New Designs in Pesticide Application Equipment for More Efficient Control and Reduced Drift

Robert E. Wolf
University of Illinois

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NEW DESIGNS IN PESTICIDE APPLICATION EQUIPMENT
FOR MORE EFFICIENT CONTROL AND REDUCED DRIFT

Robert E. Wolf
Extension Specialist Agricultural Engineering
University of Illinois

Introduction

When applying pesticides there is always a chance some will escape from the target area. Inefficient application has long been an issue facing the pesticide application industry. Drift is of concern because it removes the chemical from the intended target making it less effective and the chemical is deposited where it is not needed and often not wanted. The second concern is generally the most critical because the pesticide becomes an environmental pollutant in the off-target area. Off-target deposits can injure susceptible vegetation, damage wildlife, and contaminate water supplies. Costly problems can result when carelessly applied pesticides, especially herbicides drift and cause damage to economically or aesthetically important crops.

Although drift cannot be completely eliminated, the use of proper equipment and spraying techniques will maintain drift deposits within acceptable limits. The primary recommendation for drift control is to read the pesticide label. Instructions are given to insure the safe and effective use of pesticides with minimal risk to the environment. Chemical company surveys indicate that a large percentage of drift complaints involved application procedures known to be "off-label".

There are two ways that herbicides move downwind to cause damage: particle and vapor drift. Vapor drift is associated with the volatilization of herbicide molecules and their movement off-target, making it independent of the application. Particle drift is the off-target movement of spray particles formed during application. The amount of particle drift depends mainly on the number of small "driftable" particles produced by the nozzle. Although excellent coverage can be achieved with extremely small droplets, decreased deposition and increased drift potential limit the minimum size that will provide effective weed control.

Droplet Size

A basic understanding of droplet size effects on postemergence herbicides is important when selecting techniques for foliar application. The relationship between droplet size and the resulting coverage on the target is complex resulting in several common misconceptions regarding droplet size and foliar application. For example, it is generally believed that applying small droplets at high spray pressures will provide increased control with low volumes of spray solution. Research data, as well as a study of particle dynamics, does not substantiate this theory. It is true that atomizing a known amount of spray solution into smaller droplets will increase the coverage possible, but you must also consider evaporation, drift potential, canopy penetration, and deposition characteristics.

Table 1 and 2 show some characteristics of various size droplets. Decreasing the droplet size from 200 to 20 microns will increase coverage 10 fold but a 20 micron water droplet will travel less than one inch before it completely evaporates in less than 1 second. Droplets less than 100 microns in size obtain a horizontal trajectory in a very short time and evaporate very rapidly. The pesticide in these droplets become very small aerosols most of which will not fall out until picked up in falling rain. Droplets over 150 microns in size resist evaporation much more than smaller droplets due to their larger
surface area. From these and other research results, we can conclude that there is a rapid decrease in the drift potential of droplets as their diameter is increased to about 150 microns in diameter.

<table>
<thead>
<tr>
<th>Table 1. Evaporation and Deceleration of Various Size Spray Droplets.*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Droplet diameter</strong> (microns)</td>
</tr>
<tr>
<td>--------------------------------</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>150</td>
</tr>
<tr>
<td>200</td>
</tr>
</tbody>
</table>

*Conditions assumed: 90°F, 36% R.H., 25 psi, 3.75% pesticide solution

Several factors determine if a spray particle will be deposited and captured by the natural surfaces of a particular weed. These include: 1) the size and content of the droplets; 2) the size, shape, and density of the target; 3) the wind speed and other meteorological conditions; and 4) the nature of the deposition surface. In general, the deposition efficiency of droplets on a weed surface increases with droplet size and wind speed, and decreases as the size of the target increases. Very small droplets (less than 50 microns) are collected efficiently by insects or by needles on coniferous plants, but tend to remain in the airstream and be carried around stems and leaves of weeds. Medium size droplets that are applied when there is some air velocity will deposit more efficiently on stems and narrow vertical leaves such as grasses while large droplets will deposit most efficiently on large flat surfaces such as broadleaved weeds. In reality, a range of droplet sizes is required to effectively deposit on the variety of weed sizes, shapes, and orientations that occur in actual field conditions.

<table>
<thead>
<tr>
<th>Table 2. Spray droplet size and its effect on coverage and drift.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Droplet diameter</strong> (microns)</td>
</tr>
<tr>
<td>--------------------------------</td>
</tr>
<tr>
<td>.5</td>
</tr>
<tr>
<td>10</td>
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<tr>
<td>20</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>150</td>
</tr>
<tr>
<td>200</td>
</tr>
<tr>
<td>500</td>
</tr>
<tr>
<td>1000</td>
</tr>
</tbody>
</table>

* Air temperature of 86°F and 505 relative humidity.

The actual droplet size range for effective control of weeds from postemergence herbicides depends on the specific herbicide being applied, the kind and size of the target weed, and the weather conditions. There have been conflicting reports regarding the ideal spray volume, pressure, and nozzle...
type to obtain the most consistent weed control. Most of the conflict is due to the large variation in the parameters mentioned above during the actual application.

Considerable research has been done to evaluate the biological performance of several postemergence herbicides when applied with a variety of nozzle types. A general summary statement can be made that experimental results to date suggest that any nozzle type that produces a droplet size spectrum in the range of 100 to 400 microns does not greatly influence biological performance over a range of conditions unless application volumes are extremely high or very low. Exceptions to this exist for specific herbicides.

**Spray Volume And Pressure**

Spray volume can have a major impact on performance of foliar herbicides. As spray volume is decreased, the herbicide concentration is increased to maintain the same applied dose of active ingredient. Table 3 shows typical results of field studies in which control was significantly increased for a broadleaved weed contact herbicides while there was very little change in weed control for two translocated grass herbicides as the volume increased from 5 to 20 gallon per acre (GPA). In general, for our studies which have been conducted for several years, a reduction in spray volume caused little difference in biological effect for translocated herbicides at a given dose, but reduced the control for contact herbicides. There are exceptions and some herbicides do not fall into either category consistently due to variations in conditions from year to year. In addition, spray additives greatly affect the effectiveness of foliar herbicides.

**Table 3. Effect of spray volume on foliar application of postemergence herbicides.**

<table>
<thead>
<tr>
<th>Spray volume (GPA)</th>
<th>Velvetleaf control (%)*</th>
<th>Grass control (%)*</th>
<th>Grass control (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>60 d **</td>
<td>65 b</td>
<td>72 a</td>
</tr>
<tr>
<td>5</td>
<td>80 c</td>
<td>64 b</td>
<td>71 a</td>
</tr>
<tr>
<td>10</td>
<td>85 b</td>
<td>64 b</td>
<td>71 a</td>
</tr>
<tr>
<td>20</td>
<td>91 a</td>
<td>72 a</td>
<td>69 a</td>
</tr>
</tbody>
</table>

*The % weed control was taken 8 days after each of the three different herbicides were applied.
** Numbers followed by the same letter in a column are not significantly different at the 10% level.

Presently there is a renewed interest in reducing spray volume from the commonly used 10-20 GPA to 5-10 GPA. A perception of some applicators is that higher pressure can substitute directly for spray volume. Some applicators are increasing spray pressure from a normal 30-40 psi range to 60-120 psi while reducing the spray volume by one-half. The idea is to "drive" the small particles into the canopy to obtain increased coverage. Our current studies do not verify this theory and we do not recommend this technique for applying herbicides. Referring back to Table 2, emphasis on the coverage characteristics of various size droplets as they exit a spray nozzle are expressed. A 50 micron droplet will decelerate to its extremely low terminal velocity in a distance of 3 inches from the nozzle. Small particles have low momentum and insufficient energy to transport them into a plant canopy.

High pressure with small nozzles have a high percentage of the spray volume in the small particles that will evaporate and drift into the atmosphere. Increasing pressure should not be used as a direct substitute for spray volume. We recommend maintaining pressure below 45 psi and increasing the spray volume to obtain increased coverage if needed.
New Equipment Technologies

In recent years there has been an increased interest by equipment manufactures to design application equipment that will effectively reduce the amount of off-target movement during the spray operation. Nozzle manufactures are engineering nozzles that will effectively reduce the volume of driftable fines found in a spray pattern. This is being accomplished with the use of a preorifice and also with turbulation chambers.

Additional emphasis is being place on the development of air-assisted sprayers and nozzles and with the use of an electrostatic charge to transport the spray to the target. Air-assist systems should prove beneficial with applications in heavy canopies with both improved efficacy and reduced drift. The electrostatic design creates an electrical charge for the spray solution that is opposite the electrical charge of the plant.

Rapid improvements in nozzle design and spray equipment are taking place with an emphasis on reducing spray drift. It is important to remember that many other factors influence the amount of drift that actually occurs. Therefore, in addition to selecting the proper type of nozzle and equipment, using as many approved drift reduction application techniques as possible can only improve the chances of reducing the problems associated with the off-target movement of spray materials.

Nozzles

Most hydraulic nozzles produce a wide range of droplet sizes through a wide range of pressures. That alone may contribute to excessive drift potential. The actual size distribution of droplets produced by a nozzle needs to be known in order to make adjustments concerning coverage, deposition and spray drift potential. To estimate the drift potential from spray nozzles, the percentage of the spray volume that is contained in small droplets is frequently used to represent the "driftable" fraction of spray produced by a nozzle (Table 4).

Table 4. Dropsize Comparisons (Data provided by Spraying Systems Co. 1996)

<table>
<thead>
<tr>
<th>Nozzle Type (All nozzles are Spraying Systems Nozzles)</th>
<th>40 psi @ 0.2 gpm</th>
<th>40 psi @ 0.5 gpm</th>
<th>60 psi @ 0.5 gpm</th>
<th>% spray volume under 200 microns (0.5 gpm @ 40 psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat-fan 80°</td>
<td>270</td>
<td>370</td>
<td>300</td>
<td>11</td>
</tr>
<tr>
<td>XR Flat-fan 80°</td>
<td>270</td>
<td>370</td>
<td>300</td>
<td>11</td>
</tr>
<tr>
<td>XR Flat-fan110°</td>
<td>224</td>
<td>310</td>
<td>250</td>
<td>22</td>
</tr>
<tr>
<td>Turbo Flat-fan</td>
<td>340</td>
<td>450</td>
<td>400</td>
<td>6</td>
</tr>
<tr>
<td>Drift Guard Flat-fan 80°</td>
<td>340</td>
<td>410</td>
<td>330</td>
<td>8</td>
</tr>
<tr>
<td>Drift Guard Flat-fan 110°</td>
<td>330</td>
<td>390</td>
<td>320</td>
<td>11</td>
</tr>
<tr>
<td>Flooding Flat-fan</td>
<td>-</td>
<td>450</td>
<td>410</td>
<td>3</td>
</tr>
<tr>
<td>Turbo Flood Flat-fan</td>
<td>-</td>
<td>710</td>
<td>650</td>
<td>less than 1</td>
</tr>
<tr>
<td>Wide Angle Full Cone</td>
<td>-</td>
<td>680</td>
<td>-</td>
<td>less than 1</td>
</tr>
<tr>
<td>Hollow Cone</td>
<td>200</td>
<td>-</td>
<td>230</td>
<td>-</td>
</tr>
</tbody>
</table>

Nozzle type must be selected depending on the potential for drift. Of the many nozzle types available for applying pesticides, a few are specifically designed for reducing drift. Several years ago,
the Raindrop® nozzle from Delavan was designed to effectively reduce the exit pressure at the spray tip resulting in larger spray droplets. Some nozzles are designed to operate effectively at low pressures. For example, the extended range flat-fan nozzles available from several manufactures provide uniform spray patterns at pressures down to 15 psi, thereby reducing the amount of small driftable spray particles in the spray pattern. However, at higher pressures produce finer spray droplets and more drift. Flooding flat-fan nozzles were designed to be used with higher application rates and at lower pressures as a means of reducing drift.

In recent years there has been a increased interest by nozzle manufactures to design ‘low-drift’ nozzles that will effectively reduce the development of driftable fines in the spray pattern. One emphasis in design has been with the ‘preorifice’ concept. A preorifice located on the entrance side of the nozzle effectively creates a flow restriction without flow rate reductions resulting in lower exit spray pressures and larger spray droplets. The term associated with this nozzle design is ‘drift reduction flat-fan nozzles’. However, similar drift reduction improvements can be achieved by using standard extended range flat-fan nozzles with increased nozzle size (flow rate) and lowered operating pressures.

The most recent design improvements have incorporated the preorifice concept with an internal turbulence chamber. This not only creates larger droplets but also has improved the uniformity of the spray pattern. Turbulence chamber nozzles are available in a turbo flood tip and now in the turbo flat-fan design. The turbo flat-fan design shows great improvement in pattern uniformity when compared to the extended range flat-fan and other drift reduction flat-fan designs. In addition, with the turbo flat-fan, a large reduction in driftable fines has occurred through a very wide range of pressures. Both of the ‘turbo’ designs are adapted to be used on the spray boom to spray in a straight-down orientation with 50 percent overlap.

Rapid improvements in nozzle design and spray equipment are taking place with an emphasis on reducing spray drift. It is important to remember that many other factors influence the amount of drift that actually occurs. Therefore, in addition to selecting the proper type of nozzle, using as many approved drift reduction application techniques as possible can only improve the chances of reducing the problems associated with the off-target movement of spray materials.

**Summary Of Drift Reduction Suggestions**

- Several factors greatly determine the amount of spray drift that occurs. The type of nozzle, pressure, height, spray volume, and environmental conditions all affect the off-target movement. The ability to reduce drift is no better than the weakest component in the spraying procedure. See the summary of recommended procedures in Table 5.

As previously mentioned, the potential for drift must be considered when selecting a nozzle type. Of the many nozzle types available for applying pesticides, a few are specifically designed for reducing drift by reducing the amount of small driftable spray particles in the spray pattern. Higher pressures and lower flow rate nozzles will also lead to more drift by producing finer spray droplets.

Spray height is an important factor in reducing drift losses. Drift can be reduced by mounting the boom closer to the ground (without sacrificing pattern uniformity). Correct spray height for each nozzle type is determined by nozzle spacing and spray angle. Wide-angle nozzles can be placed closer to the ground than nozzles producing narrow spray angles. On the other hand, wide-angle nozzles also produce smaller droplets. When this occurs, the advantages of lower boom height are negated to some extent.
Using larger nozzle sizes is a means of minimizing drift. Increasing the spray volume by using higher capacity spray tips results in larger droplets that are less likely to move off-target. The only effective means of reducing drift by increasing spray volume is to increase the nozzle size.

Weather conditions can have a major impact on the amount of off-target drift. Factors affecting drift include wind speed and direction, temperature, relative humidity, and atmospheric stability. Wind speed is usually the most critical factor of all meteorological conditions affecting drift. The greater the wind speed, the farther off-target small droplets will be carried.

<table>
<thead>
<tr>
<th>Recommended Procedure</th>
<th>Example</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select nozzle type that produces coarse droplets.</td>
<td>Raindrop, Wide-angle full-cone, Flooding</td>
<td>Use as large droplets as practical to provide coverage necessary.</td>
</tr>
<tr>
<td>Use lower end of pressure range.</td>
<td>Use 20 to 40 psi for Raindrop. Less than 25 psi for other types.</td>
<td>Higher pressures generate many more small droplets (less than 100 microns)</td>
</tr>
<tr>
<td>Lower boom height.</td>
<td>Use as low a boom height as possible to maintain uniform distribution. Use drops for systemic herbicides in corn.</td>
<td>Wind speed increases with height. A few inches lower boom height can reduce off-target drift.</td>
</tr>
<tr>
<td>Increase nozzle size.</td>
<td>If normal gallonage is 15 to 20 GPA, increase to 25 to 30 GPA.</td>
<td>Larger capacity nozzles will reduce spray depositing off-target.</td>
</tr>
<tr>
<td>Spray when wind speeds are less than 10 MPH and moving away from sensitive plants.</td>
<td>Leave a buffer zone if sensitive plants are downwind. Spray buffer zone when wind changes.</td>
<td>More of the spray volume will move off-target as wind increases.</td>
</tr>
<tr>
<td>Do not spray when the air is completely calm or an inversion exists.</td>
<td>Inversions generally occur in early morning or near bodies of water.</td>
<td>Calm air or inversions reduce air mixing and spray can move slowly downwind.</td>
</tr>
<tr>
<td>Use a drift control additive when needed.</td>
<td>Several long-chain polymers are available (See Table 7).</td>
<td>Drift control additives increase the average droplet size produced by the nozzles.</td>
</tr>
</tbody>
</table>

Determining the wind direction relative to sensitive crops is important in attempting to minimize damage from drift. The presence of sensitive vegetation downwind often is overlooked by applicators. Leaving a buffer zone at the downwind edge of a spray area will reduce greatly damage to sensitive plants. After the wind has died down or changed direction, the buffer zone can be safely sprayed.

Temperature and humidity also affect the amount of drift that occurs through evaporation of spray particles. Although some evaporative loss of spray occurs under all atmospheric conditions, these losses are less pronounced in cool and damp conditions. Temperature also influences atmospheric air turbulence, stability, and inversions.
A stable atmosphere or "inversion" can be recognized by observing a column of smoke. If the smoke does not dissipate or if it moves downwind without vertical mixing, conditions are not good for spraying. The best way to avoid drift associated with atmospheric conditions is to eliminate the formation of small particles from the spray. Once this is done, weather stability factors essentially can be ignored.

One of the best tools available for minimizing drift damage is the use of drift control additives to increase the spray droplet size. Tests indicate that downwind drift deposits are reduced from 50 to 80 percent with the use of drift control additives. Drift control additives make up a specific class of chemical adjuvants and should not to be confused with products such as surfactants, wetting agents, spreaders, and stickers. Drift control additives are formulated to produce a droplet spectrum with fewer small droplets.

A number of drift control additives are commercially available, but they must be mixed and applied according to label directions in order to be effective (Table 6). Some products are recommended to be used at a rate of two to eight ounces per 100 gallons of spray solution. Increased rates may further reduce drift but also may cause nozzle distribution patterns to be nonuniform. Drift control additives will vary in cost depending on the rate and formulation, but are comparatively inexpensive for the amount of control provided. They do not eliminate drift, however, and common sense must still remain the primary factor in reducing drift damage.

Table 6. Drift control agents, percent principal agents, suggested rates, and sourcesa

<table>
<thead>
<tr>
<th>Product</th>
<th>% Principal Agent</th>
<th>Rate/100 Gal*</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>MORE</td>
<td>Polyvinyl Polymer (Polyacrylamide) 30%</td>
<td>4-10 oz</td>
<td>Exacto Chemical Co. P.O. Box 90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Solon Mills, IL 60080</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>815/675-6060</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>800/798-9761</td>
</tr>
<tr>
<td>FORMULA 358</td>
<td>Polyvinyl Polymer (Polyacrylamide) 1%</td>
<td>1-4 qts</td>
<td>Loveland Industries Inc. P.O. Box 1289</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Greeley, CO 80632</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>303/356-8920</td>
</tr>
<tr>
<td>CHEM-TROL</td>
<td>Polyvinyl Polymer (Polyacrylamide) 1%</td>
<td>1-4 qts</td>
<td>Precision Laboratories P.O. Box 127</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Northbrook, IL 60065</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>800/323-6280</td>
</tr>
<tr>
<td>38-F</td>
<td>Polyacrylamide Polymer 32%</td>
<td>2-5 oz</td>
<td></td>
</tr>
<tr>
<td>DIRECT</td>
<td>Polyvinyl Polymer (Polyacrylamide) 30%</td>
<td>2-4 oz</td>
<td></td>
</tr>
<tr>
<td>BORDER</td>
<td>Blend of water-soluble Polymers and Formulation aids 100%</td>
<td>1-5 oz</td>
<td></td>
</tr>
<tr>
<td>Product</td>
<td>% Principal Agent</td>
<td>Rate/100 Gal*</td>
<td>Company</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------</td>
<td>--------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td><strong>WINDFALL</strong></td>
<td>Linear Aclylexpoxide Polymer 1.98%</td>
<td>5 pints</td>
<td>Terra International, Inc. 3506 N. Mattis Avenue Champaign, IL 61821 217/398-1575</td>
</tr>
<tr>
<td><strong>POLYCONTROL-2</strong></td>
<td>Polyacrylamide Copolymer 30%</td>
<td>3-8 oz</td>
<td>JBL Int'l Chemical, Inc. P.O. Box 6006 Vero Beach, FL 407/562-0555</td>
</tr>
<tr>
<td><strong>DRIFTGARD</strong></td>
<td>Anionic Polyacrylamide 50%</td>
<td>4-8 oz</td>
<td>Custom Chemicides P.O. Box 11216 Fresno, CA 93772 209/264-0441</td>
</tr>
<tr>
<td><strong>SPRAY-TROL</strong></td>
<td>PolyOxyethelene</td>
<td>1-3 oz</td>
<td>Spectrum Technologies, Inc. Plainfield, IL 60544 815/436-4440</td>
</tr>
<tr>
<td><strong>DRIFGON</strong></td>
<td>Polyvinyl Polymer 30% Polysaccharide Polymer - 20%</td>
<td>2-10 oz</td>
<td>SanAg 3959 Goodwin Ave. Los Angeles, CA 90039 213/245-6781</td>
</tr>
<tr>
<td><strong>41-A DF</strong></td>
<td>Polyacrylamide Polymer - 27% Polysaccharide Polymer - 3%</td>
<td>3-4 oz</td>
<td></td>
</tr>
<tr>
<td><strong>38-F</strong></td>
<td>Polyacrylamide Polymer 32%</td>
<td>4-8 oz</td>
<td></td>
</tr>
<tr>
<td><strong>NALCOTROL</strong></td>
<td>Polyvinyl Polymer 30%</td>
<td>4-8 oz</td>
<td>Nalco Chemical Co. One Nalco Center Naperville, IL 60563-1198 708/305-1000</td>
</tr>
<tr>
<td><strong>NALCOTROL II</strong></td>
<td>Polyamide Copolymer 30%</td>
<td>4-8 oz</td>
<td></td>
</tr>
<tr>
<td><strong>STAYPUT</strong></td>
<td>Polyvinyl Polymer 1.0%</td>
<td>1-3 qts</td>
<td></td>
</tr>
</tbody>
</table>

*Aerial, ground, and air-carrier applications rates will vary.

*aMention of a trade name is for specific information only and does not constitute a guarantee or warranty of the product by the University of Illinois and does not imply endorsement of the product over other products not mentioned. Precautions should be taken to refer to drift reduction agent labels for specific application recommendations.
Air-Assisted Sprayers and Nozzles

The use of air-assisted sprayers and nozzles for the application of agricultural pesticides has increased in recent years. The increase in use has developed from renewed interest in being more efficient in the application process. Two factors are playing a role in the adaptation of this technology. One is the desire to reduce drift and the other is an attempt to get better coverage on the target. Better coverage on the target in turn may reduce the drift amount.

Air-assist technology is not new to the sprayer industry. Air-assist is the process of using pneumatic energy to aid in the atomization, penetration, and deposition of spray products. In most situations the air stream becomes the carrier and will assist in the depositing of the spray solution to the target. With this design, there is the potential for reduced rates of the carrier and active ingredients.

Several companies are commercially involved in developing systems that will adapt for use on current post-emergence application devices. There are two basic styles of air-assist systems. The types that involve an air-curtain or air-shield booms or the types that employ the use of air-atomizer nozzles. The air-curtain or air-shield booms are designed with an external blower fan system that will create a high velocity of air that will either entrain the spray solution as it exits a conventional spray boom or will provide a shield in front or to the rear of the conventional spray boom pattern.

The basic concept behind either design is to increase efficacy of contact crop protectants, provide better coverage to the underside of leaves, to promote deeper penetration into the crop canopy, to obtain more surface area coverage for smaller droplets, get more acres per load, and to reduce drift. Research is still being done to verify any truth to the above mentioned claims. Current studies (Howard et al., 1995) have shown that conventional sprayers continue to provide adequate control in the top of the canopy, while the air-assisted sprayers tended to show improved control in the mid to lower canopies. Mid to lower canopy penetration and coverage is an important concept when working with insecticides and fungicides but may not be as critical when applying herbicides. The air stream tended to move the canopy around and help the spray mix and attach within.

Another finding in the above mentioned research was that air-assisted boom sprayers may tend to drift more in bare ground situations. The increased air velocities and the lack of a crop canopy in typical row crop settings actually created a situation that allowed for more drift to occur. However, when the air-assist boom sprayers are used in higher canopy situations the extra energy created by the air stream is absorbed in the crop and drift may actually be reduced.
Table 7 is designed to show some of the different styles of air-assist sprayers, the companies involved commercially, and the approximate cost for the technology. The costs are an estimate based on available information. Many of the air-assist systems are available as an add-on to current boom sprayers.

<table>
<thead>
<tr>
<th>Design</th>
<th>Manufacturer(s)</th>
<th>Price (estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airtec Boom</td>
<td>Ag Chem, Airtec Sprayers Inc., Gallenberg</td>
<td>$100,000+ self-propelled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$20,000+ 3-point hitch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$35,000+ Pull type/cart</td>
</tr>
<tr>
<td>Hardi Twin</td>
<td>Hardi Inc.</td>
<td>$35-40,000 3-point hitch and pull type</td>
</tr>
<tr>
<td>Spray-Air</td>
<td>Spray-Air USA Inc.</td>
<td>$25,000</td>
</tr>
<tr>
<td>Air Curtain</td>
<td>Tyler Industries</td>
<td>$100,000+ self-propelled</td>
</tr>
<tr>
<td>AirTrak/Spray Air</td>
<td>Willmar Mgf. Co.</td>
<td>$100,000+ self-propelled</td>
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</table>

Other air-assist technology involves the use of air incorporated into the spray nozzle. Several different designs are currently being developed and marketed for use. Basically the air is entrapped into the spray solution at some point with in the nozzle and the two will exit together with air providing energy to help transport the liquid to the target. It is hoped that the air will replace some of the carrier and result in less spray solution needed. Look for more information on this in the future.

**Electrostatic Spray**

The use of an electrostatic charge to aid in the transfer and attachment of the spray particle to target is now being used commercially. A new process, Energized Spray Process (ESP), is being field tested to determine the effectiveness for this technology in improving spray efficiency and reducing drift.

The process uses the principal of contact charging the liquid solution prior to it reaching the nozzles. The charge produced by the ESP system creates a high intensity electrostatic field that helps transfer the spray droplets toward the target at a high velocity. Contact charging differs from earlier electrostatic systems that used induction charging of the spray solution at the nozzle. Contact charging adds 40,000 volts to the liquid spray solution in a charging chamber and then distributes the solution in the charged state to the boom and nozzles. The electrostatic spray process shows promise with increased coverage to both the upper and lower sides of the target leaves.

**What the Future Holds**

The use of site-specific farming practices will guide the develop of new sprayer technology that will be able to apply crop protectants only to specific regions of a field. This technology could lead to reduced amounts of herbicides applied to fields that were not uniformly covered with weeds. The use of site-specific application systems for crop protectants will require accurate information about the spatial distribution of pest populations and a computer controlled applicator interfaced with a navigation system.

Information about the distribution of pests in a field may be gathered using several different approaches. One method, suitable for postemergence herbicides, is to map the weed distributions as
close to the time of application as possible. Geographical information systems (GIS) and geographical positioning systems (GPS) will need to be used to develop application maps for this purpose. Crop scouts, aerial photography, or automated sensing devices could also be used in combination with the GPS/GPS technology to develop the application maps.

Optical sensors have been developed to distinguish weeds from soil in the postemergence spot spraying in fallow fields. It is difficult for these sensors to distinguish weeds from the growing crop. More complex sensors are being designed that use machine vision to recognize morphological differences between weeds and the crop.

Many options exist for the recognition of crop pests for mapping and application use. Currently, insufficient data on spatial distributions of crop pests is available to determine which method may be best. Even less information exists on the benefits economically and environmentally to the adaptation of this technology.

Disclaimer

Mention of a trade name is for specific information only and does not constitute a guarantee or warranty of the product by the University of Illinois and does not imply endorsement of the product over other products not mentioned.
References Cited


