Rec'd 10,000- 9-12-69
New - Hoffman

FACT SHEET

L-848

CONTROLLING DRIFT OF HERBICIDAL SPRAYS

Garlyn O. Hoffman and Robert H. Haas*

Spray drift is a major problem in applying herbicides for brush or weed control. The problem is two-fold:

1. Drift from the spray operation may contaminate crops and animals on adjacent areas.
2. Loss of spray material from the target area may reduce the efficiency of the treatment.

From a safety standpoint, the first of these problems is more serious. Safe application of herbicides must limit the spray deposit to the target area.

In Texas, the primary problem of herbicidal drift is what happens to susceptible crop plants. Some plants are extremely sensitive to the phenoxy-type herbicides and will show effects from exposure to minute amounts. Cotton, for example, may develop characteristic 2,4-D symptoms at rates of 1/1000 pound per acre and seed cotton yields may be reduced when sprayed with as little as 1/100 pound per acre. Herbicides may drift several miles in sufficient quantities to cause effect on susceptible crops if weather conditions are conducive to drift and large acreage is treated.

WHAT HERBICIDAL SPRAY DRIFT IS

Spray drift is the movement of herbicides away from the target area. The different kinds of herbicidal movement are:

Vapor drift occurs when the herbicide volatilizes after being deposited on the target area. Vapor drift most likely occurs when the ester formulation of herbicides is used. These materials are separated as "volatile" or "low volatile" formulations. Amine and salt formulations are referred to as "non-volatile." These are relative terms and even "non-volatile" herbicides will vaporize to some degree under extreme weather conditions. The "low volatile" esters generally vaporize slowly when the temperature is below 90-100 degrees F., while the "volatile" esters vaporize readily at 65 degrees F. The relative volatility of a herbicide is related to its formulation, and "vapor drift" *can be controlled* by using the proper herbicide formulation.

Physical drift is defined as the movement of droplets or particles away from the treated area before they reach the intended target. Physical drift results from wind carrying the small particles away from the target area. Also, temperature inversion may prevent the settling of very small droplets and allow their movement away from the target area under very calm conditions. Physical drift can be reduced also by making the herbicide application when the wind velocity is low, but when there is no temperature inversion.

FACTORS AFFECTING PHYSICAL SPRAY DRIFT

Spray drift is determined primarily by meteorological conditions and spray droplet size. The important meteorological factors include thermal conditions, wind velocity and humidity. The degree to which these forces exert their influence depends on droplet size. Small droplets are easily displaced. Table 1 shows the approximate distances that water droplets of different sizes may be displaced while settling 10 feet in a 3 mph wind. A greater fall distance or higher wind velocity will markedly increase the drift distance. For example, a 100 micron droplet falling 50 feet in a 3 mph wind would be displaced 265 feet; in a 5 mph wind it would move 435 feet from the point of release. One micron is 1/25,400 of 1 inch.

Table 1. Approximate distances various size water droplets would travel while settling 10 feet in an air flow averaging 3 mph.

Droplet diameter (microns)	Description	Distance traveled (feet)
1000	Moderate rain	5
500	light rain	7.5
300		10
200	drizzle	18
100	mist	50
50		200
15	coarse aerosol	2000

*Extension range brush & weed control specialist and assistant professor, Department of Range Science Texas A&M University.

30.2

Evaporation of the droplets as they fall increases the driftability of a spray. Droplet size affects evaporation rate because the descent velocity and surface to volume relationship both are functions of droplet diameter. As the diameter of a droplet decreases, the surface area to volume ratio increases and evaporation proceeds at an increased rate. The time of exposure to evaporative conditions also increases with decreasing droplet size. A droplet 200 microns in diameter falls an estimated 50 feet in 13 seconds, whereas a 50-micron droplet takes 3.4 minutes to fall 50 feet. Measurements of the lifetime of droplets in an atmosphere of 86 degrees F. and 50 percent relative humidity have shown water droplets of 50 and 200 microns in diameter to have a lifetime of 3.5 seconds and 56 seconds respectively.

Research with ground and aerial spray equipment has shown that increases in spray pressure result in a higher percentage of small droplets in the spray. As pressure increased, the median droplet diameter decreased with either a water or No. 2 fuel oil carrier. Comparison of water and fuel oil carriers in these tests shows that median droplet diameters from water sprays were approximately 1.7 times as large as those from diesel oil sprays applied under the same conditions.

Nozzle orifice size and design affects the spray particle size. Larger orifices or nozzle tips that produce solid jets generally produce coarse sprays. Research with oil-base sprays from aircraft has shown that *as the nozzle orifice diameter is increased the amount of drift susceptible spray is reduced appreciably*. This is a reduction, not elimination of small droplets.

With aerial application, the orientation of nozzles relative to the thrust line of the aircraft also markedly affects breakup of sprays. Orientating the nozzles straight down or forward causes the spray to be broken up more than if the nozzle is oriented back and into the air stream. Orientating the nozzle so the spray is released in less turbulent air aids in reducing droplet breakups.

The potential amount of spray drift varies with methods of application. Ground application generally is safer than aerial application because the distance between the point of release and the target is less and because coarse sprays can be formed. Sprays from aircraft are drift susceptible for these reasons: (1) spray from the nozzle is subject to shear by high velocity air movement past the nozzle tip, and (2) sprays usually are released from considerable height above the target. Sprays from fixed-wing aircraft commonly have a droplet size distribution in which 50 percent or more of the droplets are smaller than 200 microns in diameter.

DRIFT CONTROL MATERIALS

During the past few years, the agricultural chemical industry has developed various materials and techniques for applying herbicides in low-drift sprays. In general, the approach has been to reduce drift by regulating the size of droplets by the application of thickened sprays.

Invert emulsions. An invert emulsion is a water-in-oil emulsion in contrast to the commonly used oil-in-water emulsion. Use of invert emulsions in the past has been limited, primarily because of problems in handling and application. The invert emulsion has a consistency similar to that of mayonnaise and is commonly produced by mixing the oil and water phases at the pump or at the nozzle.

Mixing the herbicide with a bifluid system has several distinct advantages: (1) premixing is eliminated; (2) herbicide and water are metered into the mixing chamber, thereby assuring a consistent, correct ratio; and (3) herbicide formulations may be designed to produce emulsions of known and predictable viscosity. Limitations are: (1) special equipment is required; and (2) only those herbicides specially formulated to invert or a specific invert additive can be used.

Invert emulsions have shown good potential in reducing spray drift. The percentage of spray volume contained by small droplets has been greatly reduced. However, the invert is also subject to factors such as nozzle tip design, orifice size and nozzle orientation, all of which affect the degree of spray atomization. Emulsion thickness also may markedly affect drift control. Thinner emulsions produce more drift-susceptible droplets.

Invert emulsions may also be premixed and applied through a conventional system. One such method makes use of special equipment by applying the premixed invert from a centrifugal disc apparatus designed to produce very coarse sprays.

Particulated sprays. A second drift control material is a water-swellable, water-insoluble polymer that forms a "particulated" spray. Upon addition of the proper amount to a water and herbicide mixture, essentially all of the solution is absorbed by the polymer particles which do not dissolve. The swollen particle size is determined by the size limit of ground dry polymer. The particulated spray solution is quite viscous and similar to that of a thin tapioca pudding. This material offers the possibility of control over droplet size; however, there is some aggregation of particles to form large particles, and some small particles are also formed from unabsorbed solution.

The volume of spray contained by small, driftable particles is substantially lower with the particulated spray than with conventional sprays. Coverage aspects are similar to those of the invert emulsion.

A disadvantage of this material is in premixing, since a small error in measuring will result in a poor mixture. If too much polymer is added, it may be very difficult to pump. If too little is added, there may be excessive free water, producing small droplets when applied from fixed wing aircraft. A limiting factor on the uses of herbicides with the particulated spray is that only water soluble herbicides may be used.

Other spray thickening agents. A third material which shows promise for controlling drift is *hydroxyethyl cellulose.* This material is a water soluble polymer that increases the viscosity of the spray solution according to the amount added. Herbicides are mixed in the thickened solution and the viscous mixture is sprayed through conventional equipment. Hydroxyethyl cellulose offers several advantages: (1) special equipment is not required and (2) water soluble or emulsifiable herbicides may be used. Herbicide mixtures can be used and oil-in-water emulsions may be prepared. The broad range of herbicides that can be used with hydroxyethyl cellulose gives this material broad potential use.

Other water soluble materials for thickening spray solutions are on the market. Although these materials have not been tested as thoroughly as the hydroxyethyl cellulose, they are expected to give similar results.

CHARACTERISTICS OF THICKENED SPRAYS

Thickened solutions tend to produce sprays having a broad range of droplet sizes. Under proper conditions they may provide a substantial degree of drift control. At the same time, a substantial number of large droplets are formed. These large droplets have a significant influence on the distribution of spray volume and result in a much lower number of droplets deposited per unit area with a given volume of spray.

As droplet diameter is doubled, there is an eight-fold increase in volume with a corresponding reduction in drop numbers. The number of droplets in a spray pattern may be especially important with low-volume applications, even though requirements vary among plant species. Some evidence shows that a minimum number of droplets per unit area is required for effective mesquite control. Proper coverage for effective control requires at least 72 droplets per square inch of leaf surface.

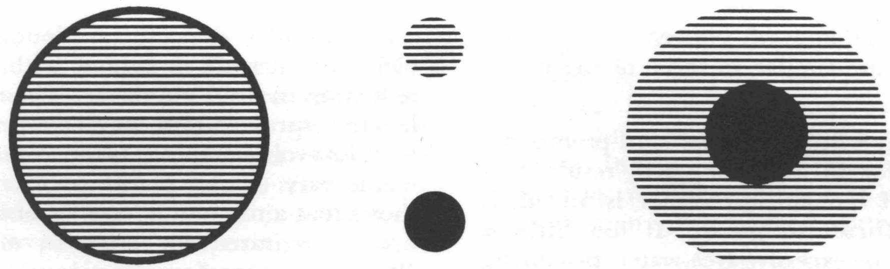
Research with invert emulsion sprays in field tests has shown that droplet size and distribution may be critical factors in obtaining maximum effective spray coverage with thickened sprays. Data in Table 2 show the range of droplet sizes from several invert emulsion spray tests compared with the conventional emulsion. If 200 microns are used as a limit for effective drift control, 7.5 percent of the conventional spray volume is in a very driftable form. The conventional spray contains ten times as much volume in droplets below 200 microns as the helicopter invert spray, and more than seven times as much as the fixed-wing invert spray.

Another significant characteristic of the spray described in Table 2 is the effect of large droplets on volume distribution. With the helicopter spray, only 7 percent of the droplets were larger than 1000 microns but they accounted for 60 percent of the spray volume. This spray, when compared with the conventional spray from the fixed-wing aircraft, provided less than a third the number of droplets per unit area. This could be a critical factor in the effectiveness of a spray application. *In field applications it appears that twice the volume per acre is required with thickened sprays as with conventional sprays to obtain satisfactory coverage for satisfactory control.*

The drift control and droplet size range characteristics shown for the invert emulsion sprays are fairly typical of other thickened sprays. Thus far, a spray in which all droplets below 200 microns were eliminated has not been observed. Reducing the number of large droplets formed without

Table 2. Relationship of droplet size distribution to volume distribution on oil-in-water spray and two invert emulsion sprays.

Emulsion	Percent of total	Droplet size range (microns): Less than 200	200-600	600-1000	Greater than 1000	Drops/sq. in. at 5 gpa
Conventional (fixed-wing)	Droplets	55.0	43.3	1.7	0	130
	Volume	7.5	63.5	29.0	0	
Invert (fixed-wing)	Droplets	22.0	66.0	10.4	1.6	65
	Volume	1.0	32.0	39.0	28.0	
Invert (helicopter)	Droplets	17.0	65.0	11.0	7.0	40
	Volume	0.7	16.3	23.0	60.0	



EMULSION TYPES

Cross Section of Typical Magnified Droplets

KEY

Water
Oil

Invert Emulsion
(Water-in-Oil)
Oil Film Surrounds
Water Particles

Conventional Emulsion
(Oil-in-Water)
Water Film Surrounds Oil

Both droplets are based on a ratio of one part of oil to 10 parts of water.

some increase in number of very small droplets also has not been achieved.

Thickened sprays in general produce a more variable spray deposit pattern than conventional sprays. Measurements made at regular intervals across spray swaths show more variation in the spray deposit with thickened sprays. They are also characterized by more abrupt cut-off points at the edge of the spray swath.

Thickening agents offer considerable promise for safer application of herbicides. Each of the materials has certain advantages and limitations. Successful use of any one requires a knowledge of its specific characteristics. Drift control is accomplished by a reduction in the percentage of small, drift susceptible droplets in the spray. Nozzle tip design and orientation, solution viscosity, airspeed and sprayer pressure appear to be important factors in determining the success of thickened sprays.

REDUCING SPRAY DRIFT BY REGULATING BREAKUP

Recent development of an air foil boom with many solid stream orifices appears to hold promise for regulating the size of droplets of conventional spray solutions. The Micro Foil Boom used with a helicopter, provides a spray having a minimum of large and small droplets. Good coverage is obtained with moderate volumes of application. Special care is required to maintain the system free of foreign matter which would plug the small orifices. The system has not been evaluated for use on fixed-wing aircraft. Further evaluation is necessary to determine the potential of this equipment for controlling drift of herbicide sprays applied in rangeland brush and weed control. Additional research is needed to develop methods of regulating spray breakup with fixed-wing aircraft application.

PRECAUTIONS

Successful use of thickened sprays depends on: (1) the use of correct concentrations of the thickening agent, and (2) use of proper nozzle tips designed and oriented to release the material in a manner that subjects the solution to the least shear forces at the nozzle. Applied under less than optimum conditions, any one of the thickened solutions can produce sprays containing considerable drift susceptible droplets.

Herbicide applications should be made (1) in slight wind conditions with a definite direction; (2) no temperature inversion; (3) clear weather conditions; (4) when spray doplets settle on target area at a rapid rate; and (5) using low sprayer pressure and large nozzle orifices.

PR-2605, Possibilities for Controlling Drift with Thickened Sprays, published by the Texas Agricultural Experiment Station, Texas A&M University, 1968, lists references about drift control. This information is available from your county Extension agent.

Cooperative Extension Work in Agriculture and Home Economics, Texas A&M University and the United States Department of Agriculture cooperating. Distributed in furtherance of the Acts of Congress of May 8, 1914, as amended, and June 30, 1914.
10M—7-69