THE EFFECT OF AERIAL APPLICATION EQUIPMENT ON HERBICIDE SPRAY PATTERNS AND ON THE CONTROL OF WEEDS AND BRUSH

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CHAPTER I

INTRODUCTION

The control of weeds and brush in range and pastures is often necessary for grass production. Airplanes are used to apply herbicides to millions of acres annually on rangeland not accessible by ground spray equipment. Although airplanes decrease the cost of herbicide application and increase the total acreage covered, the drift of herbicides is greatly enhanced by airplane application. Spray drops released from airplanes are subject to natural air turbulences as well as artificial turbulences created by the airplane. Air-borne spray drops may move downwind for many miles often endangering valuable crops.

Within recent years, the use of herbicides such as 2,4,5-T has become a matter of intense public concern. To insure safe use of such herbicides, application techniques must be developed which reduce the drift hazard. Several types of application equipment have been developed which offer some control of drift. However, this equipment must be evaluated to determine, not only drift control but also the control of target plants.

The objectives of this study were (1) to compare the spray distribution achieved by each of four spraying systems, (2) to evaluate the effectiveness of each of these systems on the control of target plants, and (3) to correlate spray distribution with herbicidal phytotoxicity.

CHAPTER II

REVIEW OF LITERATURE

Factors Affecting Herbicide Drift

One of the inherent problems associated with the aerial application of herbicides is that of spray drift (35). Spray drift is the lateral movement of airborne spray particles and is dependent upon such things as drop size, wind speed, and height of spray release above the ground (28). There are two important reasons why spray drift should be kept to a minimum.

1. Herbicide loss by spray drift may cause damage to susceptible crops for several miles depending upon weather conditions. For example, cotton (*Gossypium hirsutum* L.) may develop characteristic phenoxy herbicide symptoms with as little as one-one-thousandth pound per acre (24). For this reason, aerial application of herbicides is often limited by the proximity of broadleaf crops such as cotton, tomatoes (*Lycopersicum esculentum* Mill.), peanuts (*Arachis hypogaea* L.), and other desirable vegetation susceptible to drift from hormone sprays during application (12).

2. The loss of spray material may considerably reduce the effectiveness of the spraying operation (29).

At the time of spraying, relative humidity may become an important parameter affecting drift. Low relative humidity may cause an increase in the evaporation of drops as they fall through the air. Conversely, high relative humidity would tend to reduce the evaporation of falling spray drops. The effect of relative humidity on the electrostatic charging system was studied by Sasser et al. (37). They found that greater particle deposition would occur by the electrostatic charging system if the relative humidity remained high.

High wind velocity at the time of application may drastically reduce the amount of spray material reaching the target area while greatly enhancing the drift hazard. Spray drops produced by most conventional spraying systems vary greatly in size and number. Spray drops with sizes ranging from less than 20 microns in diameter to more than 1000 microns in diameter are not uncommon. Klingman (28) calculated the distance traveled by various sized water drops in a 3 mile per hour breeze. He found that large drops (1000 microns in diameter) would follow nearly a vertical downward path, mist-sized drops (approximately 100 microns in diameter) could travel as far as 409 feet downwind while falling only 10 feet vertically, and very small, fog-sized drops (approximately 5 microns in diameter) might travel as far as 3 miles downwind.

Fisher and Young (17) compared various drop sizes with wind speeds when airplanes were used. They found that moderately coarse drops were less hazardous as far as drift was concerned as compared to fine-sized drops when the wind was blowing at a velocity of 12 miles per hour.

Morgan et al. (34) conducted spray drift tests with varied pressure, air velocity, and nozzle size. Their tests were conducted in a wind tunnel using six fan-type weed spray nozzles of various sizes. The effect of wind on the spray pattern at pressures of 30 and 45 pounds per square inch was determined. The air velocities selected were 0, 2, 6.5, and 13.5 miles per hour. Spray distribution was measured by collecting the spray on corrugated trays. Measures of drift beyond the corrugated trays were made by collecting spray on 4 (1 by 3 inch) stainless steel plates placed on the floor of the tunnel. Results of their studies showed that spray patterns of small orifice nozzles were more subject to drift than patterns from high discharge nozzles. Increased pressure caused greater drift with all nozzles tested. There was less spray drift, on a volume basis, from high discharge nozzles than from low discharge nozzles at 6.5 miles per hour. At 13.5 miles per hour, there was about the same amount of drift from both sizes of nozzles. A negligible difference in drift was produced at the two different pressures at the lower air velocity of 6.5 miles per hour. The drift of spray material at 45 pounds per square inch was significantly greater than drift at 30 pounds per square inch at the higher air velocity of 13.5 miles per hour.

High operating pressures tend to cause more atomization of the spray material as it leaves the nozzle. Hedden (22) found that drop median diameter decreased linearly as operating pressure increased from 20 pounds per square inch to 200 pounds per square inch. French (18) using a compressed air sprayer, collected oil drops and found that the average diameter of the drops decreased as the pressure increased from 20 to 110 pounds per square inch. The air pressure most commonly used with this sprayer was between 60 and 90 pounds per square inch which gave drop sizes averaging between 30 and 45 microns in diameter.

That smaller sized drops are more susceptible to drift than larger drops has been well documented (3, 8, 23, 28). Extensive interest has developed within recent years with the increasing use of the ultra low volume (ULV) spraying techniques. Since ULV spraying makes use of much smaller volumes of spray than was common in conventional systems, it becomes necessary to use more concentrated sprays. Drift then becomes extremely hazardous due to higher concentrations in each drop (38). Spray drops must be numerous enough to cover the foliage yet large enough to avoid drift to non-target areas.

Smith and Burt (39) in a study of ULV drops in cotton, found that small drops (approximately 100 microns in diameter) were deposited as far downwind as 66 feet while larger sized drops (approximately 300 microns in diameter) essentially remained within the treated row. Wind velocities in this study were approximately 1½ miles per hour. Hedden (22) found that small drops of less than 20 microns in diameter made up over 90 percent of the total drops produced by flat and cone-spray nozzles. However, only about 1 per cent or less of the total spray volume was in this size range. In this experiment, operating pressure was 100 pounds per square inch.

Effect of Droplet Size and Distribution on Phytotoxicity

One of the earliest attempts to correlate drop size with herbicidal phytotoxicity was made by Hull (26). He treated velvet mesquite seedlings /*Prosopis juliflora* var. *velutina* (Woot.) Sarg./ with the propyleneglycol butylether ester of (2,4,5-tricholorophenoxy) acetic acid (2,4,5-T). On one set of plants all leaflets were treated and on another set only every third leaflet was treated. His findings suggested that coarse drop sprays would not contact every leaf and leaflet. Thus some leaves and leaflets would still be left to carry on photosynthesis which then would aid in translocation of herbicide within the plant.

In another study, Behrens (6), using mesquite seedlings, found that, within limits, drop spacing was more important than drop size, spray volume, and herbicide concentration on the effectiveness of 2,4,5-T sprays. An average drop spacing of 3100 microns (equivalent to 72 drops per square inch) was found to be the optimum distance between drops. Previously, Behrens et al. (7) reported that 200 micron drops applied at the rate of 575 per square inch were most effective in controlling mesquite seedlings.

Numerous researchers have reported that medium to coarse-sized drops (250-550 microns average diameter) give equally as effective herbicidal responses as do fine-sized drops (less than 100 microns in diameter) (13, 16, 26, 40). Fisher and Young (17) found that 2,4,5-T was slightly more phytotoxic to mesquite when medium to coarse drops were sprayed from an airplane as compared to fine-sized drops.

Smith (40) using a DeVilbiss paint-spray gun calibrated to produce large drops (250-560 microns average diameter) and small drops (30 microns average diameter) treated kidney bean (<u>Phaseolus vulgaris</u> L.) with the ammonium salt of (2,4-dichlorophenoxy) acetic acid (2,4-D). The 2,4-D was applied at weight rates of 0.5, 1.0, and 2.0 milligrams per square yard. Each rate was applied at volume rates of 10, 30, and 60 milliliters per square yard. He found that those plants treated with larger drops were more effectively controlled than those plants treated with smaller drops. However, the sprays of small-drop size were found to be more effective when applied in the larger volumes of 60 milliliters per square yard.

Contrary to the results of Smith, Ennis and Williamson (15) using a DeVilbiss paint-spray gun treated Black Wilson soybean (Glycine max. Merr.) with spray drops of different sizes. The ethyl ester and triethanolamine salt of 2,4-D were applied with fuel oil and water respectively as carriers. By measuring the yield of threshed soybeans, they found that herbicide toxicity increased as the drop diameter decreased from 0.3 millimeters to 0.1 millimeters.

Way (43) treated lettuce (Lactuca sativa L.) with /(4-chloro-o-toyl) oxy/ acetic acid (MCPA) using drop sizes of approximately 100 and 500 microns in diameter. The drops were produced by a spinning disk apparatus. He found a significant decrease in fresh weight of lettuce when treated with small drops at 0.022 pound per acre compared to 0.005 pound per acre. In all experiments, there was a trend for a greater number of leaves to be severely affected by the smaller drop application.

Hurtt et al. (27) applied butyl esters of 2,4-D and 2,4,5-T to beans at a volume of 0.59 microliters per plant. Using a spinning cup apparatus which produced drops ranging between 125 and 500 microns in diameter, they observed a 5-fold increase in activity as the drop size decreased from 500 to 125 microns.

Buehring (9) conducted field studies to determine the effect of herbicide spray drop size and carrier volume on the control of pigweeds (Amaranthus spp.). Single jet orifices were used with a magnetostrictive device to produce drops of uniform size. The single jet nozzle orifices used were 200, 400, and 600 microns producing sprays in which drop diameter sizes were 401, 699, and 860 microns respectively. Also included in this study was a conventional nozzle producing drops having a mass median diameter of 375 microns. Herbicides were 1,1-dimethyl-3-(a,a,a-trifluoro-m-tolyl) urea (flometuron) plus monosodium methanearsonate (MSMA) applied at 1.1 plus 2.2 and 1.7 plus 3.3 kilograms per hectare at carrier volumes of 47, 94, 188, and 281 liters per hectare. His results indicated that as carrier volume decreased and drop size increased, pigweed control decreased but increased herbicide rate and carrier volume masked the effects of drop size. He concluded that smaller drops at low carrier volumes were more effective on pigweed. Buehring et al. (10) had previously reported that the herbicidal activity generally decreased with increasing drop size and that drop size significantly affected the phytotoxicity of 1,1'-dimethyl-4-,4'bipyridinium ion (paraquat), 3-(3,4-dichlorophenyl)-1,1-dimethylurea (diuron), and fluometuron.

A study by Douglas (13) using paraquat and 6,7-dihydro-dipyrido (1,2-a:2',1'-c) pyrazinediium ion (diquat) on broad bean (Vicia faba L.) indicated that herbicidal effectiveness was optimum when the drop size ranged between 400 and 500 microns. Diquat was applied at concentrations of 0.09-0.34 per cent ion and paraquat applied within the range 0.0625-0.75 per cent. Optimum concentration efficiency was found to be 0.09-0.34 per cent for diquat ion and 0.25 per cent for paraquat.

In a study to correlate phytotoxicity with operating pressure, Anliker and Morgan (5) sprayed bean plants with the proplylene glycol butylether ester of 2,4-D. In this study spray volume was 25.4 gallons per acre with 2,4-D concentration of 2000 parts per million. Three spray nozzles (650033, 650067, and 65015) were used which delivered 0.15, 0.067, and 0.033 gallons per minute at 30 pounds per square inch. The quantities of spray applied with the three nozzles at pressures of

20, 30, 40, 60, and 80 pounds per square inch were equalized by adjusting the speed which the test plants moved under the nozzle. They found that as the operating pressure increased from 20 to 80 pounds per square inch there was a decrease in the terminal growth of beans. At the higher operating pressures more fine-sized drops are produced.

Reducing Spray Drift

Inverts

The invert emulsion has been recognized as one means of confining drift to the treatment area. In contrast to the commonly used oil-in-water emulsion, an invert is a water-in-oil emulsion. Lehman et al. (30) compared the invert emulsion with the standard oil-in-water emulsion on post oak (*Quercus stellata* Wangenh.), blackjack oak (*Quercus marilandica* Muenchh.), and mesquite. They used fixed-wing aircraft for the mesquite and helicopters for the oaks. They found little difference between emulsion types on post oak; but on blackjack oak the invert emulsion gave consistently lower leaf defoliation. Mesquite results were erratic when the spray volume was reduced from 10 gallons per acre to 5 gallons per acre with the invert emulsion giving less herbicidal response. The invert emulsion appeared to give poor spray distribution across the swath.

Somewhat similar results were reported by Haas and Darrow (20) in a study of invert emulsions. Using 2,4,5-T they found that 8 gallons per acre of invert emulsion was needed to approach the effectiveness of 5 gallons per acre of standard emulsion on post oak. Again in this study, drop size and distribution of the invert emulsion reduced its effectiveness.

Polymers

A second type of drift control material is the particulated sprays described as a water-swellable, water-insoluble polymer which forms a "particulated" spray (24). Holmsen et al. (25) using a particulating agent on a ground rig reported that the spray drift was confined to within 10 feet of the spray swath when winds were less than 5 miles per hour and within 25 feet with wind speed near 12 miles per hour. Mann and Francisco (31) applied a particulating agent and Tordon 101 mixture[1] by helicopter to various brush species. Their results showed a loss of herbicidal effectiveness when the particulating agent was used.

Hydroxyethyl cellulose is a water soluble polymer which increases the viscosity of the spray solution according to the amount added (19). According to Hoffman and Haas (24) it offers the advantages of not needing special equipment and it can be used with either water soluble or emulsifiable herbicides. Mann and Francisco (31) compared hydroxyethyl cellulose with other drift control materials and found it did not effectively control drift. However, McMurray and Sutton (32) reported a reduction in drift when hydroxyethyl cellulose was applied with various herbicides in drainage ditches in Florida.

In studies conducted to determine the tolerance of several crops to particulating agents, hydroxyethyl cellulose, and pseudo-plastic spray gel (composed of natural carbohydrates), Ekins et al. (14) found little increased injury caused by the adjuvants. In other studies they

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[1]Contains 2,4-D and picloram (4-amino-3,5,6-trichloropicolinic acid) in a 2 + ½ mixture.)

found that either hydroxyethyl cellulose or the pseudo-plastic spray gel added to paraquat plus surfactant did not reduce the efficacy of paraquat. However, particulating agents did reduce the efficacy of paraquat either with or without surfactant. Results of vapor studies showed that the pseudo-plastic spray gel and particulating agents did reduce the vapor loss of the ethyl ester of 2,4-D from plant surfaces. In addition, the particulating agent reduced the number of drops reaching the plant surface.

Microfoil Boom

The Microfoil Boom[2] has found its main use as a drift control device for helicopters. The Microfoil Boom controls drift through the production of uniform drops with a minimum amount of fine or "satellite" drops being produced. Air-foil-shaped nozzles are used in which each nozzle contains 60 needle-like orifices along its trailing edge. The hypodermic-like needle orifices are available in two sizes: 0.013-inch inside diameter which produces drops with a volume mean diameter of 800 microns and 0.028-inch inside diameter producing 1700-micron drops. Akesson et al. (3) studied the Microfoil nozzles along with several other types of nozzles. Using a helicopter at speeds less than 60 miles per hour they recovered 98-99 per cent of the spray material in the applied swath. Only approximately 1 microgram herbicide per square foot was recovered 100 feet downwind. The 0.013-inch inside diameter orifices were used in this study. However, when the Microfoil was used on a Pawnee fixed-wing airplane nearly 500 micrograms herbicide per

[2]Aerial drift control with the Microfoil Boom. Amchem Product's Inc. Technical Data Sheet. Ambler, Pennsylvania.

square foot was recovered 100 feet downwind. Also, herbicide was recovered as far as 5000 feet downwind.

The Microfoil, mounted on helicopters, has shown encouraging results for brush control on rights-of-way, conifer release, and controlling cattails (_Typha_ spp.) and water hyacinth in drainage ditches in Florida (1, 4).

Electrostatic Charging

One of the earliest studies involving the production of drops by electrical charging was conducted by Vonnegut and Neubauer (42). They found that streams of highly electrified uniform drops about 0.1 millimeter in diameter could be produced by applying potentials of 5-10 kilovolts of alternating or direct current to liquids in small capillaries. This basic theory has been utilized in the production of uniform drops for use in applying herbicides by ground equipment or aircraft.

Roth (36) conducted laboratory experiments to determine the atomization characteristics of a laminar flow jet stream with and without voltage applied to a 6-inch cylindrical aluminum tube surrounding the jet stream. For this experiment, he used a Delavan CS-1 cone nozzle (operating pressure was 3 pounds per square inch and electrical potential was one kilovolt) and a Spraying System X-1 cone nozzle (operating pressure was 1 pound per square inch and electrical potential was two kilovolts). With the swirl cores removed these nozzles provided circular orifices of 250 and 530 microns in diameter, respectively. He found that the charged tube surrounding the jet stream was very effective in eliminating the small drops associated with laminar flow jet stream sprays.

According to Splinter (41) there are three methods of charging aqueous sprays: ionized field charging, induction charging, and combination charging. Each method has had some success in industry.

The ionized field charging method has been used for charging dusts. Essentially, it includes a grounded ring placed adjacent to but outside the spray path. An electrode is centered ahead of the ring and also ahead of the spray nozzle. A voltage applied to the center electrode then imparts charge to spray drops passing through the ring.

The induction charging method simply involves eliminating the center electrode and placing a voltage on the ring. As spray is emitted through the nozzle it passes through the charged ring and consequently receives a charge opposite to that of the ring. Induction charging is limited to use only with conductive sprays.

In the combination method the voltage is given to the ring while the center electrode is grounded. The outer electrode induces a charge of opposite sign on conducting spray issuing from the spray nozzle while a corona discharge from the center electrode creates ions of the same sign as the spray. The spray then is charged by both methods of charging in an additive manner.

Splinter conducted experiments using all three methods of charging spray drops. He found them all applicable to agricultural spraying although induction charging was not effective for charging nonconducting sprays. Consequently, it was learned that charging of spray drops did not affect their evaporation and also that evaporating molecules do not carry the surface charge with them.

Carlton (11) listed several environmental and non-environmental factors which greatly influence the electrostatic charging process. The environmental parameters include atmospheric ionization, fair weather current, electrical field intensity of the earth, and humidity. Among the non-environmental factors were type of aircraft and related properties, spray flow rate, and the electrical properties of the spray itself.

Foaming Additives

One of the earliest foaming applicators for herbicides was constructed by McWhorter and Barrentine (33). Their applicator was capable of producing from 300 to 400 gallons of foam from 1 gallon of water. Using various herbicides plus foaming additives, they were able to obtain weed control in soybeans equal to or superior to straight herbicides plus water mixtures.

According to Akesson et al. (2) one of the inherent problems of using foam is the production of large drops which give poor coverage. Also, there is a problem sometimes encountered when foams are applied by airplane in which the foaming agent does not hold the small clusters of foam together. These small bubbles of foam may then drift downwind for an extended distance.

CHAPTER III

MATERIALS AND METHODS

Pasture Studies

Pasture plots were established in May, 1971 on the Downey Ranch west of Stillwater, Oklahoma. The area is a rolling, upland range site which is typical of much of the pasture land in north-central Oklahoma. Previously, this land had been row-cropped to cotton. Later, it was converted to pasture for beef cattle grazing. Overgrazing typifies much of this land; and consequently, there are many weedy species present. Common weedy forbs include western ragweed (*Ambrosia psilostachya* D.C.), sagewort (Artemisia ludoviciana Nutt., var. ludoviciana), and common broomweed /*Gutierrezia dracunculoides* (D.C.) *Blake*/.

Types of Studies

Microfoil and Foam. This study included a comparison of Amchem Product's Microfoil Boom, Velsicol Chemical Corporation's Foamwet Air Emulsion Spray System, and a conventional spraying system (2 2½ foot boom with adjustable nozzles). All three systems were mounted in turn on a Piper Pawnee fixed-wing airplane. The Foamwet and conventional nozzles were interchangeable on the same boom.

Field plot layout was in a randomized complete block design with three replications. The plots were sprayed May 18 and 19, 1971. Temperature, wind velocity, and wind direction recordings were made during each application. Herbicide rates of 3/4 pound (active) per acre and one pound (active) per acre of the butoxyethanol ester of 2,4-D were applied in 2 gallons of solution volume per acre with the Microfoil System, Foamwet System (0.5% and 1% foam with foaming nozzles), and the conventional system.

Electrostatic System. A study was conducted to determine the effect of Electrogasdynamic's Electrostatic Charging System on spray drift and herbicide effectiveness. A fixed-wing airplane equipped with the Electrostatic Charging System was used. The charging apparatus was designed so that the generator could be turned on to produce charged spray drops.

In this study a split-plot design (main plots were treatments and subplots were charged and uncharged drops) with four replications was used. Rates of 2,4-D and spray volumes were 3/4 pound (active) per acre of 2,4-D in 1 gallon of water per acre, 1 pound (active) per acre of 2,4-D in 1 gallon of water per acre, and 1 pound (active) per acre of 2,4-D in 2 gallons of water per acre.

Plots were sprayed May 25, 1971. Temperature, wind direction, and wind velocity recordings were made during each application.

General Plot Information

Plots were 660 feet long and 100 feet wide. The airplane swath width was 50 feet and the center of flight was midway or 50 feet from each side of the plot. The plots were established in a perpendicular position to the prevailing north and south winds.

Deposition samples for the Microfoil and Foamwet study were collected in two replications of those plots sprayed with 1 pound per acre of 2,4-D. For the electrostatic study, sampling was conducted in two replications of those plots sprayed with 1 pound per acre of 2,4-D in a volume of 1 gallon per acre and 1 pound per acre 2,4-D applied in a volume of 2 gallons per acre.

Methods of Measuring Drift and Deposition

Deposition on Plates. Stainless steel collection plates were placed on 12-inch wire-rod holders in each sampling plot. Four 24-gauge plates, each measuring 1 by 3 inches, were placed on an individual holder. The holders were perpendicular to the line of flight and spaced at five foot[1] intervals upwind and downwind from the center of flight for the entire width of the plot. Additional holders were placed 200 and 400 feet downwind.

After each plot was sprayed, the stainless steel collection plates were immediately collected from each holder and immersed in benzene. Later, in the laboratory, the benzene samples were evaporated below 10 milliliters. They were then transferred to marked test tubes and brought up to the 10 milliliter mark with benzene.

A 1 microliter sample was taken from each 10 milliliter sample and this was injected into a Hewlett-Packard Model 5750 gas chromatograph equipped with an electron capture detector for herbicide analysis. The ionization source was NI 63. The injector, column, and detector temperatures were 290, 220, and 240 degrees centigrade, respectively. A ¼ inch by 6 foot glass column was used. It was packed with 80 to 100 mesh Chromosorb WAWDMCS coated with 3% silicone gum rubber (SE 30). The

[1]Holders and bean plants were spaced 10 feet apart in the electrostatic study.

flow rate of the carrier gas (5% methane-95% argon) was approximately 40 milliliters per minute through the column with an additional purge flow of 80 milliliters per minute.

Areas under the curves on the graph paper corresponding to the herbicide were then cut out with scissors and weighed on a scale. The weights of these areas could then be compared with the weights of areas from known standards. From that data, calculations were made to obtain the amount of herbicide deposited at each location. Duncan's multiple range statistical test was conducted at the 5% level and is indicated by small letters in the data.

Bean Bioassay. Burpee stringless beans were used as bioassay plants to determine the biological response at various distances from the spray swath. The beans had been grown in the greenhouse to the 3 to 6 leaf stage in styrofoam cups. They were transported to the field in a closed vehicle. During the actual spraying operations, the vehicle and remaining plants were kept upwind from the treatment area. In the test plots, they were placed adjacent to the stainless steel plates in wire-rod holders.[2] Bean plants were collected immediately after each plot was sprayed. Uncontaminated checks were placed with each group of treated beans as they were removed from the treated plots.

The bean plants were transported from the field to the Agronomy Research Station where they were placed in a protected area. Visual injury ratings were taken two weeks after spraying using a scale of 0 to 10 in which 0 equaled no plant damage grading up to 10 which indicated

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[2]For the electrostatic study the soil in the styrofoam cups was grounded to the metal holders by tying one end of a short length of wire to the holder and inserting the other end into the soil within the cup.

that the plants were completely killed. The ratings were then transformed into degrees arcsin before analysis. Duncan's multiple range statistical test was conducted at the 5% level and is indicated by small letters in the data. Pictures of the plants were also taken.

<u>Weed Control</u>. Two weeks after spraying, visual injury ratings were made on western ragweed. The ratings were made as previously described for the bean bioassay. Injury ratings were rated at ten-foot intervals across the spray swath, upwind to the edge of each plot and downwind to 120 feet. Four weeks after spraying, western ragweed counts were taken at four substations in each plot. At each substation, the number of dead ragweeds out of a total of fifty was counted. These ratings were converted to degrees arcsin before analysis. Duncan's multiple range statistical test was conducted at the 5% level and is indicated by small letters in the data. Yields of western ragweed, sagewort, and common broomweed were taken in the treatment plots the following autumn. Yields were also taken in adjacent unsprayed areas at that time. Duncan's multiple range statistical test was conducted at the 5% level and is indicated by small letters in the data.

Brush Studies

Brush studies were initiated June 15, 1971, to compare spray deposition and brush control from aerial applications of herbicides with the Microfoil, Foamwet, and conventional systems. Plots were established on the Autry Ranch, east of Wetumka, Oklahoma.

According to Harlan (21), this area is located within the cross-timbers region of Oklahoma. The area has been hand-cleared of all large trees prior to becoming reinfested with blackjack oak and post oak. The overstory blackjack oak and post oak were between 20 and 30 feet high and formed a dense cover.

General Plot Information

Plots were established in a randomized complete block design with five treatments and three replications. Plots were 700 feet in length and 200 feet wide (four-fifty foot swaths).

In this study herbicide rate remained constant while volume of spray solution varied. Two pounds (active) per acre of the butoxyethanol ester of 2,4,5-T at spray volumes of 2 and 4 gallons per acre were aerially applied from a Piper Pawnee single-winged aircraft. Microfoil, Foamwet (5% foam), and conventional systems were tested using a spray volume of 4 gallons per acre. In addition, spray volumes of 2 gallons per acre were applied with the Foamwet and conventional systems. Temperatures, wind velocity, and wind directions were taken during each application.

Spray Deposition and Distribution

The deposition and distribution of spray was measured in those plots sprayed at a volume of 4 gallons per acre. Two (4 by 4 inch) cards of linagraph paper[3] were placed on each of 3 (6 foot) stands along the centers of each sample plot to determine distribution. To avoid contamination, dye cards were placed on the stands just prior to spraying and were removed immediately after spraying. These cards were then used to estimate drop number, size, and spacing.

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[3]Kodak linagraph paper number 480.

The amount of 2,4,5-T deposited was determined by leaf sampling. Leaf samples were taken from overstory and understory blackjack oak. Five substations were sampled in each plot. At each substation 3 overstory and 3 understory leaf samples were taken. Twig pruners were used to cut leaves from overstory trees. A round cutting tool (5 centimeters diameter) was used to cut leaf samples from each leaf. The leaves were placed on a piece of flat styrofoam and the cutter was then pressed against the leaf and turned sharply. This resulted in a leaf portion 5 centimeters in diameter. These samples were immediately immersed in bottles containing benzene. Later the benzene samples were analyzed in the laboratory by gas chromatography as described previously in the pasture study.

Oak Control

The initial effect of spraying blackjack oak and post oak was determined by rating desiccation and defoliation in the treatment plots July 15, 1971, and in September, 1971, respectively. Canopy reduction (visual rating) and apparent kill was determined in May, 1971. All data was converted to percentage and transformed to degrees arcsin before analysis. Duncan's multiple range statistical test was conducted at the 5% level and is indicated by small letters in the data.

CHAPTER IV

RESULTS AND DISCUSSION

Pasture Studies

Microfoil and Foam Study

Deposition on Steel Plates. The deposition of 2,4-D by the conventional system is shown in Figure 1. The large decrease in deposition downwind from the center of flight is considered to be "prop wash" which tends to displace the spray pattern laterally. Largest deposition of 2,4-D occurred in an effective swath of approximately 70 feet with 0.04 pound per acre of 2,4-D deposited 375 feet downwind in replication I. The largest amount of 2,4-D deposited was 0.47 pound per acre near the center of flight.

Effective swath for the Microfoil System (Figure 2) was approximately 55 feet. The spray patterns of replications I and II were uniform with 2,4-D depositions decreasing rapidly outside the spray swath. However, as much as 0.04 pound per acre of 2,4-D was deposited 165 feet downwind in replication I. Only small amounts of spray drifted upwind. The wind velocity (Table I) for replication II was 3.8 miles per hour compared to 1.7 miles per hour for replication I.

The spray pattern produced by the Foam System at 0.5% (Figure 3) was uniform within limits at both replications. The effective swath width was approximately 65 feet. Downwind deposits of 2,4-D decreased

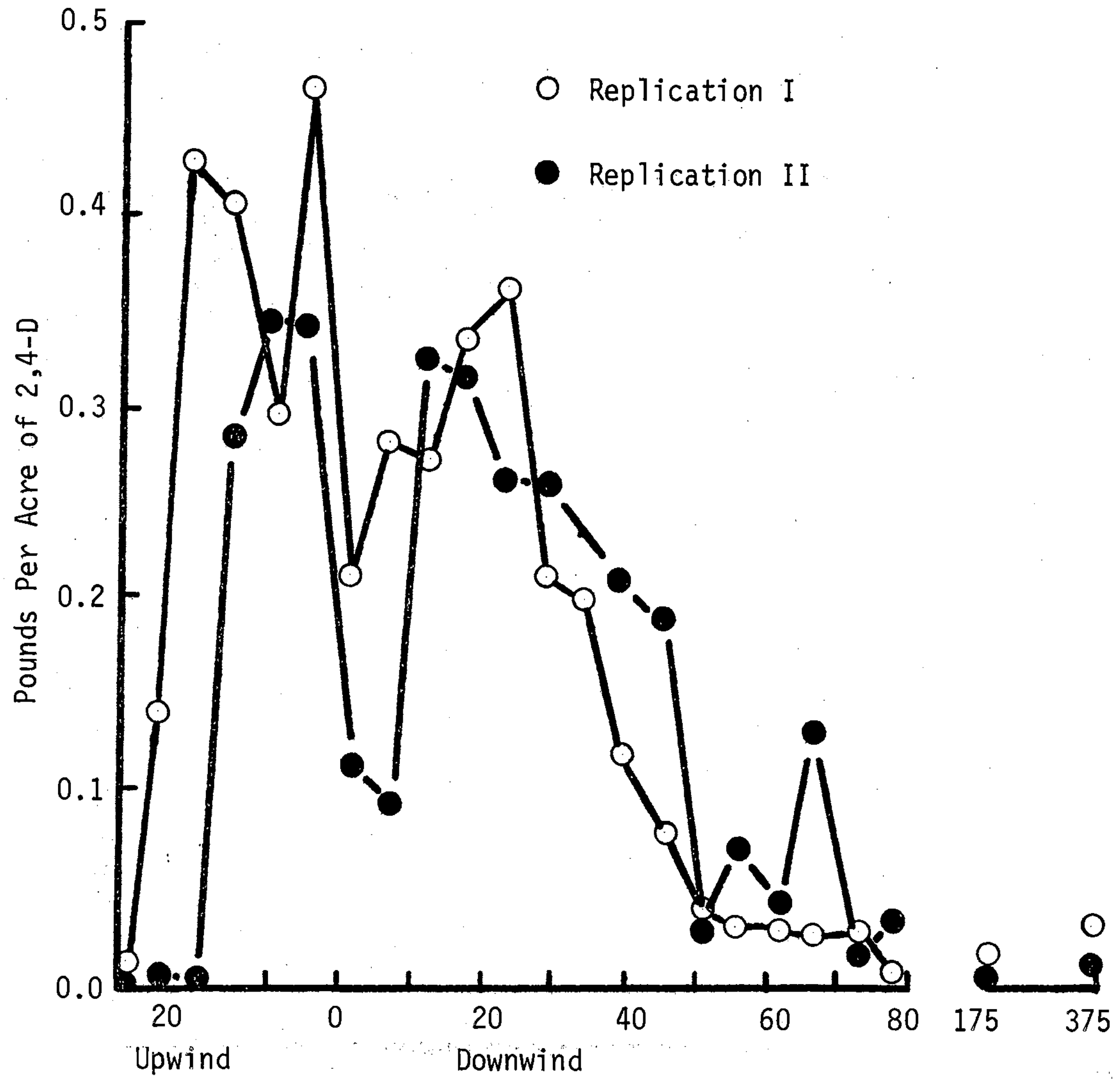

Figure 1. Deposition of 2,4-D Applied by the Conventional System and Collected on Steel Plates Placed at Various Distances Upwind and Downwind From the Center of Flight When the Rate of Application Was 1 Pound Per Acre

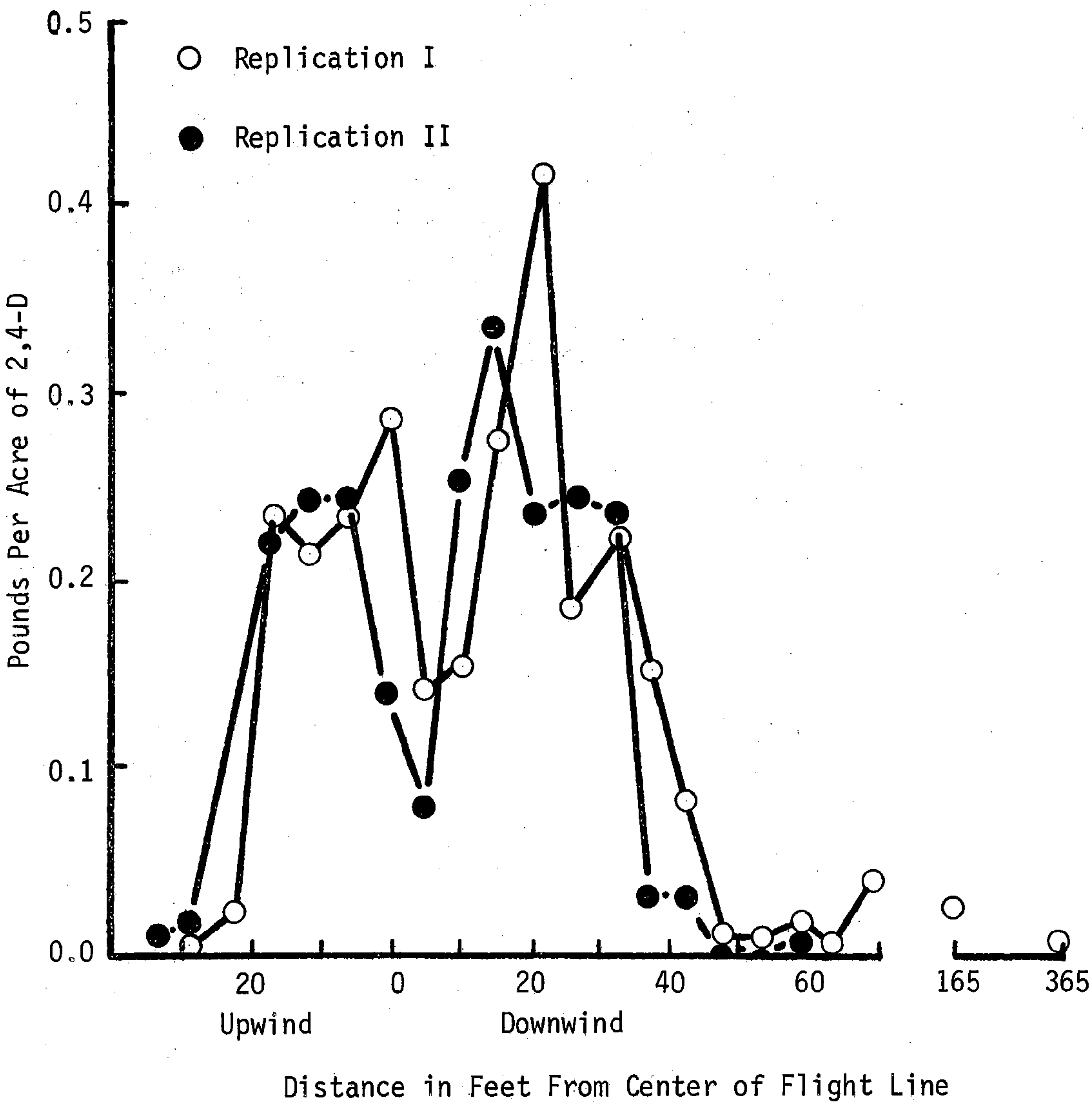

Figure 2. Deposition of 2,4-D Applied by the Microfoil System and Collected on Steel Plates Placed at Various Distances Upwind and Downwind From the Center of Flight When the Rate of Application Was 1 Pound Per Acre

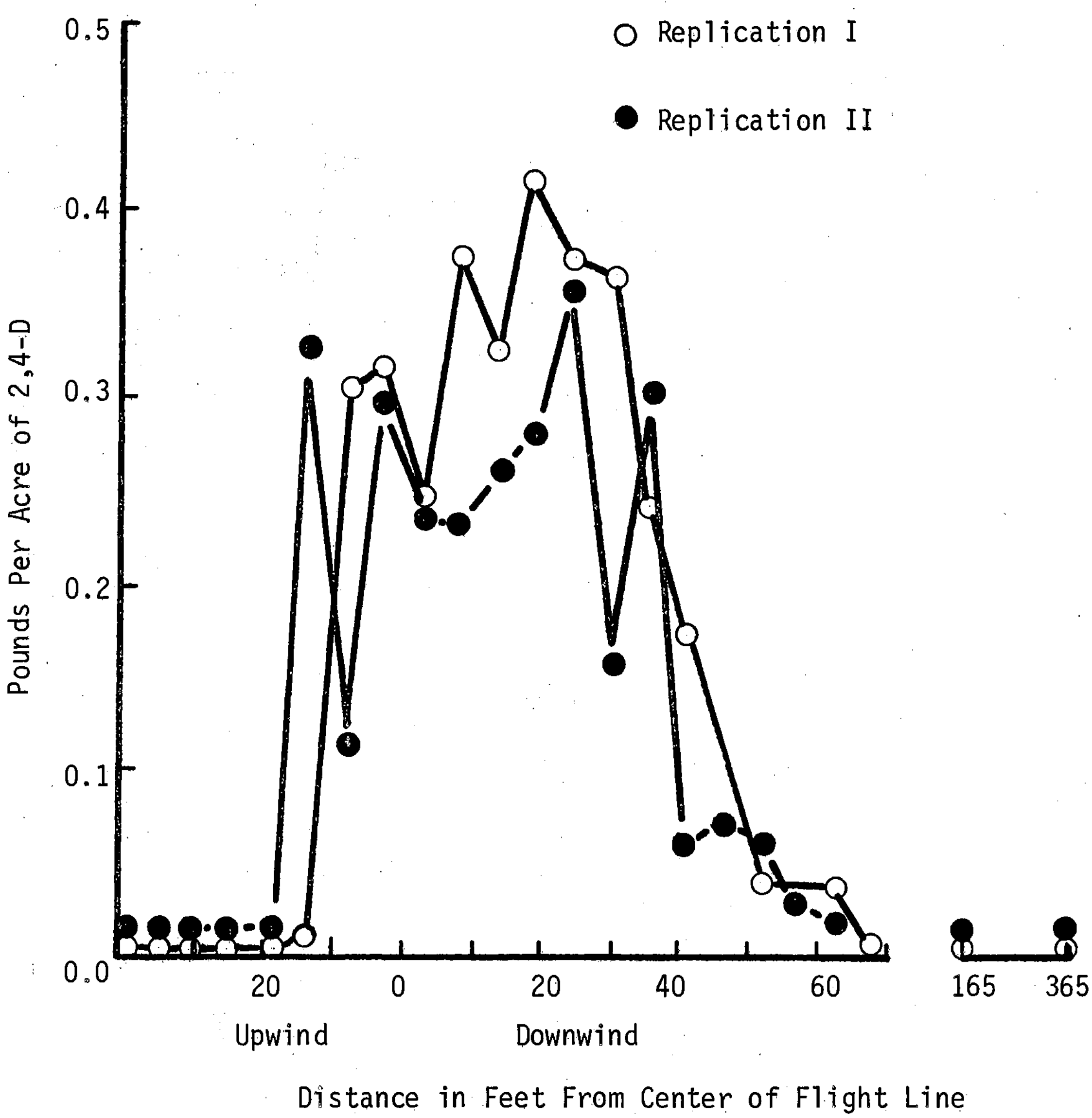

Figure 3. Deposition of 2,4-D Applied by the Foam System (0.5% Foam) and Collected on Steel Plates Placed at Various Distances Upwind and Downwind From the Center of Flight When the Rate of Application Was 1 Pound Per Acre

rapidly from the spray swath and very little 2,4-D was detected beyond 70 feet downwind.

TABLE I

WIND VELOCITY DATA AT THE TIME OF SPRAY APPLICATION FOR PASTURE STUDIES

Spraying System	Miles Per Hour	
	Replication I	Replication II
	Microfoil and Foam Study	
Conventional	2.9	2.0
Microfoil	1.7	3.8
Foam at 0.5%	2.5	3.0
Foam at 1.0%	4.8	5.0
	Electrostatic Study	
2,4-D at 3/4 lb. in 1 gal.	3.1	3.1
2,4-D at 1 lb. in 1 gal.	1.0	4.3
2,4-D at 1 lb. in 2 gal.	1.4	5.1

The spray pattern produced by the Foam System at 1% (Figure 4) was less uniform than the spray pattern from the Foam System at 0.5%. However, there was no upwind movement of spray at either rate of foam. Wind velocity (Table I) was 5 miles per hour for the Foam System at 1% compared to approximately 3 miles per hour for the lower rate of foam.

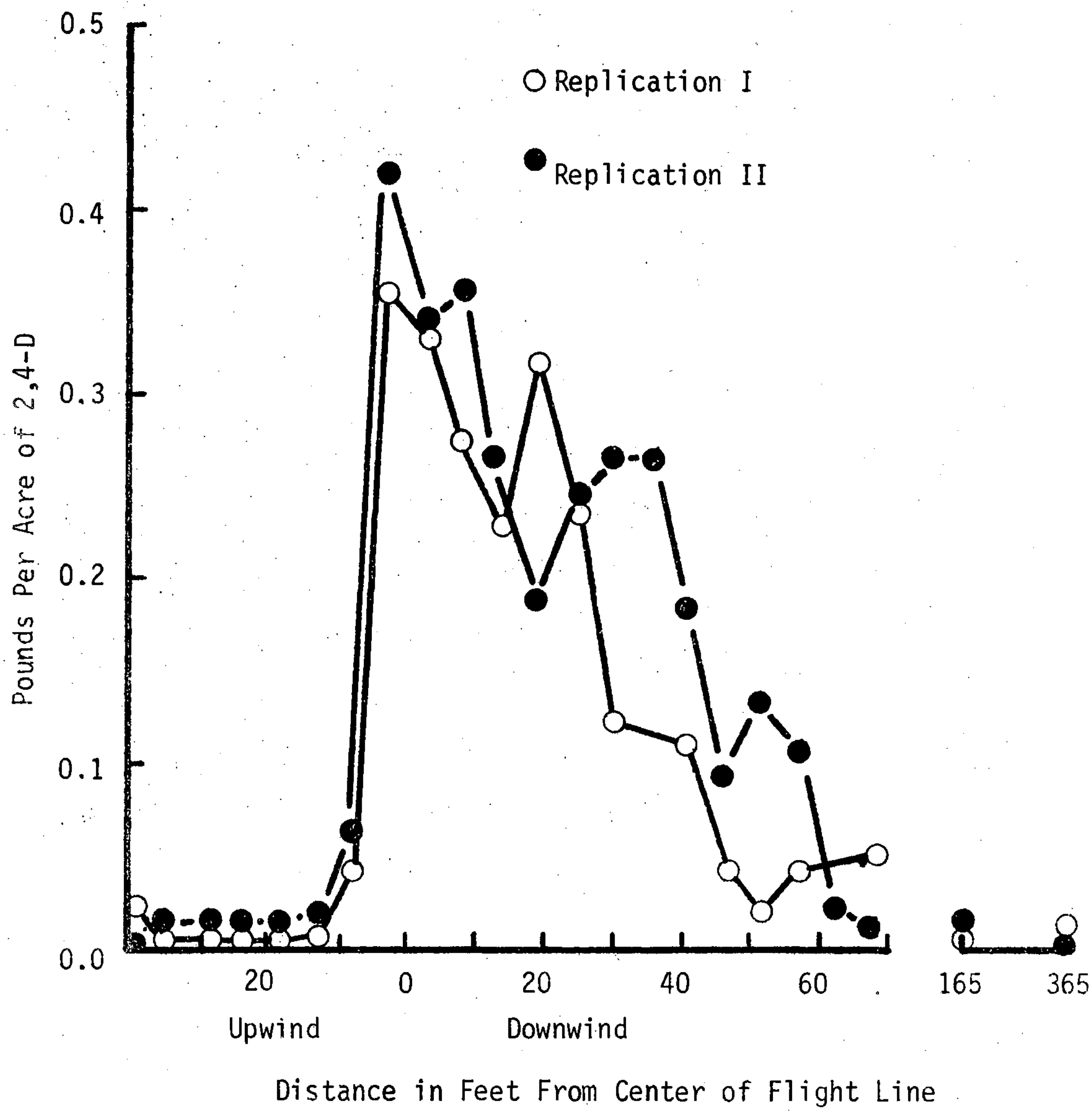

Figure 4. Deposition of 2,4-D Applied by the Foam System (1.0% Foam) and Collected on Steel Plates Placed at Various Distances Upwind and Downwind From the Center of Flight When the Rate of Application Was 1 Pound Per Acre

Nearly 0.05 pound of 2,4-D was deposited 70 feet downwind. However, no 2,4-D was deposited 165 or 365 feet downwind.

Comparing all spraying systems, there was more movement of 2,4-D upwind and downwind from the conventional system. The Microfoil System produced less drift and more uniform spray patterns. When the Foam System was used, the effective swath was intermediate between the conventional and Microfoil Systems. The weather parameters; temperature, wind velocity, and relative humidity may have contributed to some of the variation between replications. Air temperatures ranged from 54-76 degrees fahrenheit during the spraying while relative humidity ranged from 76-35 per cent from the first treatment in the morning to the final afternoon treatment.

<u>Phytotoxic Effects on Beans</u>. The per cent injury of beans from the conventional system is shown in Figure 5. Control of beans was nearly 100 per cent across 90 feet of the plot. About 20 per cent injury occurred on beans placed 175 feet downwind and 10 per cent on beans 375 feet downwind.

Beans sprayed with the Microfoil System (Figure 6) were damaged severely only within a 65 foot swath. Some visual injury was evident on all beans and beans 365 feet downwind had over 40 per cent visual injury. Wind velocity (Table I) was 1.7 miles per hour during replication I and 3.8 miles per hour during replication II.

Only replication I is shown in Figure 7 for foam at 0.5%. Bean response was highly variable; however, highest visual injury occurred within a swath approximately 60 feet wide. This is in agreement with the deposition of 2,4-D on steel plates. Visual injury was 40 per cent at 165 feet downwind and 20 per cent at 365 feet downwind.

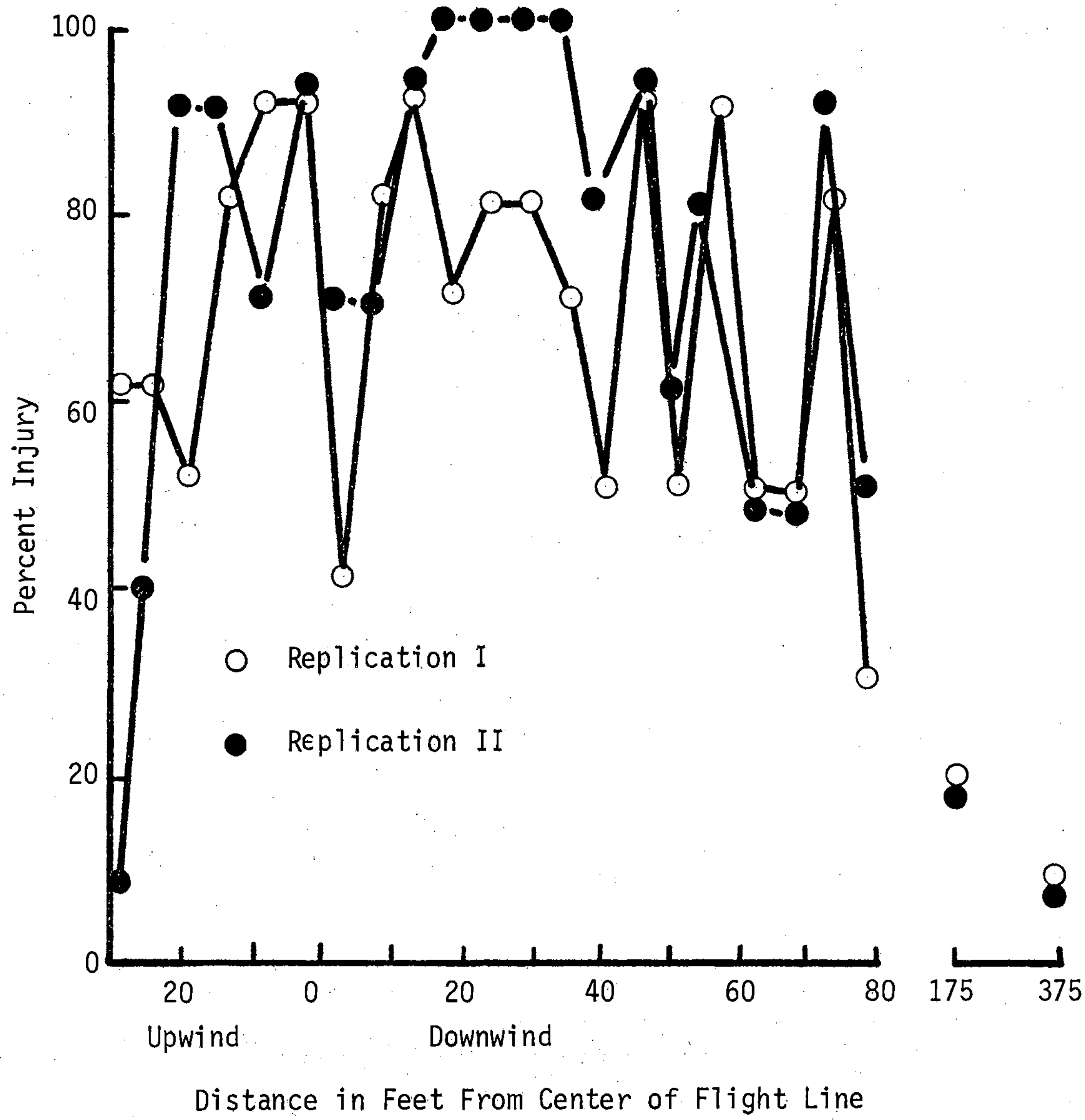

Figure 5. Effect of the Conventional System on the Visual Injury of Beans Placed at Various Distances Upwind and Downwind From the Center of Flight

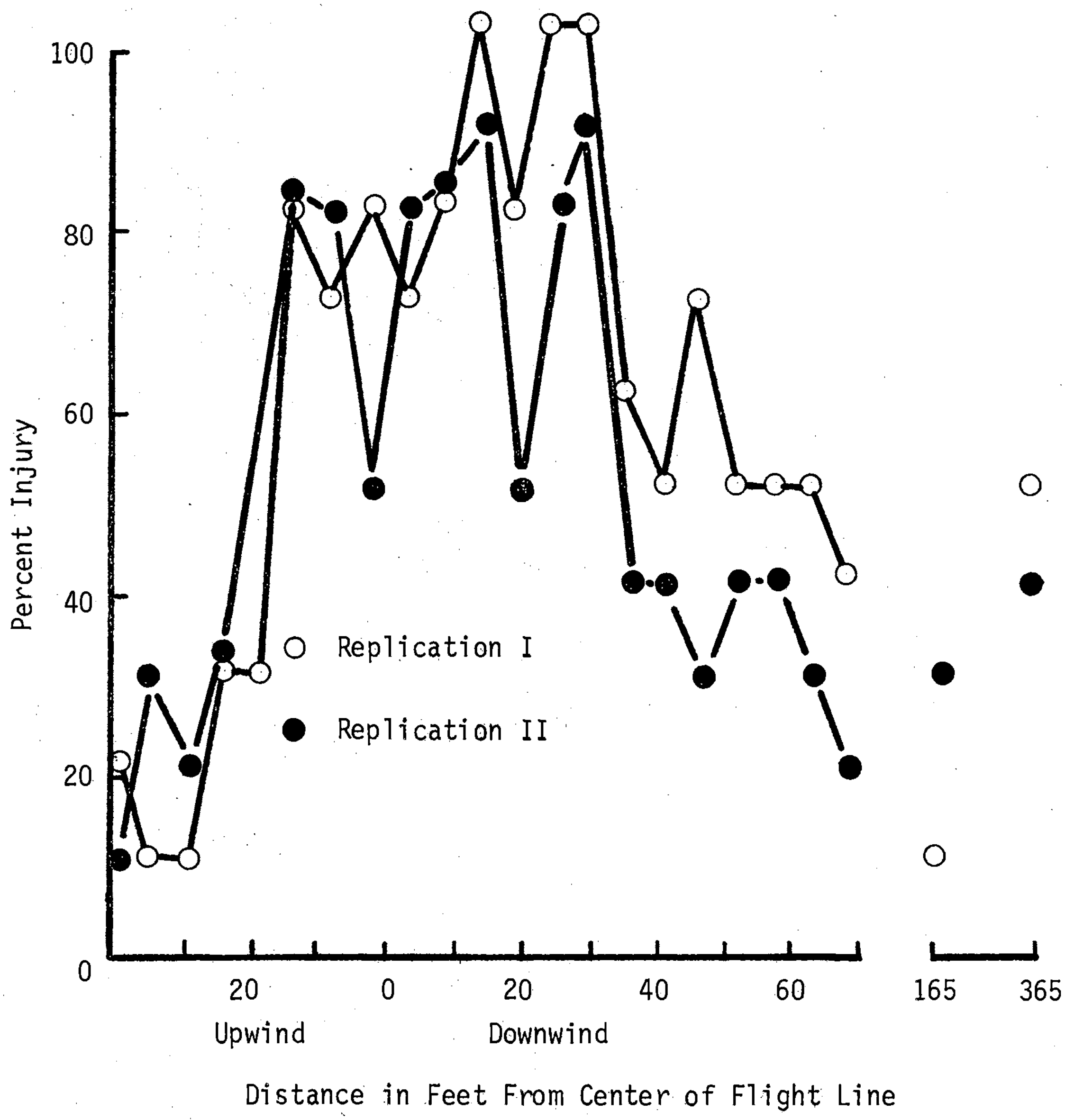

Figure 6. Effect of the Microfoil System on the Visual Injury of Beans Placed at Various Distances Upwind and Downwind From the Center of Flight

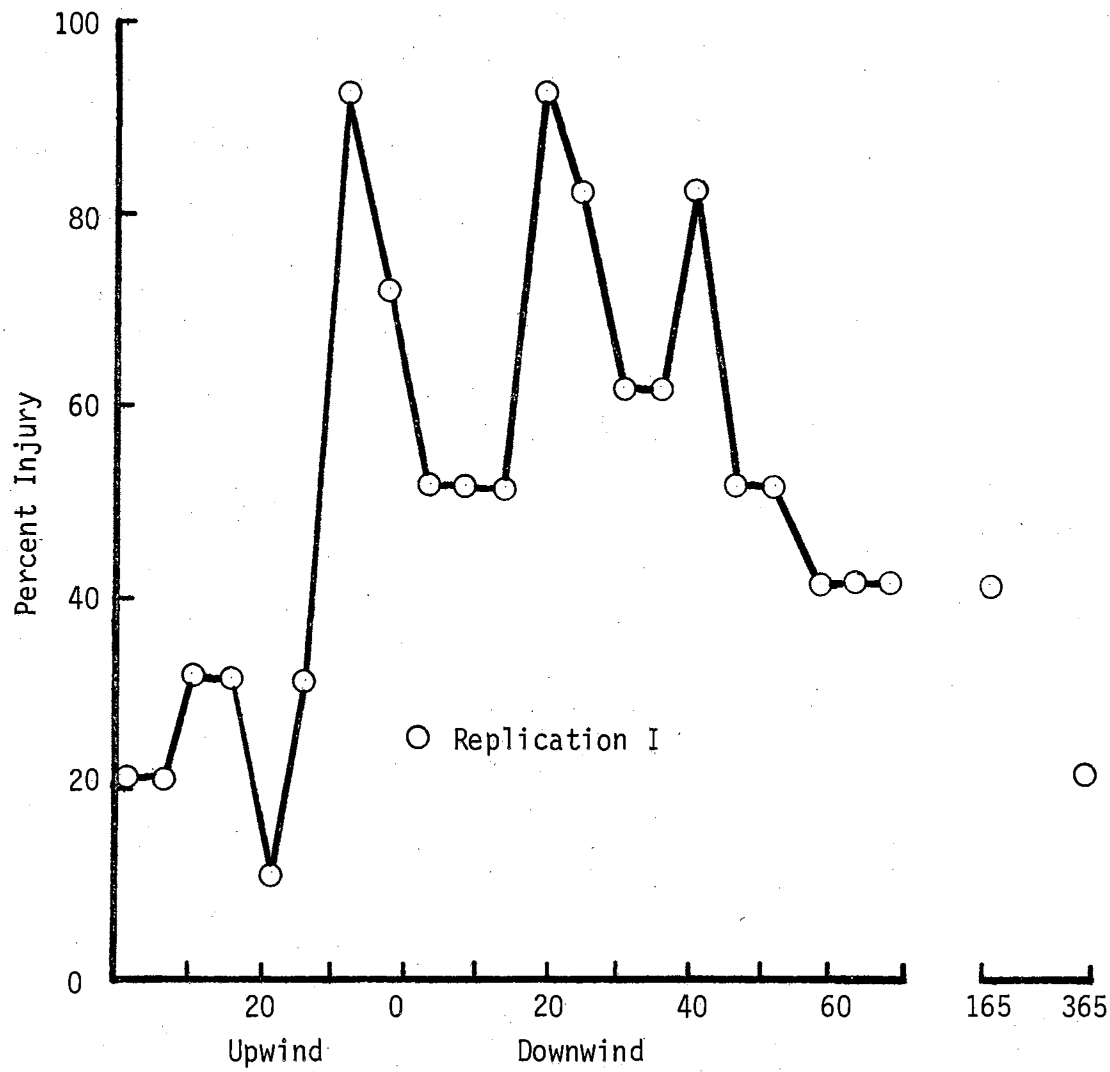

Figure 7. Effect of the Foam System (0.5% Foam) on the Visual Injury of Beans Placed at Various Distances Upwind and Downwind From the Center of Flight

Wind velocity was a major factor in spray movement from the Foam System at 1% (Figure 8). Bean response upwind from the center of flight was only 20-30 per cent. However, as much as 50 per cent response occurred 165 feet downwind.

The visual injury of beans is an effective method of determining spray movement. It is not, however, as precise as deposition determinations. Results from bean response agree generally with deposition determinations. Highest bean response in the spray swath occurred with the conventional system. Spray coverage was an important factor for the conventional system. The Microfoil System did not give effective bean response outside the swath. Foam at both rates gave effective bean control but did not provide satisfactory drift control outside the swath. More uniform bean response occurred from the higher rate of foam.

Bean plants sprayed with the conventional, Foam at 1%, and Microfoil Systems are shown in Figure 9. The upper, middle, and lower rows were sprayed with conventional, Foam, and Microfoil Systems, respectively. The conventional system gave complete control of beans within a 70 foot swath, compared to 65 feet for Foam at 1% and 55 feet for the Microfoil System.

<u>Phytotoxic Effect on Weeds</u>. The per cent visual injury of western ragweed sprayed with various spraying systems using 2,4-D at 3/4 and 1 pound per acre is shown in Figures 10-13. Statistical analysis showed that differences between the 3/4 and 1 pound per acre rates were not significant but the effect of the systems was significant within the spray swath. Significantly lower ragweed injury occurred from the Microfoil System at both rates of 2,4-D compared to the other spraying systems. Ragweed response from all spraying systems gave a typical bell-shaped curve.

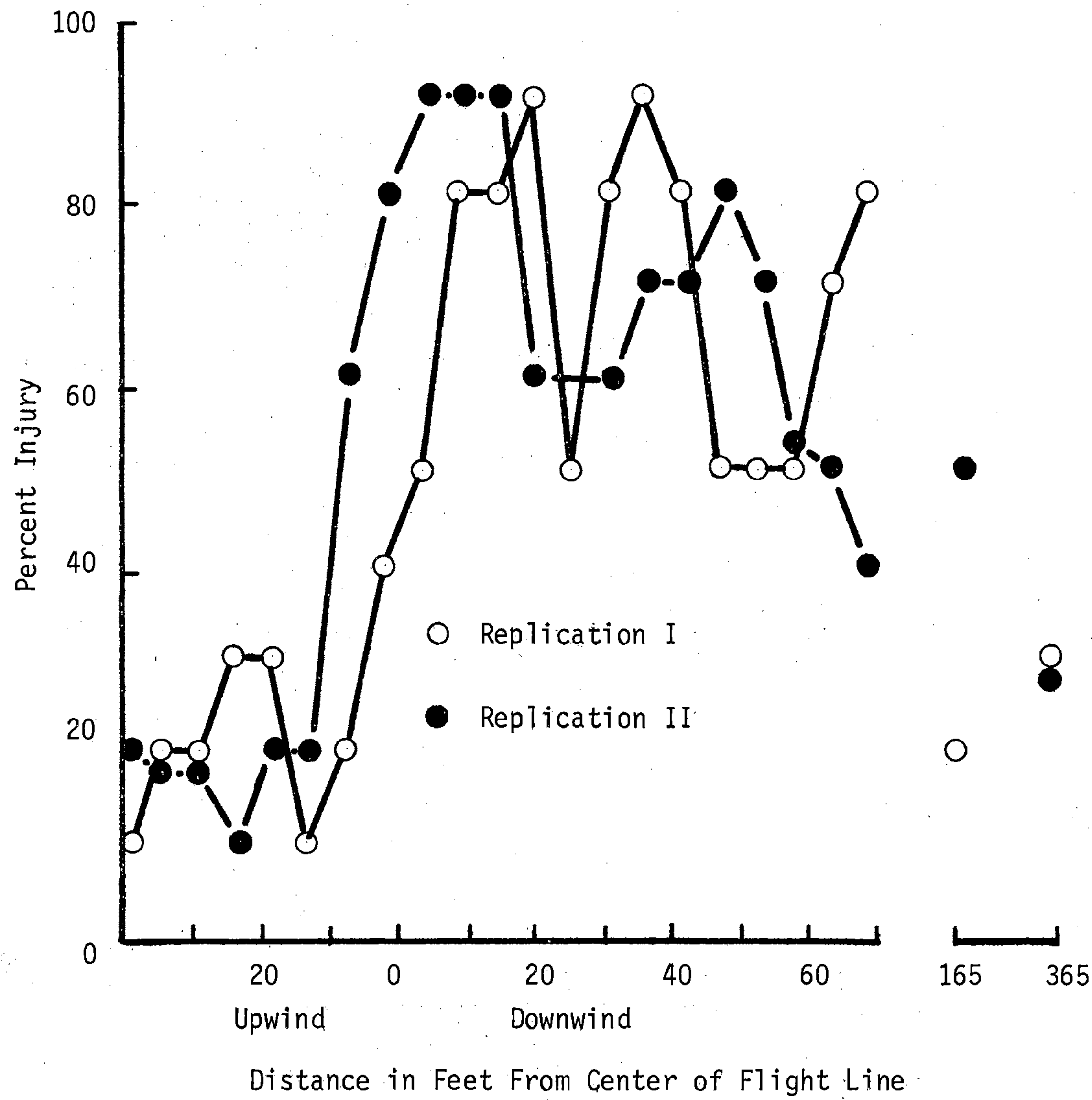

Figure 8. Effect of the Foam System (1.0% Foam) on the Visual Injury of Beans Placed at Various Distances Upwind and Downwind From the Center of Flight

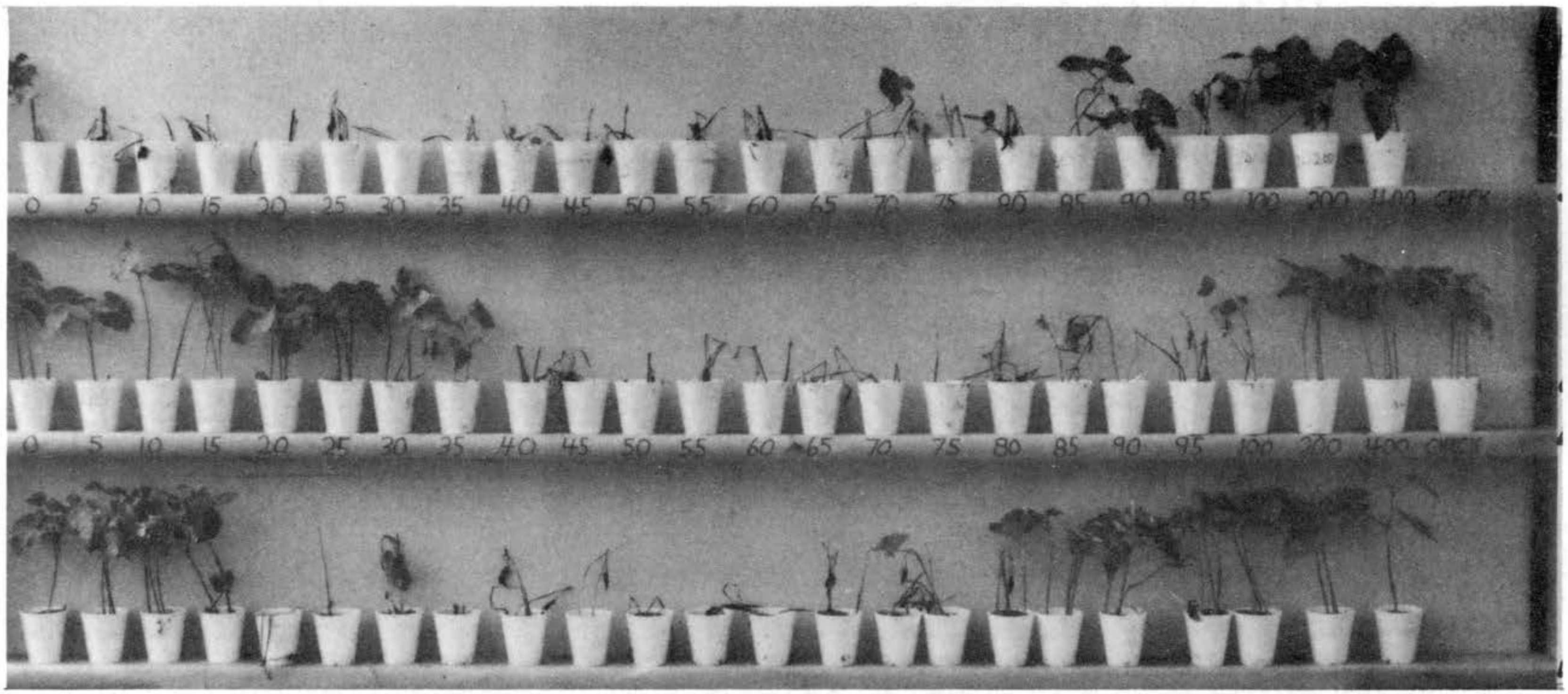

Figure 9. Effect of Conventional (Upper Row), Foam at 1% (Center Row), and Microfoil (Lower Row) Systems on the Visual Injury of Beans Placed at Various Distances Upwind and Downwind From the Center of Flight

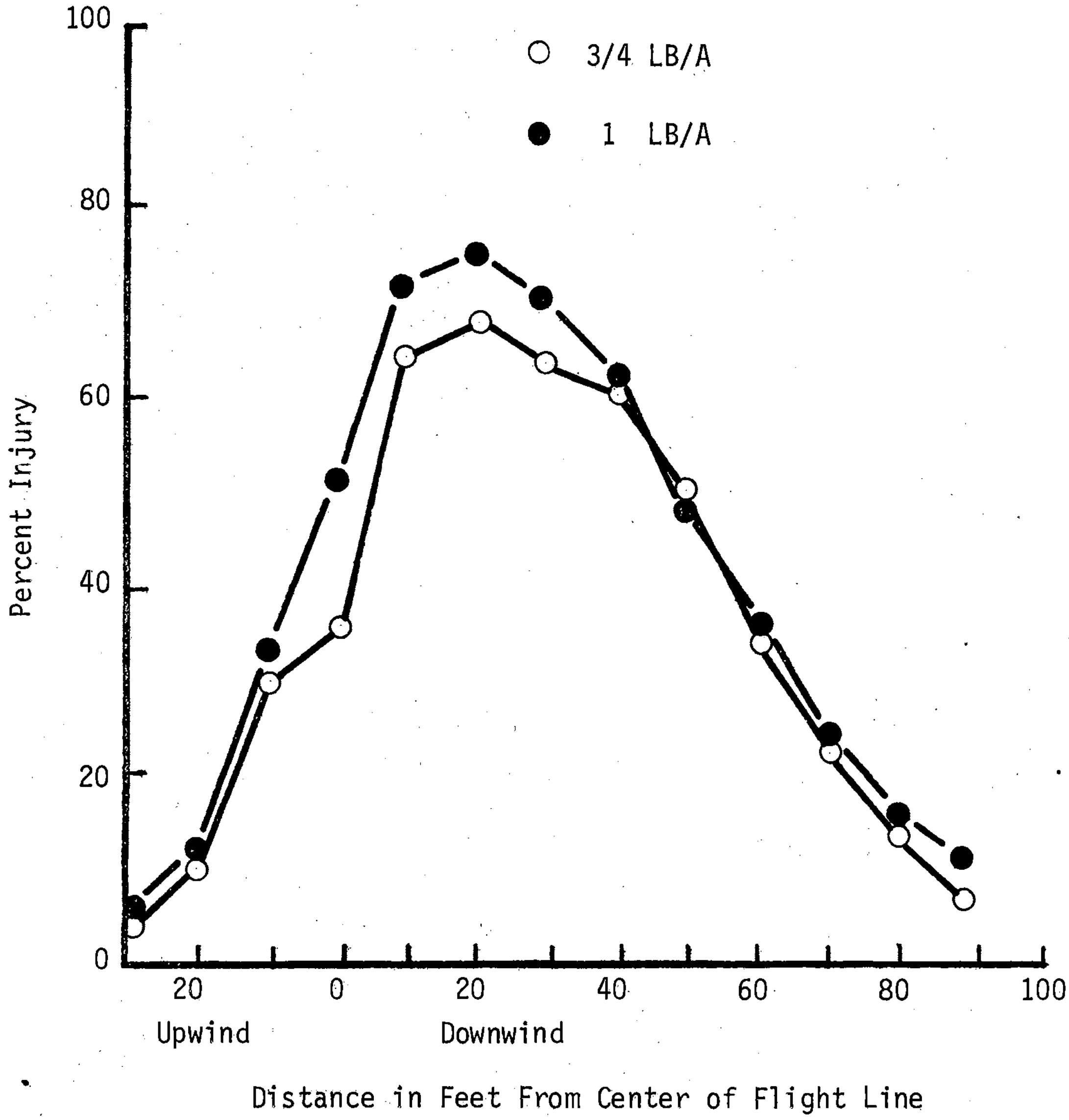

Figure 10. Effect of the Conventional System With Two Rates of 2,4-D on the Visual Injury of Western Ragweed Upwind and Downwind From the Center of Flight

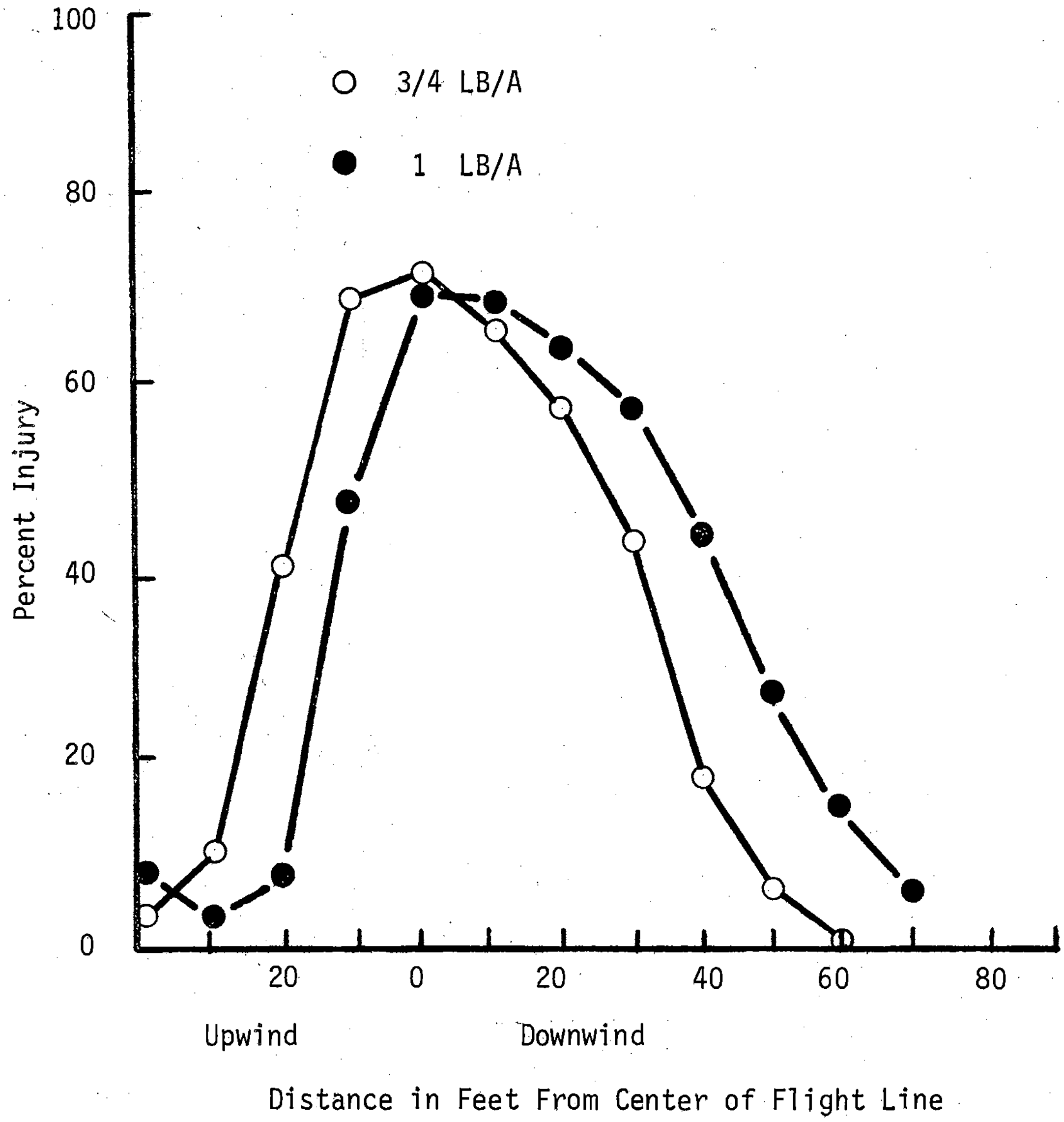

Figure 11. Effect of the Foam System (0.5% Foam) With Two Rates of 2,4-D on the Visual Injury of Western Ragweed Upwind and Downwind From the Center of Flight

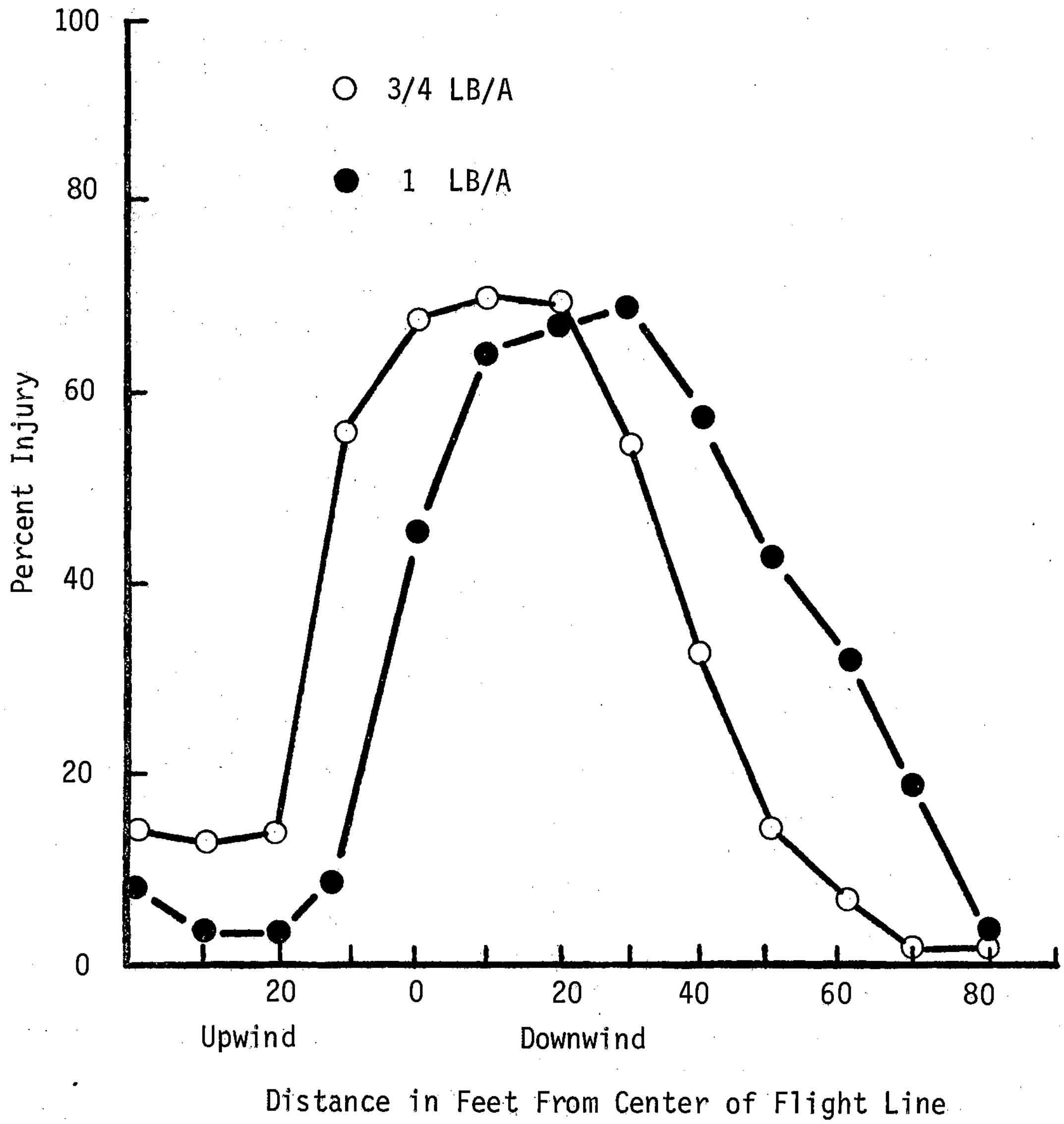

Figure 12. Effect of the Foam System (1.0% Foam) With Two Rates of 2,4-D on the Visual Injury of Western Ragweed Upwind and Downwind From the Center of Flight

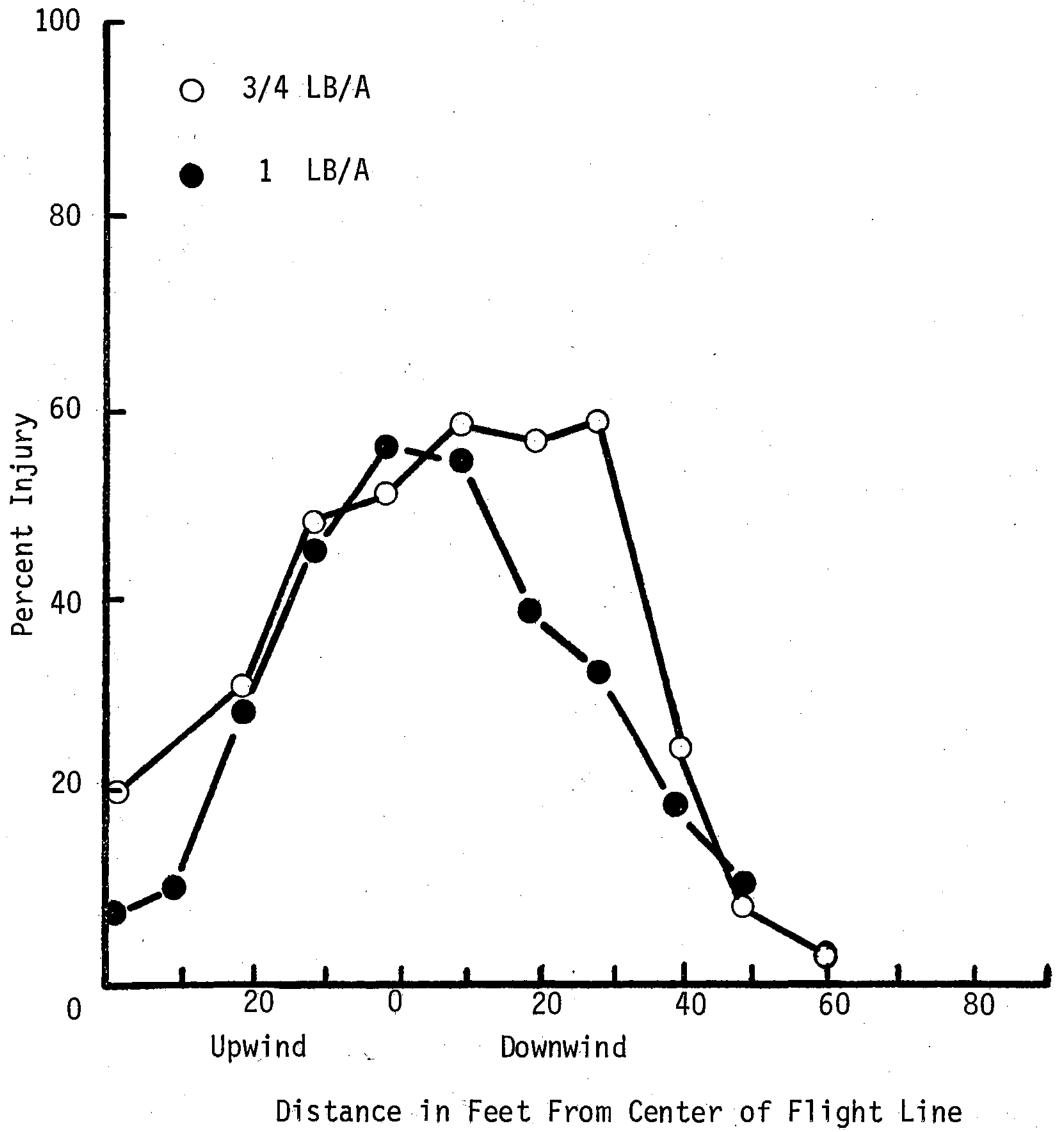

Figure 13. Effect of the Microfoil System With Two Rates of 2,4-D on the Visual Injury of Western Ragweed Upwind and Downwind From the Center of Flight

The data are in general agreement with the results from bean injury and 2,4-D deposition. The same trend is evident for more downwind movement of spray from the conventional and Foam Systems as compared to the Microfoil System.

The per cent of dead ragweeds in the treated plots four weeks after spraying is shown in Table II. There appeared to be less per cent kill with the Microfoil System but large variation in kill within the spray swath occurred and the differences were not statistically significant at the 95% level.

TABLE II

DEAD RAGWEEDS WITHIN THE SPRAY SWATH FOUR WEEKS AFTER TREATMENT WITH TWO RATES OF 2,4-D USING VARIOUS SPRAYING SYSTEMS

Spraying Systems	2,4-D (LB/A)	Percent[1]
Conventional	3/4	47
	1	48
Microfoil	3/4	25
	1	33
Foam at 0.5%	3/4	51
	1	58
Foam at 1.0%	3/4	51
	1	59

[1]Means do not differ significantly at $P < .05$.

Yields of weedy forbs in the treated plots and adjacent unsprayed areas are given in Table III. All of the treatments were effective in reducing the yield of weeds. Significant interaction occurred for western ragweed control between the systems and the herbicide rate. At the 1 pound per acre rate there were no differences in ragweed control from the various spraying systems, but at the 3/4 pound per acre rate the weed control from the Microfoil system was less effective compared to the other spraying systems.

TABLE III

YIELDS OF THREE WEEDY FORBS FIVE MONTHS AFTER SPRAYING WITH TWO RATES OF 2,4-D USING VARIOUS SPRAYING SYSTEMS

Spraying System	2,4-D (LB/A)	Pounds Per Acre		
		Ragweed	Sagewort	Broomweed
Conventional	3/4	70	80	20
	1	130	50	60
Microfoil	3/4	480	110	90
	1	160	60	80
Foam at 0.5%	3/4	70	10	50
	1	90	50	30
Foam at 1.0%	3/4	20	10	70
	1	130	80	20
Check (Adjacent Unsprayed Areas)		610	390	180

Sagewort and broomweed yields are also shown in Table III. These weeds were not uniformly distributed over the spray areas and therefore statistical analysis was not possible. However, the results appear similar to the results on western ragweed.

Electrostatic System

Deposition on Steel Plates. The effect of charged drops on 2,4-D deposition on stainless steel plates is shown in Figures 14, 15, 16, and 17. There appears to be more deposition on the steel plates with the charged drops when applying one gallon of solution per acre (Figures 16 and 17). The large variations in deposition patterns may be due to windspeed (Table I) and also due to the failure of the pilot to fly over the center sample lines. Weather conditions during these treatments may have contributed to the variation. Temperature was approximately 82 degrees fahrenheit with 33 per cent relative humidity.

Phytotoxic Effects on Beans. In Figure 18, bean response is shown for the Electrostatic System when the 2,4-D rate was 1 pound per acre in 1 gallon per acre. The visual injury due to charged and uncharged drops was very similar (approximately 60 per cent at the center of flight). Bean response was approximately 20 per cent 165 and 365 feet downwind for charged or uncharged drops.

The effect of increasing spray volume from 1 to 2 gallons per acre is shown in Figure 19. Again the visual injury of beans was approximately 60 per cent in the spray swath with both charged and uncharged drops. Also some bean response was detected 165 and 365 feet downwind with both charged and uncharged drops.

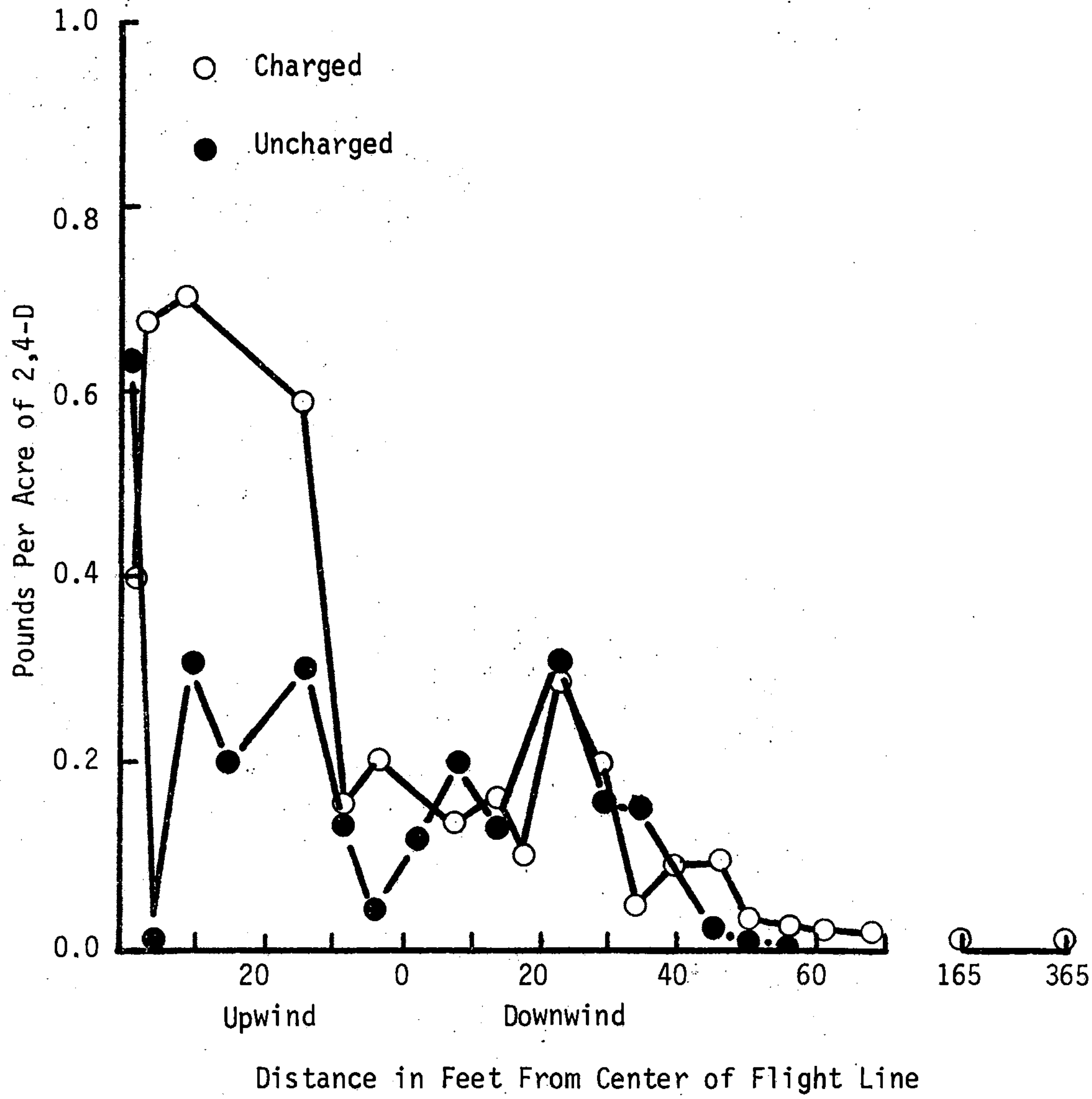

Figure 14. Replication I. Deposition of 2,4-D Applied With Charged or Uncharged Drops in a Volume of 1 Gallon Per Acre and Collected on Steel Plates Placed at Various Distances Upwind and Downwind From the Center of Flight

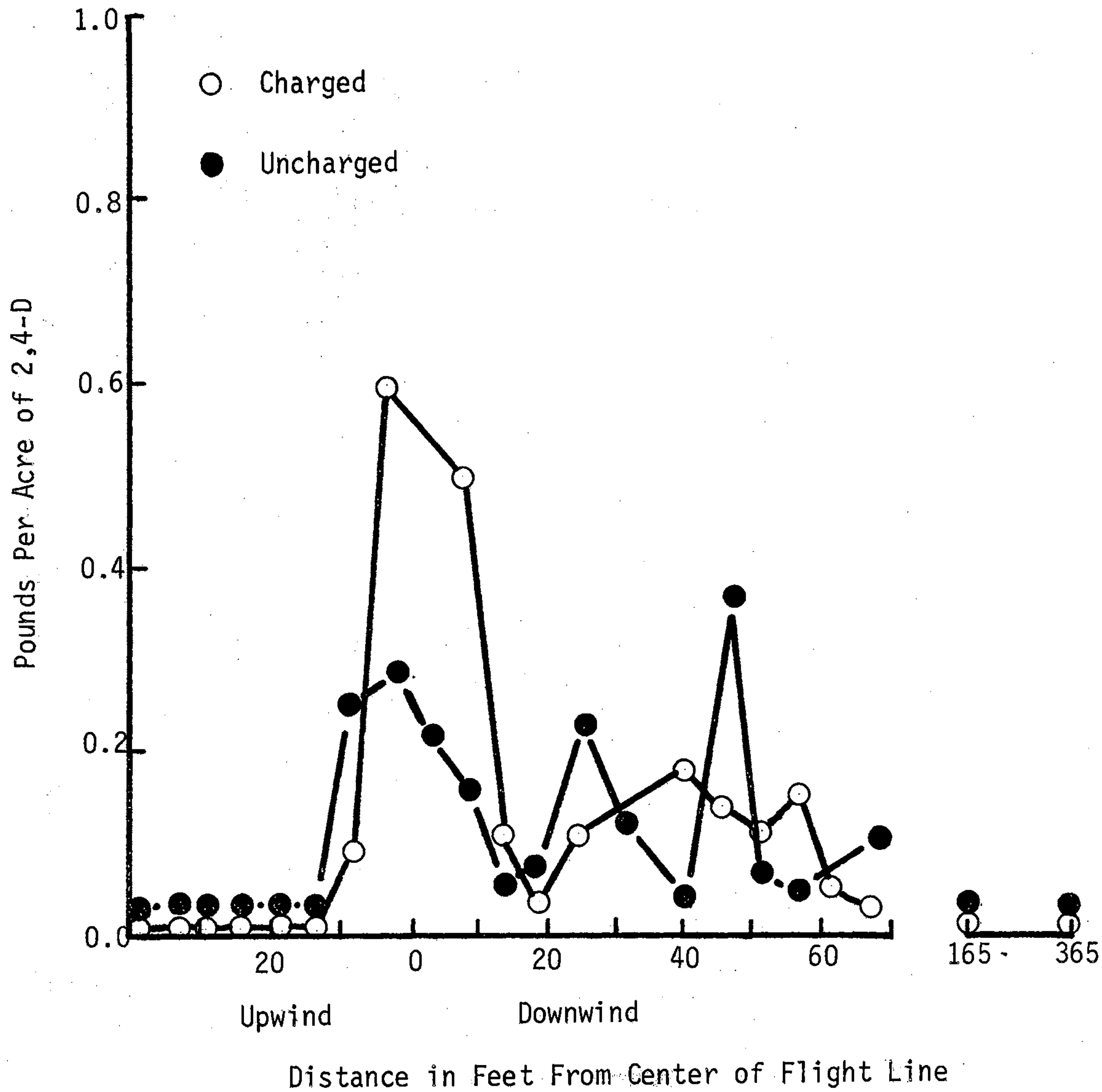

Figure 15. Replication II. Deposition of 2,4-D Applied With Charged and Uncharged Drops in a Volume of 1 Gallon Per Acre and Collected on Steel Plates Placed at Various Distances Upwind and Downwind From the Center of Flight

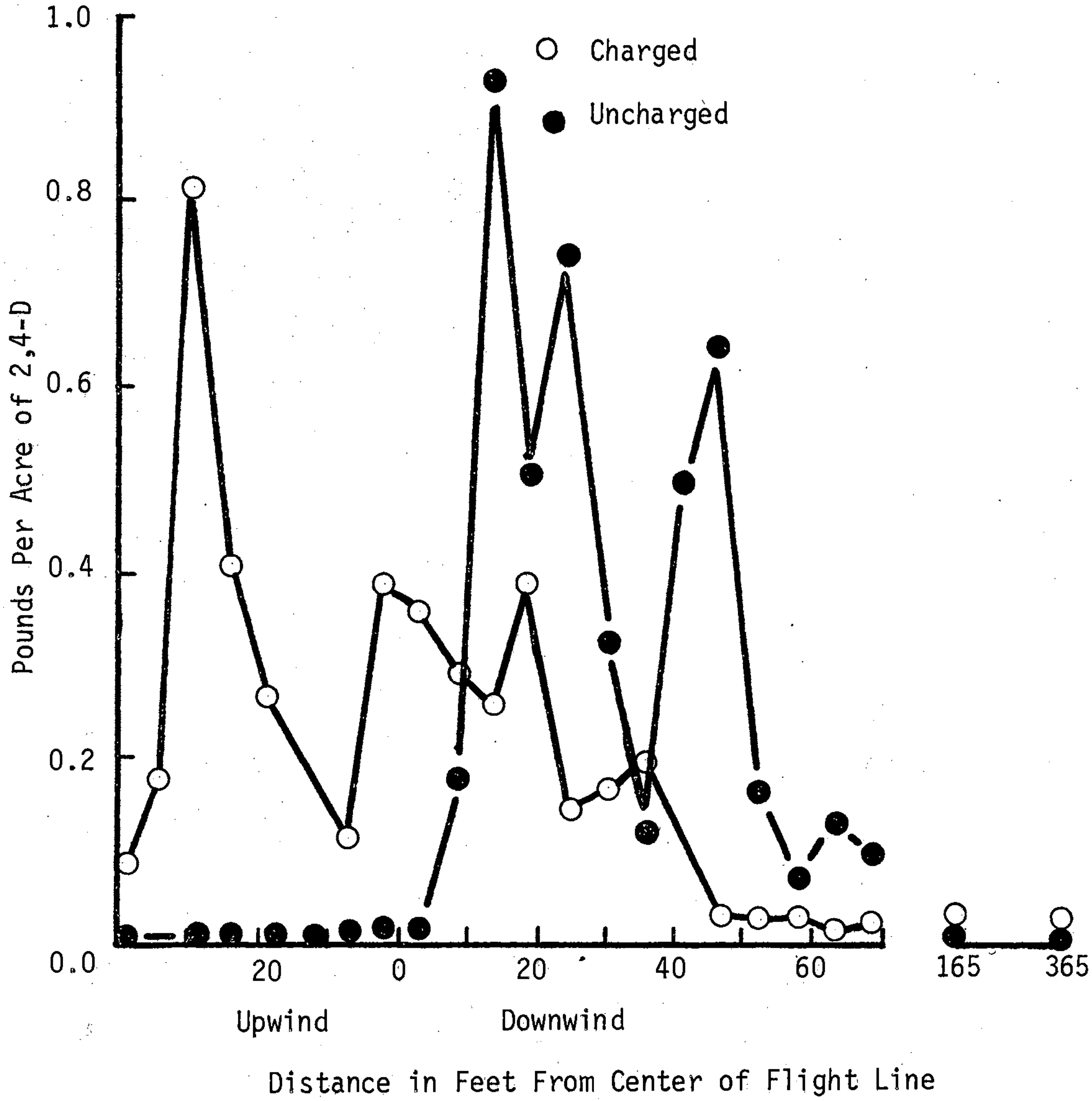

Figure 16. Replication I. Deposition of 2,4-D Applied With Charged and Uncharged Drops in a Volume of 2 Gallons Per Acre and Collected on Steel Plates Placed at Various Distances Upwind and Downwind From the Center of Flight

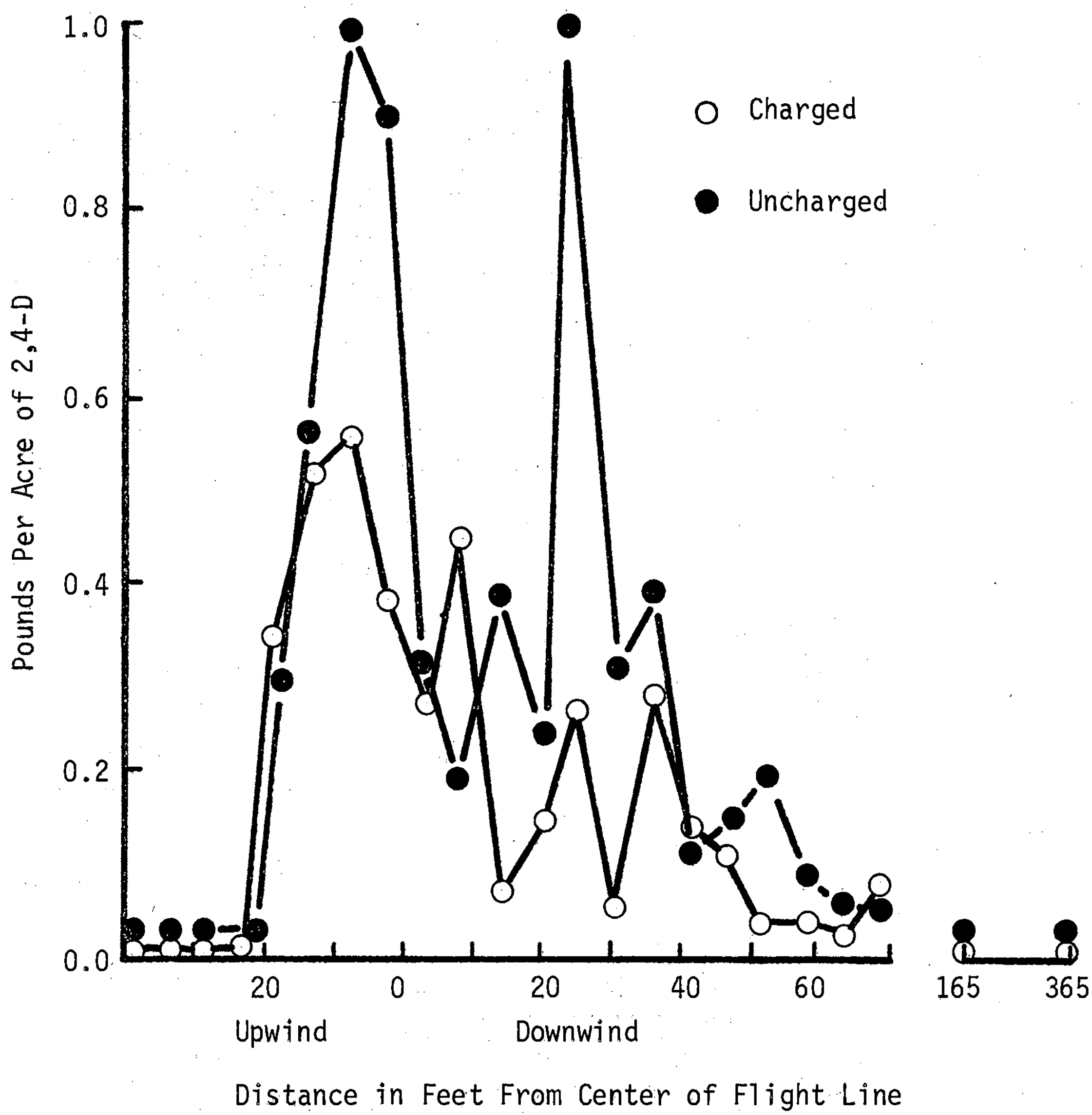

Figure 17. Replication II. Deposition of 2,4-D Applied With Charged and Uncharged Drops in a Volume of 2 Gallons Per Acre and Collected on Steel Plates Placed at Various Distances Upwind and Downwind From the Center of Flight

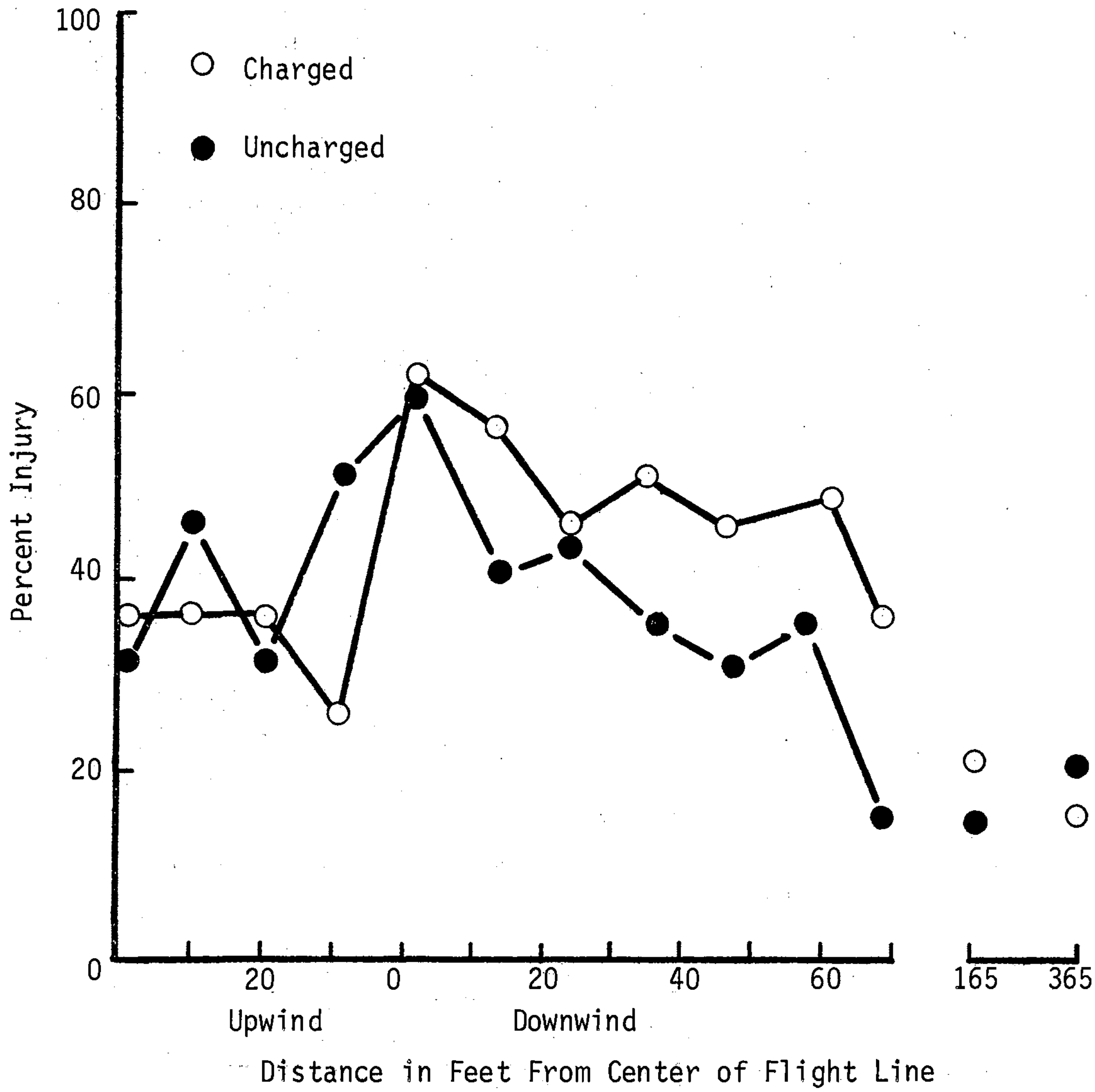

Figure 18. Effect of Charged and Uncharged Drops at a Volume of 1 Gallon Per Acre on the Visual Injury of Beans Placed at Various Distances Upwind and Downwind From the Center of Flight

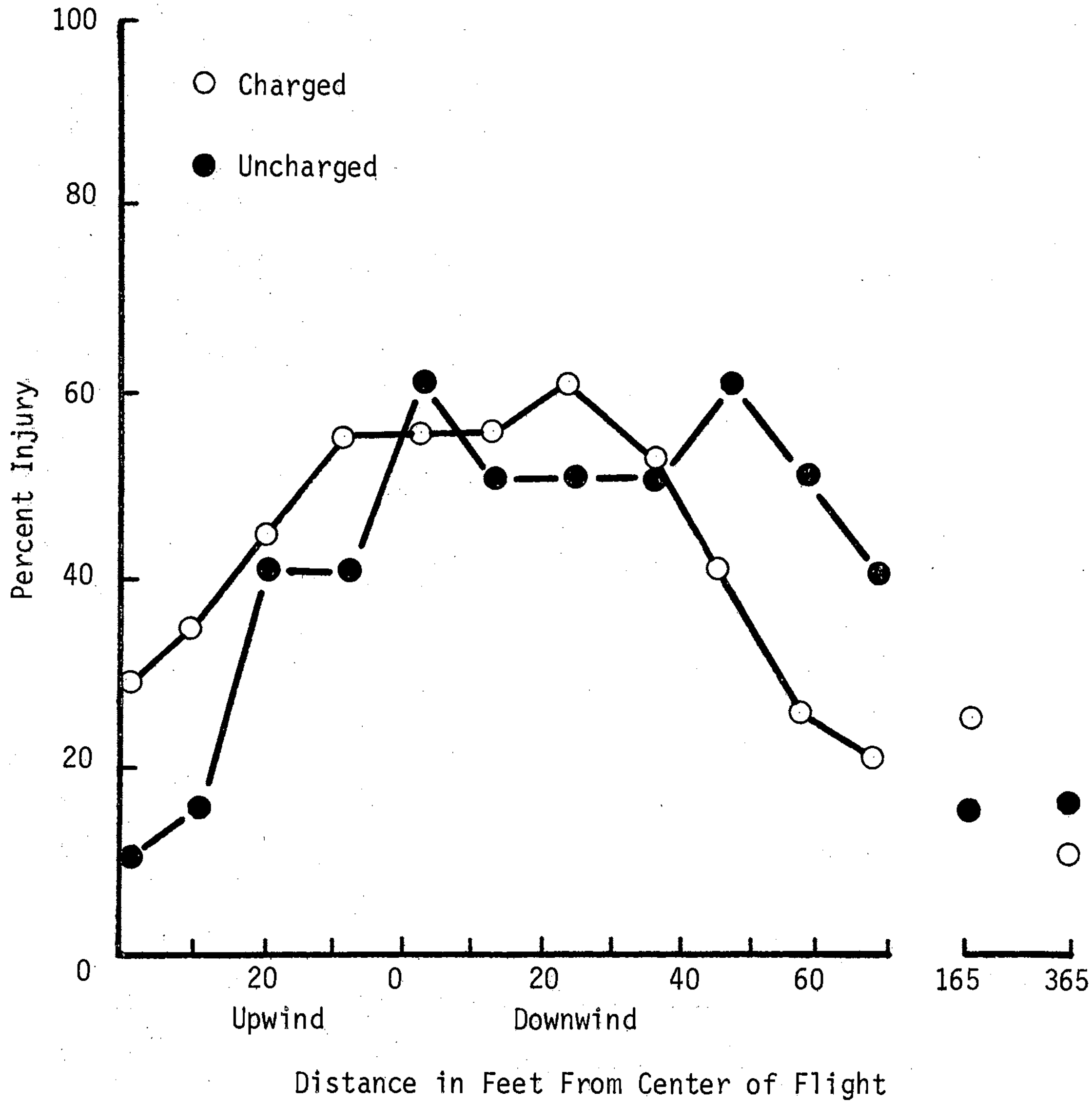

Figure 19. Effect of Charged and Uncharged Drops At a Volume of 2 Gallons Per Acre on the Visual Injury of Beans Placed at Various Distances Upwind and Downwind From the Center of Flight

<u>Phytotoxic Effects on Weeds.</u> The effects of charged and uncharged drops on western ragweed are shown in Figures 20, 21, and 22. As with bean response, highest ragweed response was only about 60 per cent near the center of the spray swath. From the center, weed response decreased rapidly upwind and downwind. Differences between charged and uncharged drops are considered negligible.

The per cent of dead ragweeds in plots four weeks after treatment is shown in Table IV. There were no differences between charged and uncharged drops at any rate and volume combination. Ragweed control was very low for all treatments.

TABLE IV

DEAD RAGWEEDS FOUR WEEKS AFTER TREATMENT WITH 2,4-D AT TWO RATES AND TWO VOLUMES USING CHARGED AND UNCHARGED DROPS

2,4-D (LB/A)	Volume (GAL/A)	Percent[1]	
		Charged	Uncharged
3/4	1	30	29
1	1	22	19
1	2	38	37

[1]Means do not differ significantly at P $\leqslant$.05.

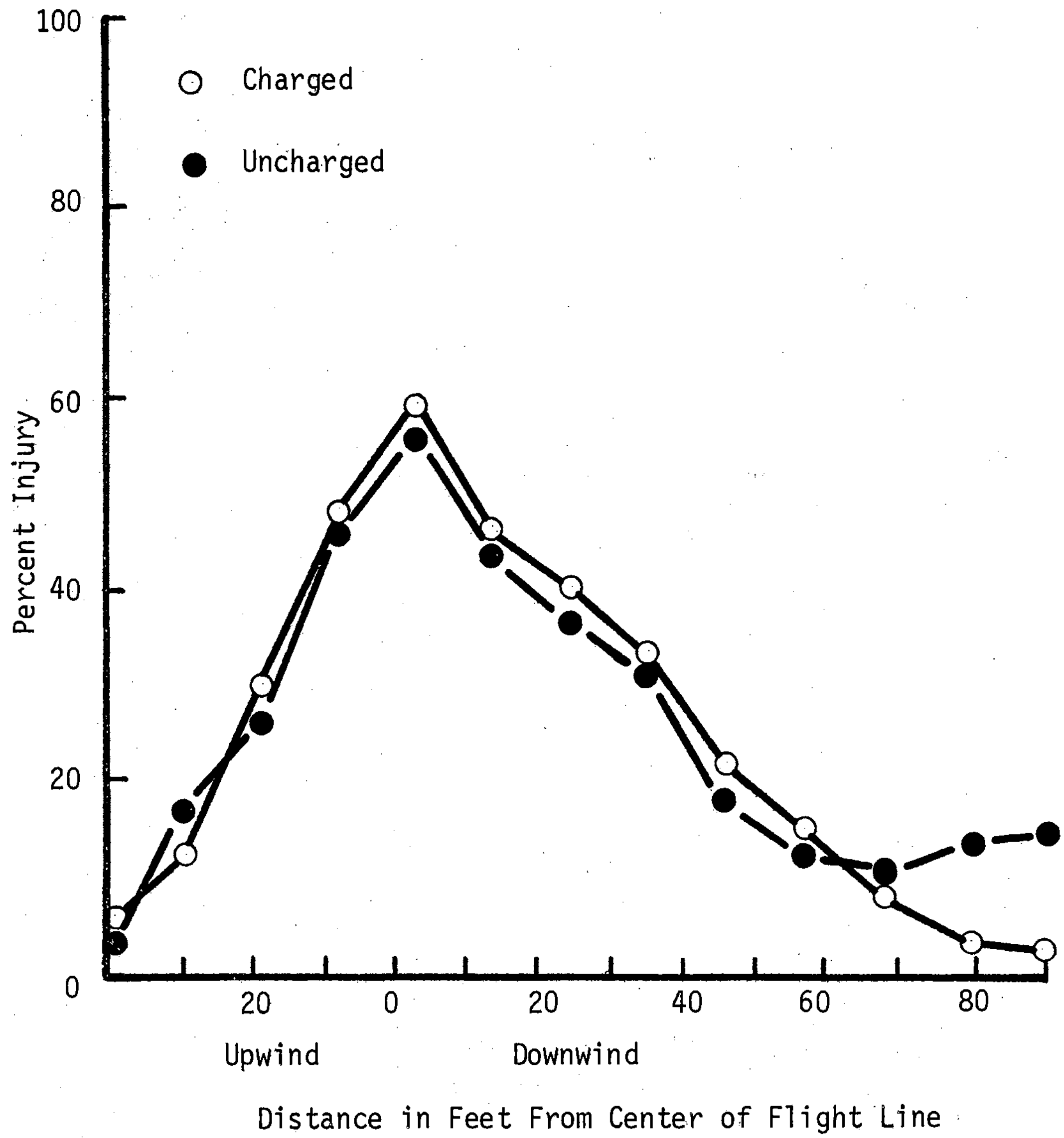

Figure 20. Effect of Charged and Uncharged Drops on the Visual Injury of Ragweed at Various Distances Upwind and Downwind From the Center of Flight When 2,4-D Was Applied at 3/4 Pound Per Acre in a Volume of 1 Gallon Per Acre

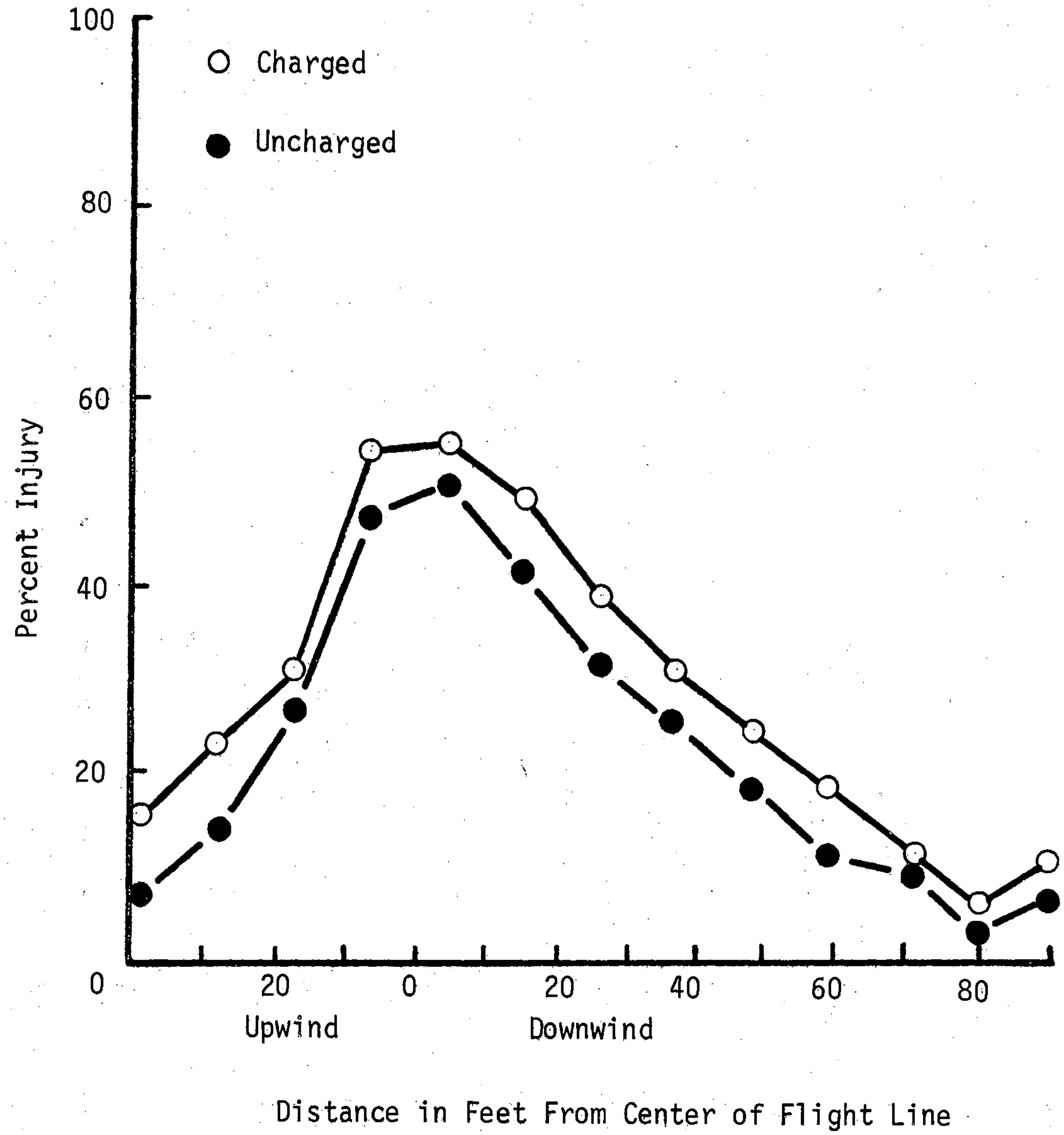

Figure 21. Effect of Charged and Uncharged Drops on the Visual Injury of Ragweed at Various Distances Upwind and Downwind From the Center of Flight When 2,4-D Was Applied at 1 Pound Per Acre in A Volume of 1 Gallon Per Acre

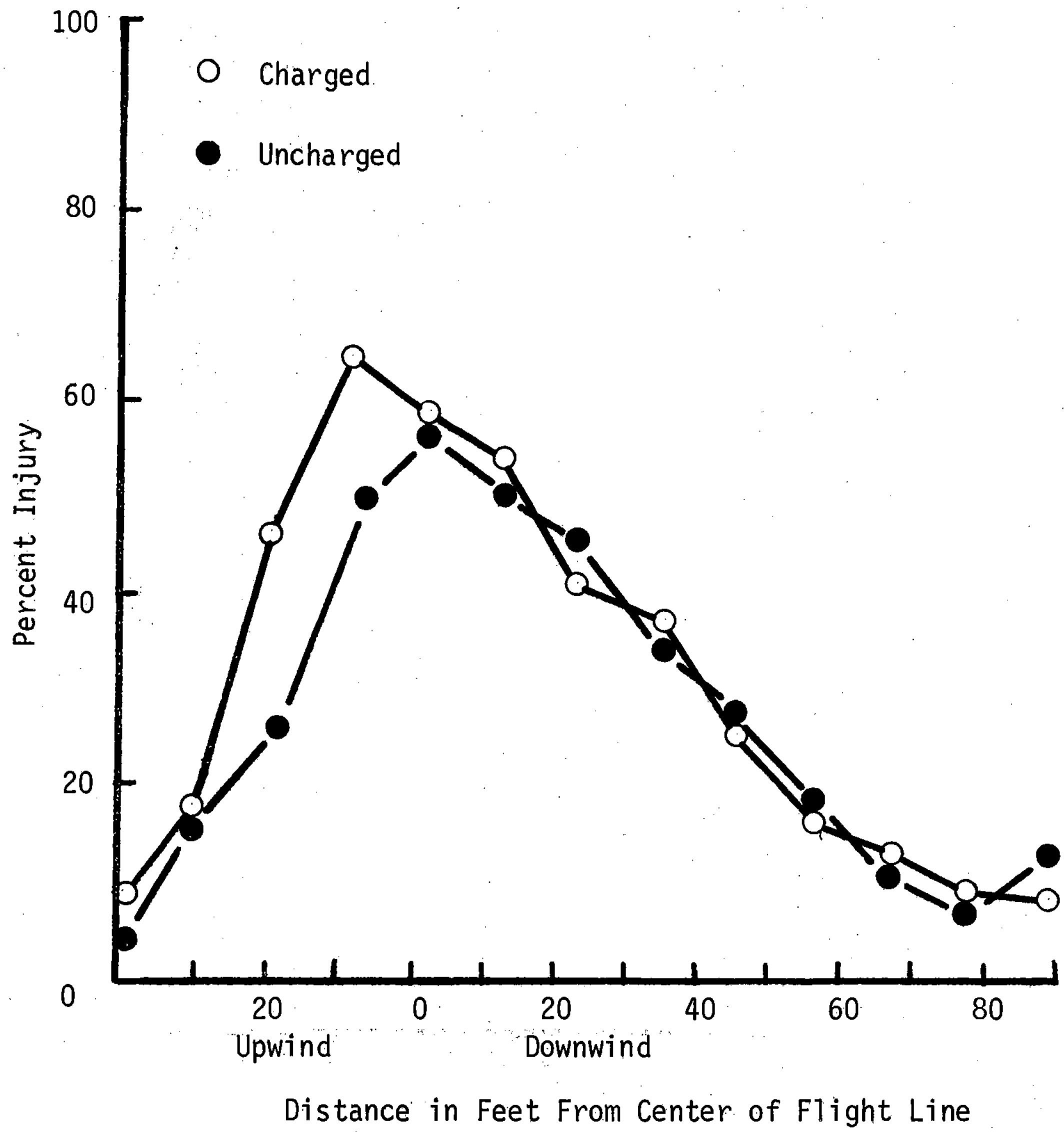

Figure 22. Effect of Charged and Uncharged Drops on the Visual Injury of Ragweed at Various Distances Upwind and Downwind From the Center of Flight When 2,4-D Was Applied at 1 Pound Per Acre in A Volume of 2 Gallons Per Acre

In general, in the Electrostatic study no trends were established between 2,4-D rates and volumes or between charged and uncharged drops. In this particular study, it was impossible to clearly establish whether the spray drops were receiving the electrical charge. More research is needed to clearly establish the effect of charged drops from airplanes.

Brush Studies

Deposition and Distribution of Spray

The deposition of 2,4,5-T on overstory and understory blackjack oak leaves is shown in Table V. The Microfoil System deposited 2.71 pounds per acre of 2,4,5-T compared to 1.82 for the conventional and 1.89 for the Foam System at 5% on overstory leaves. Amounts of 2,4,5-T deposited by the Foam System were significantly less on understory leaves compared to all spraying systems on overstory leaves. Amounts of 2,4,5-T deposited by all spraying systems on understory leaves were significantly less compared to the Microfoil on overstory leaves. The Microfoil System deposited 1.49 pounds per acre on understory leaves compared to 0.87 for the Foam System and 1.36 for the conventional system.

Although there was a greater deposition trend by the Microfoil System on overstory and understory leaves, the number of drops deposited by the Microfoil was much less (Table VI). The total number of spots per square inch was 63 for the Microfoil, 403 for the conventional and 219 for Foam. The spots produced by the Microfoil System were fairly evenly distributed among the three size ranges with about half of the drops making spots on linagraph paper larger than 1500 microns in diameter. In contrast, over 80 per cent of the spots produced by drops

TABLE V

DEPOSITION OF 2,4,5-T IN POUNDS PER ACRE AT TWO LEVELS WHEN SPRAYED WITH VARIOUS SPRAYING SYSTEMS

Spraying System	Pounds Per Acre Deposited[1]	
	Overstory	Understory
Conventional	1.82ab	1.36bc
Microfoil	2.71a	1.49bc
Foam at 5%	1.89ab	0.87c

[1]Values followed by the same letter do not differ significantly at $P \leq .05$.

TABLE VI

NUMBER AND SIZE DISTRIBUTION OF SPOTS PER SQUARE INCH PRODUCED BY VARIOUS SPRAYING SYSTEMS

Spraying System	Diameter of Spots (Microns)			
	$<$500	500-1500	$>$1500	Total
Conventional	354	49	0	403
Microfoil	15	18	30	63
Foam at 5%	156	53	10	219

from the conventional system were less than 500 microns in diameter with spots 1500 microns or larger. Over 70 per cent of the total spots produced by drops from the Foam System were less than 500 microns in diameter with about the same number of spots between 500 and 1500 microns as produced by the drops from the conventional system. Less than 5 per cent of the spots produced by drops from the Foam System were greater than 1500 microns in diameter.

Weather conditions during these treatments were favorable for herbicide deposition. Air temperature ranged from 84-87 degrees fahrenheit and relative humidity ranged from 64-70 per cent.

Effect of Spraying Systems on Blackjack Oak and Post Oak

Desiccation. Differences in desiccation from the various spraying systems were not significant on blackjack oak or post oak (Table VII). However, there appears to be some trend developing. Generally, in blackjack oak and post oak, desiccation was highest from the conventional and and Foam Systems at the higher spray volume of 4 gallons per acre. The conventional system at 2 gallons per acre gave slightly more desiccation than the Microfoil at 4 gallons per acre. On blackjack, least desiccation occurred from the Foam System at 2 gallons per acre.

Defoliation. Defoliation from the Microfoil System and conventional system at 2 gallons per acre was significantly less from the other systems on blackjack oak. Defoliation on blackjack oak was 88-89 per cent for the conventional system at 4 gallons per acre and the Foam System at both volumes.

TABLE VII

DESICCATION AND DEFOLIATION OF OAKS ONE AND THREE MONTHS, RESPECTIVELY, AFTER SPRAYING WITH 2,4,5-T USING VARIOUS SPRAYING SYSTEMS

Spraying System	Vol. (GAL/A)	Percent Desiccation		Percent Defoliation[1]	
		Blackjack Oak	Post Oak	Blackjack Oak	Post Oak
Conventional	4	74a	68a	88b	86bc
	2	66a	60a	80a	83ab
Microfoil	4	59a	53a	74a	78a
Foam at 5.0%	4	70a	63a	88b	88c
	2	54a	59a	89b	85bc

[1]Values followed by the same letter in a vertical column do not differ significantly at $P \leqslant .05$.

Post oak defoliation followed the same trend as blackjack oak. Defoliation was less on post oak sprayed with the Microfoil System and conventional system at 2 gallons per acre.

Canopy Reduction. Canopy reduction on blackjack oak and post oak was less from the Microfoil System (Table VIII). The conventional and Foam Systems at 4 gallons per acre gave highest canopy reductions on both species. Generally, conventional and Foam Systems at 2 gallons per acre gave intermediate canopy reduction. The trend for higher response of post oak to 2,4,5-T is also evident. Blackjack oak was less susceptible to 2,4,5-T from all treatments.

Apparent Kill. The per cent of blackjack oak and post oak trees considered to be completely killed are shown in Table VIII. Trees with 100 per cent canopy reduction but with root or stem sprouts are omitted. For both species, the conventional and Foam Systems at 4 gallons per acre gave higher apparent kill than the Microfoil. Only 1 per cent of the blackjack oak was completely killed by the Microfoil. Again, lowering the spray volume from 4 gallons per acre to 2 gallons per acre reduced the effectiveness of the conventional and Foam Systems. Although differences appeared, they were not significant at the 5 per cent level of significance.

TABLE VIII

CANOPY REDUCTION AND APPARENT KILL OF OAKS TWELVE MONTHS AFTER SPRAYING WITH 2,4,5-T USING VARIOUS SPRAYING SYSTEM

Spraying System	Vol. (GAL/A)	Percent Canopy Reduction		Apparent Kill[1]	
		Blackjack Oak	Post Oak	Blackjack Oak	Post Oak
Conventional	4	52bc	68a	17a	30a
	2	42ab	56a	8a	19a
Microfoil	4	33a	46a	1a	7a
Foam at 5.0%	4	59c	70a	16a	27a
	2	38ab	52a	4a	14a

[1]Values followed by the same letter in a vertical column do not differ significantly at $P \leq .05$.

CHAPTER V

SUMMARY

Field studies were conducted to determine the effect of four spraying systems used during the aerial application of herbicides. The objectives of these studies were to determine (1) the spray patterns produced by various spraying systems, (2) the effect of each spraying system on target plant species and (3) to correlate phytotoxicity with spray patterns produced by each spraying system. The spraying systems tested were the Microfoil System, Foam System using various rates of foam, Electrostatic System, and a conventional system. All four systems were used to spray pasture plots using two rates of 2,4-D and all systems except the Electrostatic were used to spray brush plots using 2,4,5-T.

Results from the pasture studies indicated that the conventional system produced a spray swath with a large amount of downwind drift. The spray from the Microfoil System was mostly confined to a spray swath of approximately 55 feet. Spray from the Foam System at either rate of foam was confined to a spray swath of 65-70 feet. Although the Microfoil System gave good confinement of the spray to the spray swath, downwind drift was measured as far as 365 feet. The spray pattern produced by the Foam System was intermediate between the Microfoil and conventional systems but drift beyond 70 feet downwind was practically eliminated. Severe drift resulted with the use of the conventional system with large amounts of herbicide detected 375 feet downwind. Results from beans and western ragweed treated with the various spraying systems showed less control from the Microfoil System as compared to the Foam and conventional systems. The conventional and Foam Systems were equally effective on the control of beans and western ragweed within the spray swath. However, more control of beans and western ragweed occurred outside the spray swath from the conventional system.

The Electrostatic Charging System was not effective in reducing drift with charged spray drops in any combination of herbicide rate and spray volume. Results from 2,4-D deposition on steel plates indicated that spray patterns were extremely variable across the spray swath. Bean and western ragweed response was poor with both charged and uncharged drops. There was no significant differences obtained when 2,4-D rates and solution volumes varied.

Results from the brush study indicate that spray coverage may be an important factor limiting the effectiveness of the Microfoil System. Only 63 drops per square inch were deposited by the Microfoil System compared to 403 and 219 for the conventional and Foam System, respectively. In addition, 50 percent of the drops produced by the Microfoil System were greater than 1500 microns in diameter while most of the drops produced by the conventional and Foam Systems were less than 500 microns in diameter.

The phytotoxic effects of the Microfoil, conventional, and Foam Systems were evaluated on blackjack oak and post oak at spray volumes of 4 and 2 gallons per acre for the conventional and Foam Systems and 4 gallons per acre for the Microfoil System. Initial desication and defoliation of blackjack oak and post oak were higher with the conventional and Foam Systems at 4 gallons per acre. Using the Microfoil System or decreasing the volume for the conventional and Foam Systems caused a decrease in oak response. The canopy reduction and apparent kill of blackjack oak and post oak 1 year after spraying again showed similar trends. The conventional and Foam Systems at 4 gallons per acre were equally effective in the control of oaks. However, a reduction in effectiveness occurred when the volume changed to 2 gallons per acre. All second year results indicated that blackjack oak was more resistant to the 2,4,5-T treatments than post oak.

Spray coverage is an important factor influencing the effectiveness of all the spraying systems. The conventional system gave excellent spray coverage due to the large number of fine-sized drops. The effectiveness of the Microfoil System is limited because it creates large, highly concentrated drops which give poor coverage on foliage. The Foam System gives equally effective spray coverage as the conventional system but because of the creation of the fine-size drop component, it does not fulfill the drift control need.

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