CONTROLLING SPRAY DRIFT THROUGH PROPER PESTICIDE APPLICATION

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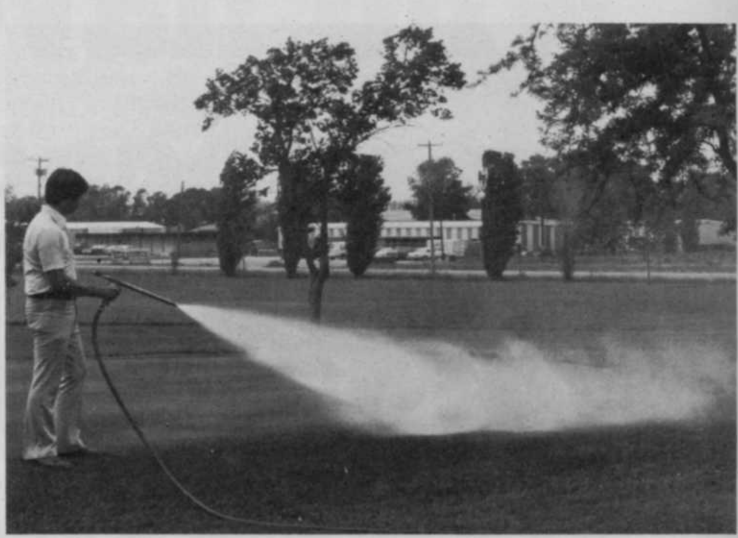
Spray drift, the movement of droplets to areas other than the intended site of application, causes many problems for the sprayer and his neighbor and is of utmost importance to control. In some cases, even a small amount of drift can be dangerous. It may damage sensitive crops nearby, produce unpleasant odors, and is generally undesirable in the environment. It also wastes chemicals too expensive to spread over non-target areas. To solve these problems and control drift, we must look at the size of spray droplets, a major factor.

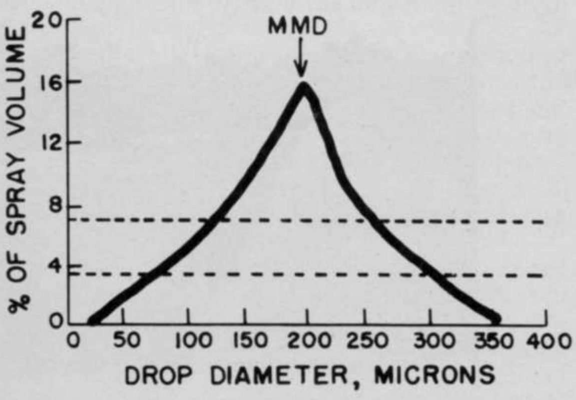
On one hand, the size droplet containing a pesticide may be excessively small (less than 20 microns in diameter—a micron is 1/25,000 inch) and float in the air until evaporated. This pesticide may be carried high in the atmosphere and so widely dispersed that a concentration necessary to cause a response is never attained. The area adjacent to the pesticide application site may receive enough deposits from droplets of this size (or slightly larger) to be detected on sensitive species. On the other hand, droplets may be so large (greater than 1,000 microns) that they will only cover a percentage of the pests or site.

In general, insecticides and fungicides are applied using smaller droplets and sometimes larger spray volumes to obtain the desired coverage of the pest (droplet size around 70 microns). Herbicides appear more likely to show up in symptoms on adjacent areas and it becomes extremely important to utilize larger droplets (200 to 500 microns) with very low numbers of fine droplets in the spray application. The large heavier droplets fall from the spray boom more directly to the ground or plant surface while small droplets require long periods to fall and may float to greater distances in the air.



Spray droplets are generally smaller for insecticides or fungicides than for herbicides to obtain the desired coverage of the pest.

Three major means exist to produce the proper size droplet and control drift as well as possible during the application of pesticides. These are the equipment, chemicals, and environmental conditions.



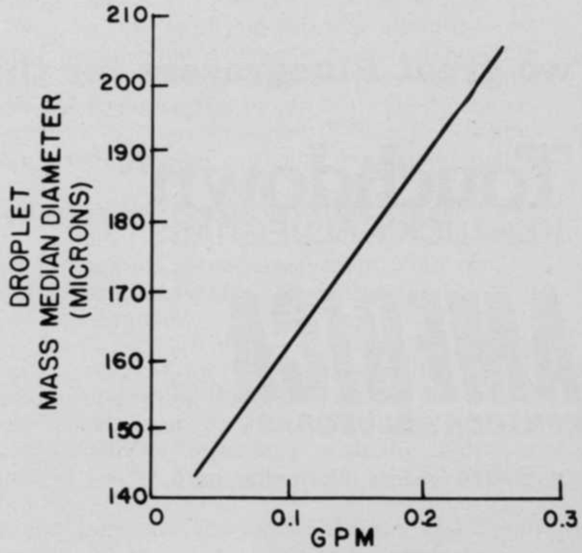


Figure 1. The typical nozzle orifice produces a wide range of droplet sizes. Overall, the spray is described by the mass median diameter, the top of the curve.

Figure 2. Mass median diameter increases as the flow rate is increased by changing to larger orifices and maintaining the same pressure. (Both graphs are modified from Tate and Janssen, 1966).

The largest droplet size that provides consistent control of the pest will be most practical for drift control. Use as large a nozzle orifice as possible and as low a pressure as consistent with spray pattern.

Equipment influences spray drift

The typical nozzle orifice on boom sprayers gives a wide range of droplet sizes and is a good place to begin seeing the effects equipment has on spray drift. Figure 1 shows the typical distribution from an orifice under 40 psi. In herbicide applications with drift hazard situations, a larger orifice size may be necessary to reduce the amount of fine droplets (less than 100 microns) below levels that may cause effect on non-target plants.

Since a wide range of droplet sizes comes out of a nozzle orifice, it is important to have a good way to express the amount of spray in various size droplets. If you double the diameter of a droplet, you must increase the volume of spray eight-fold to achieve the same amount of spray. For example, in figure 1, about 7 percent of the spray volume is in 130 micron diameter droplets and 7 percent in 260 micron droplets. Yet, at 130 microns there are eight times as many droplets as at 260 microns. In another comparison, 3½ percent of spray is in 75 micron droplets and the same amount is in 300 micron droplets. There are 64 times as many droplets having the small diameter. These are too small in most herbicide applications, even in still air. Then, the term used to describe the droplet distribution from various orifices frequently is "mass median diameter" (MMD), which refers to the diameter with ½ of the spray in droplets larger and ½ of the volume in droplets smaller. There may be many times more small droplets in comparison to large droplets.

The angle of spray pattern is also important to consider. Generally, cone and flat fan type orifices provide about the same droplet spectrum if the spray angles are about equal. At the same pressure, the flow rate increases with larger nozzle orifices (equal spray angle) and droplet size rate increases in almost direct proportions (Figure 2). A wide angle spray pattern (80 degrees) has more small droplets than narrow patterns (65 degrees). For example, at a 0.2 gallon per minute (GPM) flow rate using 40 psi, the MMD is about 380 microns for 80 degree flat fan nozzle orifice and about 450 microns for 65 degree flat fan (Figure 3) orifice. The operating pressure is regulated by a pressure regulator through returning excess spray back to the tank. If the operator uses larger nozzle orifices and reduces the pressure to obtain the same flow rate, the MMD is also increased. Figure 3 shows that reducing pressure to 10 psi provided a MMD of 490 microns compared to 380 microns using an 80 degree spray angle and 40 psi.

Assuming the boom has a fixed nozzle spacing or the flow rate per unit of boom length is to remain the same, an orifice providing a larger spray angle (80 degrees) would necessitate a low boom height (about 18 inches) compared to an orifice with narrow angle (65 degree) pattern (about 22 inches high). The importance of nozzle height and distance a droplet must travel to the target will be discussed under environmental effects later.

Since droplet size is a major factor in spray drift control, let us describe these related equipment aspects. First, the nozzle orifice size has a great impact on droplet size. Additional pressure, especially using a smaller orifice to provide a similar flow rate, will result in larger numbers of small droplets. As the spray angle from the orifice becomes larger at a given flow rate, it will produce more small droplets.

The speed of the sprayer and the orientation of the nozzle orifice to the direction of travel will also have an impact on droplet size. If the nozzle is spraying in the direction of travel, the droplets will be small. When spraying perpendicular to travel direction, a median droplet size is obtained. And spraying backward from the travel direction, with all other conditions the same, results in the largest droplets.

Some developments in nozzle design have greatly improved drift control. Nozzles are designed to reduce the number of small droplets in the spray pattern. The nozzles utilize a core and disc for swirling and metering the spray passing through the system. The secondary swirl chamber in the nozzle cap alters the flow of liquid, resulting in few fine droplets being discharged from a secondary large orifice in the cap. This is further improved by a special passageway extending from this orifice in the nozzle cap. Thus, nozzle design has been improved to reduce the range of droplet sizes and effectively reduce the number of fine droplets delivered from the boom.

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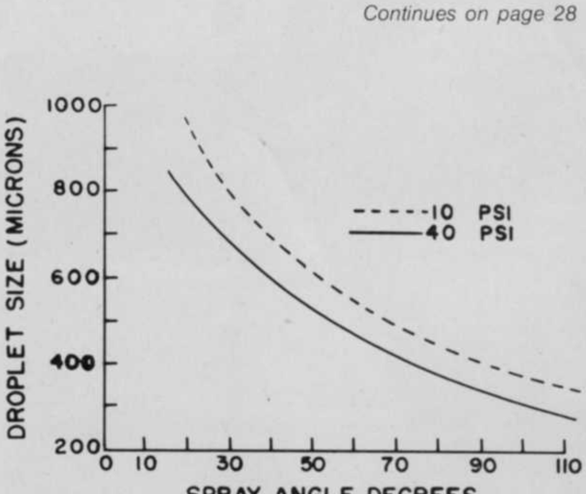


Figure 3. Droplet size gets smaller as the spray angle increases. Lower pressure provides larger size droplets. (Modified from Spraying Systems Co., 1967)

Hooded sprayers are available for many types of pesticide application; for example, herbicides to turfgrass areas. In this case, the hood contains somewhat rigid flaps hinging from about 10 inches above the soil level to provide cover rubbing along the top of the turfgrass. Gauge wheels maintain the hood and boom under the hood at a uniform height. These sprayers are generally mounted on a three-point hitch and are raised for turning (stop spray during turning because drift occurs from lifting hood).

Wick applicators are designed to apply pesticide through ropes rubbing on the plants (Figure 4). The rope is usually mounted through holes in the boom containing the spray material and trails along the bottom of the boom. Droplets are not formed until on the plant surfaces. Therefore, spray drift is almost completely controlled. This type of applicator is used primarily for weeds that are taller than the crop or desirable plants.

There is also a recirculating sprayer which utilizes streams of spray material directed from nozzles on one side of a row to trap on the other side. Weeds must be taller than the crop for effective coverage with less pesticide on the crop. There are very few fine droplets from this application except when the stream of spray splatters as it hits the target plants.

With equipment, it is important to remember that droplet size and distance from droplet release to target are prime factors in drift control. Nozzle orifice size and pressure utilized are also essential. Less spray drift comes from a large orifice, low pressure boom sprayers, and low boom height. Operators should utilize the largest droplet size that will provide the desired control of the pest in order to reduce spray drift.

Chemical aspects influencing spray drift

A pesticide formulation contains many ingredients to improve the final application results. Surfactants, emulsifying agents, and other additives affect the droplet size during application. Any change toward larger droplets usually reduces drift potential. Generally, formulation ingredients increase viscosity of the spray and increase droplet size during application.

During the last several years, thickeners have been widely evaluated and used in reducing spray drift during pesticide application. One thickening agent is a polyvinyl polymer material which provides some increase in mass median diameter of the spray droplets during application, but the major improvement lies in the fact that it effectively reduces the number of small droplets through elastic surface properties (Figures 5 and 6). The addition of anti-drift thickeners provides a greater margin of safety from spray drift; however, acceptable results must be attainable with slightly larger droplets. These compounds are particularly suited for drift control while applying auxin-type herbicides.

Even with polyvinyl polymers included in the spray mix to reduce the chances for significant spray drift, drift can still occur. Then, it continues to be important to use common sense in regard to pesticides that are particularly proned to produce bad effects or residues on nearby sensitive plants.

Droplets as large as 200 microns drifted 15 feet or more in a 7½ mph wind while falling 7½ feet from a nozzle tip in a wind tunnel (Figure 5). Using 1 pint of Nalco-Trol (polyvinyl polymer from Nalco Chemical Co.) per 100 gallons of water reduced drift to barely detectable levels using a dye to determine droplet deposits on glossy paper at 5 feet down wind under similar conditions.

In addition to drift control, the polyvinyl polymer formulations provide spreading properties on the leaf surface and improve uptake of several herbicides. Thus, herbicide effectiveness may be improved by keeping the droplet on the foliage, spreading, and improving absorption for longer periods (droplets dry on leaf surface much slower).

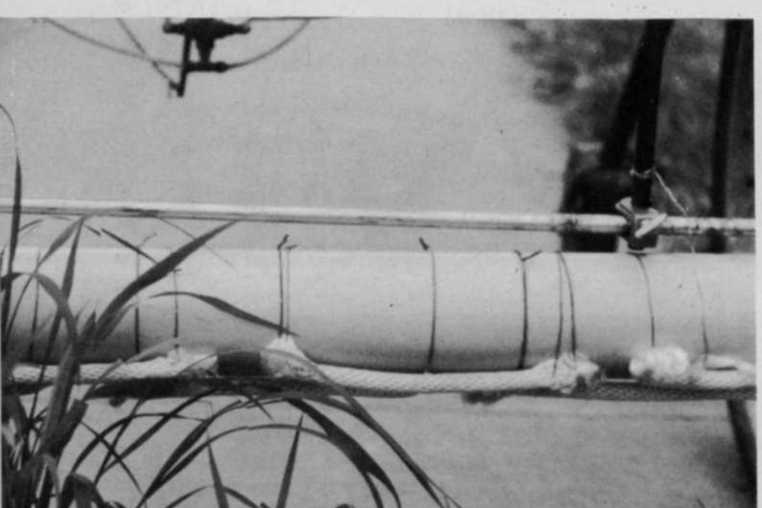


Figure 4. Wick applicator boom showing rope which applies the herbicide to weeds that are taller than the crop.

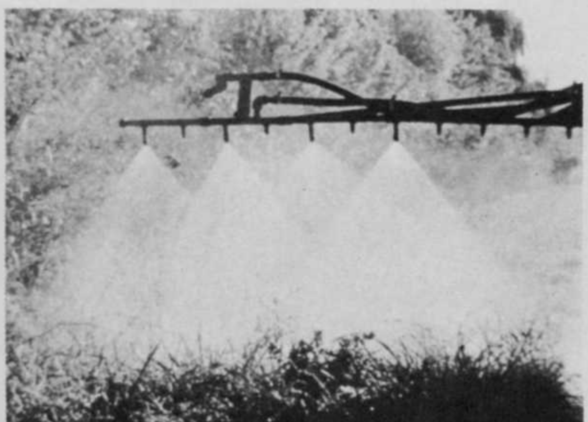
Environmental conditions influence spray drift

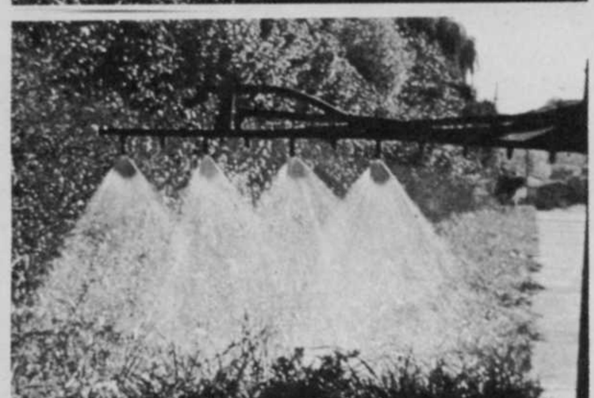
Wind speed is usually considered the major factor in drift of spray. For water spray solutions, droplets of 100 micron diameter will fall about 1 foot per second and in a 3 mph breeze will drift about 40 feet in a second. A droplet of 500 micron diameter will fall 1 foot in 0.15 seconds and drift less than 1 foot during this time in a 3 mph breeze. Even in a 15 mph wind, these large droplets will drift only about 3 feet while falling 1 foot. Wind significantly reduces the number of days to spray herbicides in the spring because of drift problems.

Temperature and humidity are also factors in drift control. Evaporation of spray droplets presents some problem when they are released several feet from the target surface. During warm weather, considerable drying down of droplets occurs and rising heat currents may become buoyant to the spray. Evaporation of the droplet eventually will give rise to particulate (wettable powder or salt crystal) pesticide which is readily carried through the atmosphere for periods of two or three days. Spray droplets evaporate during fall under low humidity conditions and rate of fall will slow as size becomes small (Figure 7). The small spray droplets evaporate fast because of large surface area per unit volume and so the rate of evaporation increases during fall to the target.

For evaporation to occur, the water molecules must migrate away from a droplet and heat toward the droplet. Thus, the largest droplet size that provides consistent control of the pest will be most practical for drift control. As mentioned earlier, small droplets are quite effective for insect applications and in large droplets require more of the pesticide which increases environmental contamination. In general, herbicides are applied to the leaf and are retained until translocation to other plant parts. Not until spray volume becomes extremely low (less than 5 gallons per acre) does one find decreasing droplet size below 100 microns improve herbicidal effectiveness using foliarly applied compounds. Exceptions may include compounds which are very poorly absorbed and translocated by the plant.

Thickening agents added to pesticides increase the diameter of spray droplets and decrease the amount of drift. Added to this sprayer, a polyvinyl polymer material also provides good spread and better absorption by leaves.





An inversion condition with stagnate layers is conducive to cloud formation from fine spray in the relatively cool air near the ground and eventually may fall on sensitive crops a distance away, producing detectable symptoms. The opposite may also occur—relatively warm air near the ground is conducive to rising convections which carry fine droplets high in the atmosphere and they become so disperse that detectable or symptomatic conditions must include wind, temperature, humidity, and conditions involving layers of warm and cool air.

Environmental, chemical, and equipment aspects

Since most of the factors in drift control centers around droplet size, we might summarize this discussion by saying that we should use the largest droplets that are consistent with the desirable level of pest control. Remember, insects and diseases may require small droplets, which are likely to drift to non-target areas during application. Herbicides present the greater problem since small residues on non-target plants yield as well as produce unwanted residues. However, larger droplets are notably effective with herbicides and drift control is quite possible.

We would, then, use as large a nozzle orifice as possible and as low a pressure as consistent with spray pattern to provide drift control and best control. Reducing the distance droplets must travel reduces the distance wind will carry droplets off target and the time for droplets to dry to smaller size. Drift control chemical agents can be added to the spray mix to reduce the fine droplets in the application. Applications during morning hours or later afternoons affect drying of small droplets. Avoid windy weather for maximum drift control. Even when all other factors are being considered, wind will still carry spray to some extent (drift is never completely controlled). Layers of warm and cool air can cause unwanted movement of pesticide fine droplets a long distance. As you can see, common sense is a major factor in drift control.

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