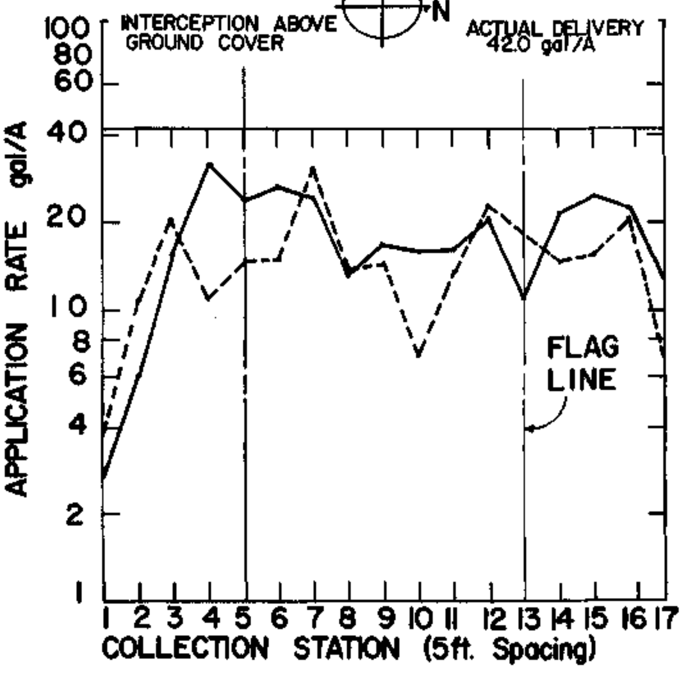
UROX B-EC 20 gal/A
HELICOPTER SPRAY APPLICATION - SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 2 N



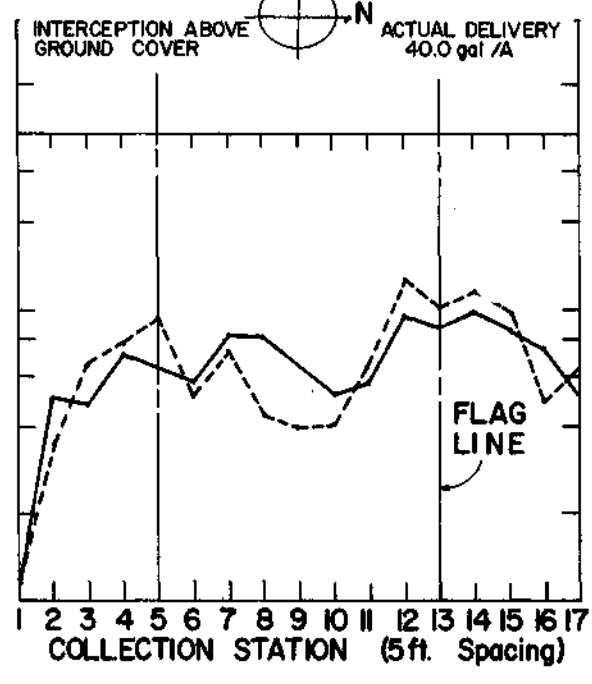
UROX B-EC 20 gal/A
HELICOPTER SPRAY APPLICATION - SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 2 N

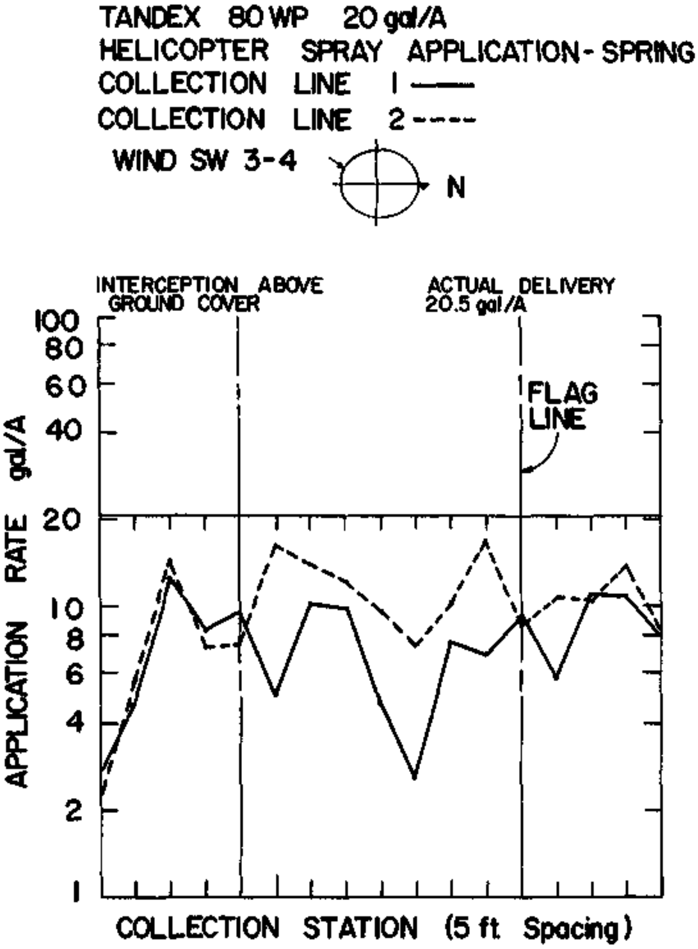


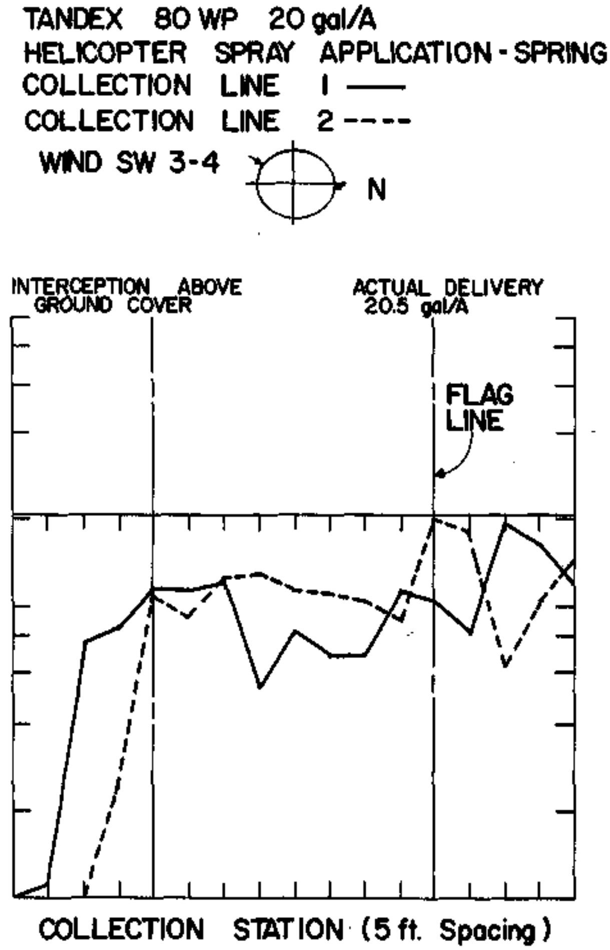
UROX B-EC 40 gal/A
HELICOPTER SPRAY APPLICATION - SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 2-3 N

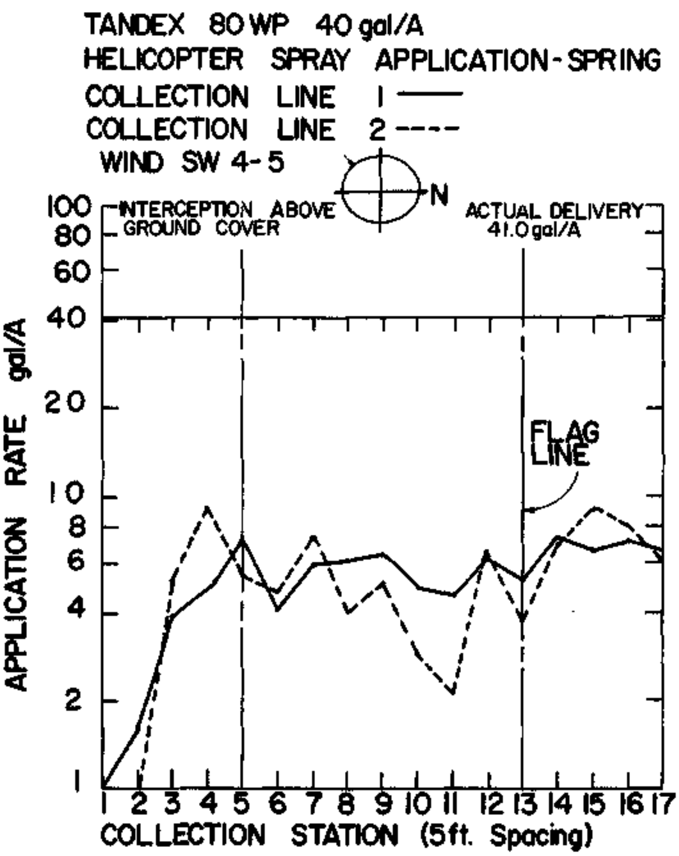


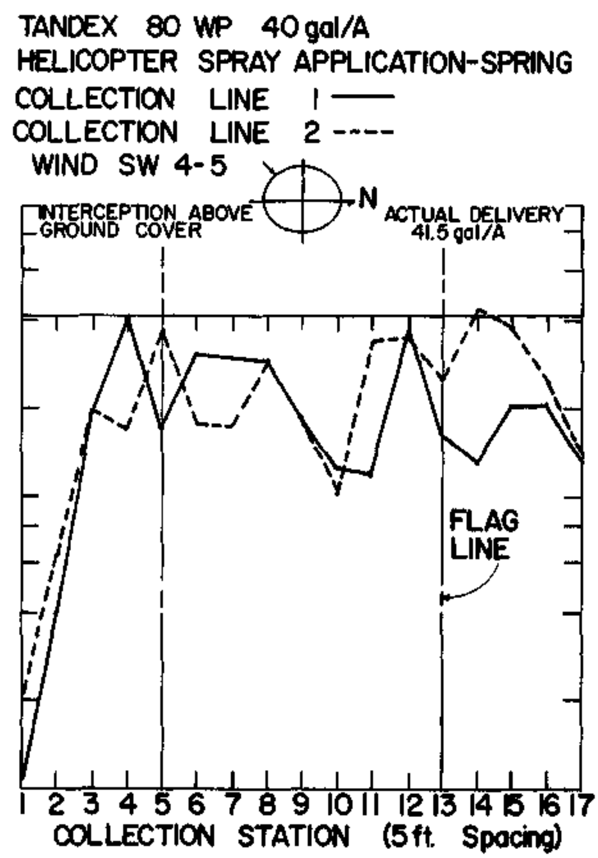
UROX B-EC 40 gal/A
HELICOPTER SPRAY APPLICATION-SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND S 2-3 N



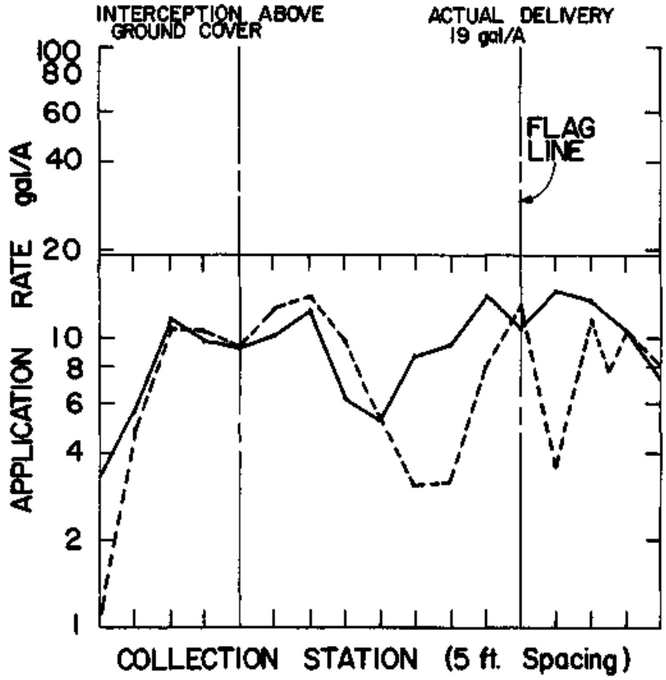

TANDEX 80 WP 20 gal/A
HELICOPTER SPRAY APPLICATION - SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND SW 3-4
N
INTERCEPTION ABOVE GROUND COVER
ACTUAL DELIVERY 20.5 gal/A
FLAG LINE
APPLICATION RATE gal/A
100
80
60
40
20
10
8
6
4
2
1
COLLECTION STATION (5 ft. Spacing)


TANDEX 80 WP 20 gal/A
HELICOPTER SPRAY APPLICATION - SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND SW 3-4
N
INTERCEPTION ABOVE GROUND COVER
ACTUAL DELIVERY 20.5 gal/A
FLAG LINE
COLLECTION STATION (5 ft. Spacing)

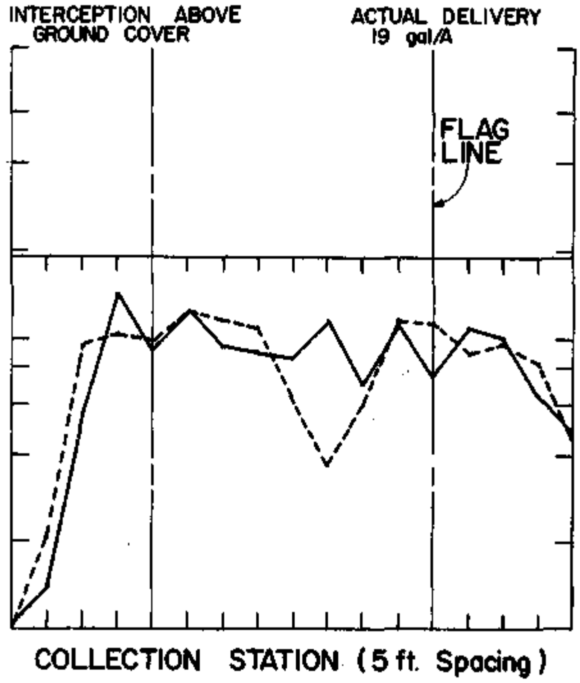

TANDEX 80 WP 40 gal/A
HELICOPTER SPRAY APPLICATION - SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND SW 4-5
N
INTERCEPTION ABOVE GROUND COVER
ACTUAL DELIVERY 41.0 gal/A
FLAG LINE
APPLICATION RATE gal/A
100
80
60
40
20
10
8
6
4
2
1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
COLLECTION STATION (5 ft. Spacing)


TANDEX 80 WP 40 gal/A
HELICOPTER SPRAY APPLICATION - SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND SW 4-5
N
INTERCEPTION ABOVE GROUND COVER
ACTUAL DELIVERY 41.5 gal/A
FLAG LINE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
COLLECTION STATION (5 ft. Spacing)

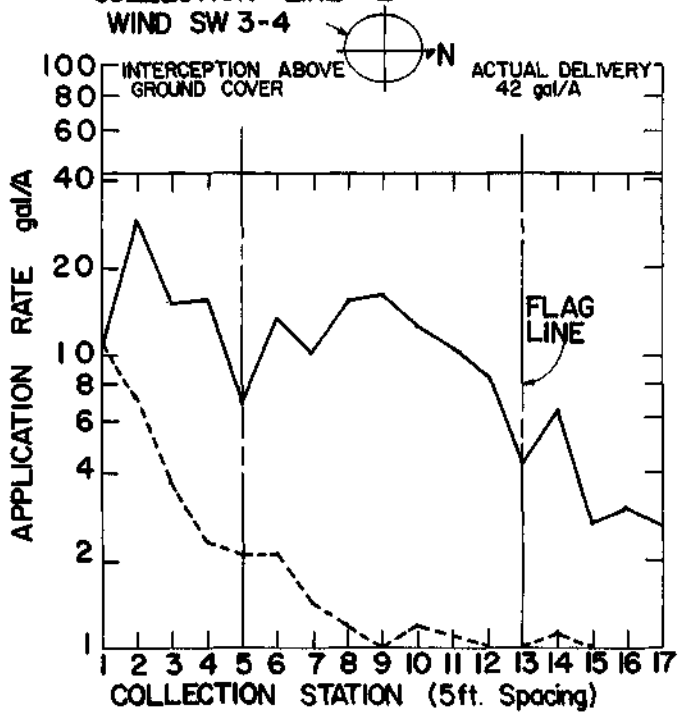
UROX 379 50WP 20 gal/A
HELICOPTER SPRAY APPLICATION-SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND SW 2-3 N



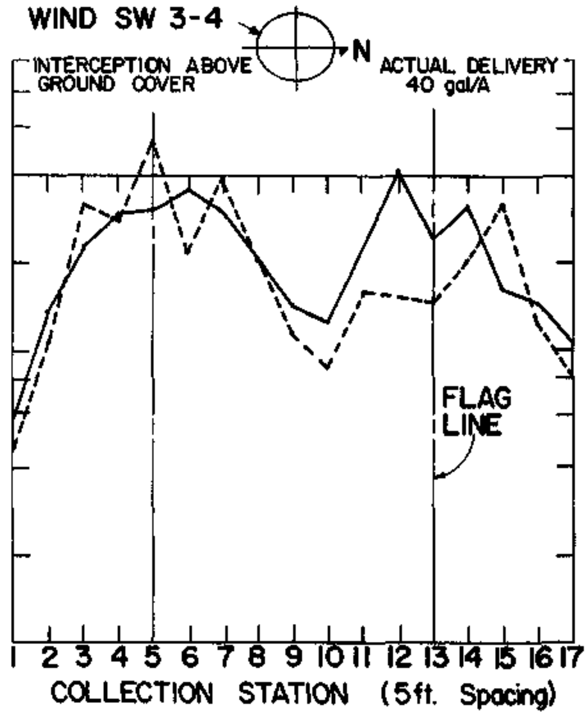
UROX 379 50WP 20 gal/A
HELICOPTER SPRAY APPLICATION-SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND SW 2-3 N



UROX 379 50WP 40 gal/A
HELICOPTER SPRAY APPLICATION-SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND SW 3-4



UROX 379 50WP 40gal/A
HELICOPTER SPRAY APPLICATION-SPRING
COLLECTION LINE 1 ——
COLLECTION LINE 2 ----
WIND SW 3-4



Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

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	2b. GROUP

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5. AUTHOR(S) (First name, middle initial, last name)

Wayne G. McCully and Charles W. Robinson

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c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
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13. ABSTRACT

Bromacil and Tandex were applied to one-acre plots as granules and as sprays using rotary-wing aircraft, and as granules using fixed-wing aircraft. Granular materials were applied at rates ranging from 11 to 200 lbs/A. Spray volumes ranged from 10 to 40 gal/A.

The spray volumes dispensed did not differ more than five percent from scheduled amounts, but the output of granular materials was more variable. The greatest difficulty in delivery was encountered with granules formed on a sand core. Individual sand grains interferred with the proper operation of gates in the rotary-wing distributors. Also, the variation between scheduled and measured delivery of granules from rotary-wing equipment was greatest when less than 25 lb/A was applied, indicating a need for a less sensitive gate design.

Distribution of applied materials was measured by collecting samples of granules for weighing or samples of dyed spray for colorimetric determination. Generally, the distribution patterns were satisfactory.

The characteristics of each type of aircraft and the different forms of materials are discussed as they would apply to a military operation.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Aerial equipment						
Bromacil and Tandex herbicides						
Colorimetric measurement of dye						
Fixed-wing Aircraft						
Granular materials						
Herbicide distribution						
Rotary-wing aircraft						
Spray volumes						