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Mitigating Pesticide Spray Drift

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The off-target movement of pesticides during application is considered spray drift. Pesticide spray can move off-target through both vapor and particle drift. Both can be damaging to sensitive crops or plants, and different strategies are necessary to mitigate each.

Vapor drift, or volatility, is the evaporation and off-target re-deposition of pesticides after reaching the initial target. Volatility is heavily influenced by a pesticide's vapor pressure and environmental conditions such as high temperatures and low humidity during and 24 hours following the application. Applicators should select low-volatility formulations and adhere to all application recommendations on the product label to avoid vapor drift. This publication will focus primarily on factors influencing particle drift.

Particle Drift

Particle drift is the off-target movement of spray droplets through air currents before reaching the intended target. Particle drift is largely controlled by equipment setup and good decisions on the part of the applicator. Ideal applications are those that deliver the appropriate rate of product to effectively control the pest, while minimizing crop injury and drift. This balanced transfer of product from application equipment to targeted pest is largely determined by the variables creating and influencing the spray droplet spectrum. These variables include controllable factors like size of spray droplets, nozzle type, spray pressure, travel speed, boom height, adjuvants and carrier volume. Uncontrollable application variables such as environmental conditions include wind speed, temperature, relative humidity and microclimates such as temperature inversions.

Spray Droplets

The size of spray droplets has a direct effect on spray coverage, pest control and drift potential. In general, the larger the spray droplet, the less likely that it will drift, while small droplets (<150 microns) fall at slower rates and have the highest potential to drift with wind currents. Spray droplet size can affect coverage and control of targeted pest, especially weeds. On grass species, research suggests that smaller droplet sizes provide increased control over larger droplet sizes because the larger droplets tend to bounce off the leaf and droplet retention is decreased. Small droplets provide increased surface area coverage compared to large droplets across multiple spray volumes. Generally, the recommended droplet range for maximum weed control across most systemic herbicide labels is between 300 and 400 microns. The British Crop Protection Council (BCPC) and the American Society of Agriculture and Biological Engineers (ASABE) developed a droplet size classification system with categories ranging from extra fine (XF) to ultra coarse (UC) based on volumetric mean diameter (VMD) measured in microns (Table 1). The 300 to 400 micron droplet range is classified as coarse (C) to very coarse (VC) by the BCPC and ASABE standards.

Table 1. Nozzle classification with color coding according to droplet size (VMD) and measured in microns. Based on BCPC specifications in accordance with ASABE standards.

Category	Symbol	Color Code	VMD (microns)
Extremely Fine	XF	Purple	~50
Very Fine	VF	Red	<136
Fine	F	Orange	136-177
Medium	M	Yellow	177-218
Coarse	C	Blue	218-349
Very Coarse	VC	Green	349-428
Extremely Coarse	EC	White	428-622
Ultra Coarse	UC	Black	>622

Controllable Factors

Spray droplet size is influenced by several applicator controlled factors such as nozzle selection, spray pressure, spray volume, travel speed and adjuvants. These variables all affect spray coverage, drift and ultimately the efficacy of the pesticide application.

Nozzle Selection

Proper nozzle selection varies based on the goals of the application, the targeted pest and the product used. For applications where drift is a major concern, nozzles should be selected that are designed to reduce drift. Examples of drift reduction nozzles are those that are listed as air induction, have a pre-orifice and/or a turbulence chamber. Each nozzle type employs different technology to ultimately increase overall droplet size.

Air induction (AI) style nozzles create air-filled droplets and emit fewer fines (Figure 1). AI tips are typically not as sensitive to droplet size changes as operating pressures increase. This helps avoid fine droplet formations when sprayer speeds increase during an application and the flow control increases pressure to ensure the correct pesticide rate. Some examples of tips that have air induction capabilities are Greenleaf Technologies AM and TD series; Hypro's ULD and GA series; and TeeJet Technologies AI and TTI series.

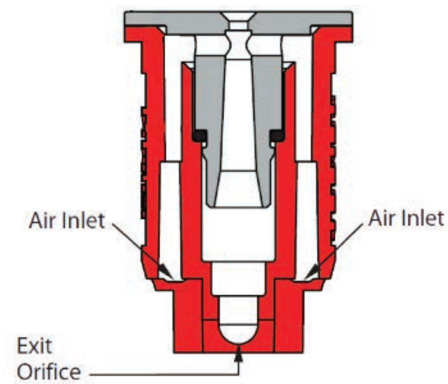

Figure 1. Cross section of a TeeJet Air Induction nozzle.

Nozzles with **pre-orifices** meter the flow of pesticide before it reaches the spray orifice (Figure 2). Usually, the pre-orifice is a smaller orifice size than the exit orifice which reduces the pressure at the exit orifice. This produces a larger droplet spectrum and helps to reduce the number of drift-prone fines. Examples of tips using pre-orifice technology include Wilger Industries SR, MR and DR tips; TeeJet Technologies DG, AI, TT, TTI and AIXR series; Hypro's GRD and GA series; and Greenleaf Technologies TDXL.

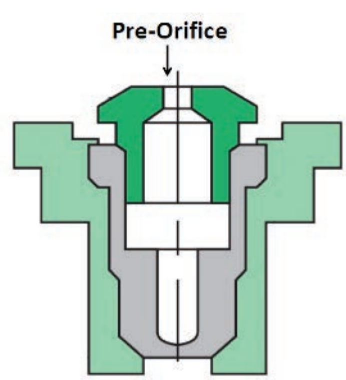

Figure 2. Cross section of a TeeJet Drift Guard nozzle that contains a pre-orifice.

Nozzles that use **turbulence chambers** use a pre-orifice to meter spray solution into a second chamber before exiting the final orifice (Figure 3). These nozzles are designed to produce a larger droplet with more uniform coverage along the boom. Examples of tips using turbulence chamber technology include Hypro's GRD and GA series; TeeJet Technologies DG, TT and TTI series; and Wilger Industries SR, MR and DR series tips.

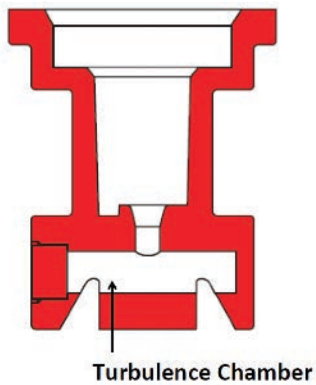

Figure 3. Cross section of a TeeJet Turbulence Chamber nozzle.

Once nozzle type is selected, identify a nozzle orifice size based on desired gallon per minute (GPM) output. If unknown, GPM output can be calculated by using the formula in Figure 4. Be sure that the nozzle's desired GPM output and droplet classification fit comfortably in the middle of the nozzle's recommended pressure range. Often, more than one orifice size will meet desired GPM output. It is then recommended to select the nozzle that has the lower suggested pressure range.

Figure 4. Select a nozzle orifice size base on required gallon per minute (GPM) output.

$$GPM\ (per\ nozzle) = \frac{GPA \times mph \times W}{5{,}940}$$

GPA – Recommended spray volume from product label

mph – Select an appropriate travel speed for equipment and application conditions

W – Measure nozzle spacing in inches

Manufacturers of spray nozzles provide a wealth of information about the selection, setup and use of their products in their catalogs and on their websites. Catalogs for the type of product you are using can be obtained from dealers or your county Extension office. Company web pages often provide nozzle selection guides and recommendations for specific applications.

Pressure

Even properly selected and calibrated nozzles can be problematic when the appropriate pressure range is not maintained. Every nozzle has a pressure range set by the manufacturer for optimal application. When pressure is too low, nozzle spray patterns can collapse and provide inadequate coverage. When pressure is above the manufacturer's recommendations, the nozzle can produce unacceptable amounts of very fine and drift-prone droplets. Even across the recommended pressure range there often will be great variation in the droplet classification. After nozzles are selected and before equipment is calibrated, the pressure range must be determined for the desired droplet size. This information is obtained through the manufacturer's nozzle catalog. It is essential to identify and remain within this specified pressure range for desired coverage and drift control.

Boom Height

Boom height is an important consideration when it comes to desired coverage and drift mitigation. Broadcast nozzles are designed to overlap ensuring appropriate uniformity and coverage. When boom height is lower than recommended, appropriate overlap and therefore desired coverage will not be achieved. When the boom is too high, more air is able to move under the boom increasing the chance for smaller droplets to drift. Recommended boom height is generally determined by a nozzle's spray angle. Most nozzles are manufactured in two common spray angles: 80° and 110°. The first numbers on a nozzle indicate its spray angle. An 8004 nozzle has an 80° spray angle, and an 11004 nozzle has a 110° spray angle. Most 80° nozzles are recommended to be at 30 inches above the target soil or plant canopy, whereas 110° nozzles are recommended to be at 20 inches. When drift is a concern, consider using the wider angle tip (11004 instead of an 8004). This allows the nozzle to be adjusted closer to the ground without changing the application rate or the width of the spray pattern where it contacts the ground. Applicators should consistently maintain the recommended height across the entire field to ensure proper coverage and mitigate drift. Always refer to nozzle manufacturer's catalog for nozzle-specific boom height recommendations.

Sprayer Volume

Spray volume designated as gallons per acre (GPA) is a crucial component to successful weed control applications. In regard to herbicide applications, spray volume can mean the difference between one, two or possibly three applications needed for effective weed control. Recommended spray volume can vary greatly depending on the herbicide that is applied. In fact, many issues with droplet size and nozzle design can be overcome with increased spray volume. This relationship depends heavily on the product's chemistry and systemic or contact activity.

Several studies and published research have found that glyphosate provides better control when sprayed at a lower GPA. This has a lot to do with glyphosate's systemic activity, but also has much to do with glyphosate molecules and their interaction with water. However, this is not true for most herbicides. Contact herbicides such as Liberty or Flexstar all recommend a minimum of 10-15 GPA on their respective labels. In fact, other systemic herbicide labels such as Newpath, Ricestar and Clincher all recommend a minimum of 10 GPA on the label. Applicators should follow label recommendations carefully regarding sprayer volume to ensure product efficacy.

Travel Speed

In the name of efficiency, applicators desire to cover more ground in less time. The ability of traveling faster has its appeal, but it often comes at a cost. Increasing travel speed decreases optimal spray deposition and increases drift potential. Traveling at higher speeds increases the air velocity that is in contact with nozzles and spray. With increasing air velocity, very fine, fine, and even medium-sized spray droplets can be suspended and drift off-target. In addition, it becomes more difficult to apply appropriate carrier volumes with increasing speed. High-speed, low-volume applications can lead to poor efficacy with many products, which can promote the development of weed resistance. Applicators should adhere closely to all travel speed recommendations from product labels, nozzle catalogs, equipment manuals and Extension guidelines.

Adjuvants

Tank additives or adjuvants are products added to the tank mix altering the physical or chemical properties of the spray solution. A subcategory of adjuvants known as drift retardants or deposition aids are those products that are designed to reduce the drift potential of a spray solution. Most deposition aids work by thickening the spray solution. Thicker solutions tend to increase the number of large droplets while decreasing small droplet production in the spray spectrum. Thicker spray patterns often appear to exit the nozzle in sheets that stick together as opposed to thinner solutions. Drift reduction agents can affect droplet size, stability and reduce unwanted movement of herbicides; however, the use of a drift reduction product does not give license to spray in higher winds or change other factors such as boom height. It is worth noting that most herbicides, insecticides, fungicides and other additives such as surfactants, crop oils, buffers, etc., can also have a positive or negative effect on spray droplet size. Read all pesticide and adjuvant labels carefully to ensure compatibility among all tank mix products. Applicators should also note that the pesticide carrier will have an impact on droplet properties. When oil-based carriers are used, nozzles can produce smaller, lighter droplets that tend to remain airborne longer compared to water carriers.

Uncontrollable Factors

Particle drift is also influenced by several uncontrollable factors such as wind speed, temperature, humidity and localized microclimates. Although little can be done to control these factors, applicators should always take them into account when spraying. Well-informed and appropriately cautious applicators will avoid costly mistakes and be more profitable in the long run. The most expensive application a person can make is one that does not work. Applicators should equip themselves with the appropriate information and instruments to be able to make the difficult call in marginal weather.

Wind Speed

Wind is the number one cause of herbicide drift. Wind gusts and sudden changes in wind speed or direction account for some of this; however, applicator judgment and spraying when the wind speed is too high is more often the problem. Even with appropriately sized droplets, drift can occur with high enough wind velocity. Most labels recommend not applying pesticides when wind is gusty or speed is greater than 10 mph. It is recommended for applicators to regularly and accurately measure wind speed to ensure proper spray deposition. Economically priced anemometers or wind meters can be obtained through most spray catalogs or found online.

Temperature and Relative Humidity

High temperature and low relative humidity causes all spray droplets to reduce in size through evaporation. Any reduction in droplet size will increase physical drift potential of pesticide spray. Spraying in cooler temperatures and higher humidity (50% or higher) conditions will reduce evaporation potential. These conditions are also ideal for preventing vapor drift. Some adjuvants can also reduce the evaporation potential of pesticides.

Temperature Inversions

Very low wind or no wind conditions should be of concern to applicators as well. With wind speeds calmer than 3 mph, the application site may be in a microclimate known as a temperature inversion. Temperature inversions are defined by increasing air temperature with increasing height. This occurs when cooler, denser air settles below warmer, less dense air. This stratification or layering of air prevents vertical mixing and only allows horizontal air movement. This becomes problematic when spray droplets become entrapped in these cooler horizontally moving envelopes. Concentrated pockets of pesticides can drift far off-target causing severe damage to sensitive vegetation.

Temperature inversions begin a few hours before sunset on clear, calm evenings and can be strongest just after sunrise following clear, calm nights. As shown in Figure 5, the presence of fog or dew is a strong indicator of a temperature inversion. If conditions are conducive to inversions but there is no fog or dew, applicators should take temperature readings of the area to ensure safe application conditions. Two measurements should be taken at different heights. The first height should be between 6 and 12 inches above the soil or just above the crop canopy. The second should be 8 to 10 feet above the ground. Ensure that the temperature sensor is shaded with each measurement. If the temperature is cooler near the ground and warmer in the air, then an inversion is present. Greater temperature differences indicate stronger inversion conditions. Applications should be delayed until more favorable conditions are present. Applicators should also note that these microclimates vary greatly with changing topography. All application decisions regarding temperature inversions should be made only regarding localized areas.

Figure 5. The presence of fog or dew is a strong indicator of a temperature inversion.

Avoid Drift

Always read and follow label directions. In addition, follow any other guidelines set forth by the State Plant Board or other state agencies that regulate the use of pesticides. Use common sense. Read, understand and follow the information in this fact sheet. Be aware of your surroundings. Know where sensitive crops are located in relation to the field or area to be sprayed (a list of relative sensitivity of crops to herbicides is available in the Extension publication MP44). Utilize the Flag the Technology program to aid in this (see FSA2162). Both MP44 and FSA2162 are available at www.uaex.edu.

Commercial products or trade names appearing in this publication are for product identification only. No endorsement is intended, and no criticism is implied of similar products not mentioned.

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