Drift-Reducing Strategies and Practices for Ground Applications

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Abstract

This publication is a companion to "A Review of the Spray Drift Literature for Ground Applications" (see preceding article). It comprises a list of strategies and practices that have been shown to reduce spray drift. The goal of this publication is to provide an inventory of best management practices to advise applicators on how to mitigate spray drift. The list was developed from a review of spray drift literature for ground applications spanning the years 2005 to 2011 as reported in this journal. Each strategy or practice listed is taken from a reviewed publication and is supported by research data. Ninety-seven items are listed and categorized into the following sections: air-blast sprayers, nozzles, buffers, the environment, simulation models, adjuvants, and miscellaneous (ex. reports and Extension publications). Though the list is quite extensive, each practice is unique to a particular study. Thus, it is difficult to develop a general list of set practices applicable to all (or most) application scenarios.

Keywords: strategies, practices, pesticide, spray drift management, ground application

Introduction

The preceding article in this journal, "A Review of the Spray Drift Literature for Ground Applications," summarizes spray drift literature between 2005 and 2011. Its purpose is to identify research-based strategies and practices effective in reducing spray drift. The review includes studies and documents that identify practices to reduce drift in the areas of air-blast applications, ground boom broadcast applications to fields, applications to rights-of-way, and applications made with handheld sprayers. After eliminating duplicates and reports that fell outside the scope of this project, the literature search ended up with 82 research studies. From a summary of each of these documents, the author developed a detailed list of recommended strategies and practices associated with reducing drift. These are categorized in the following sections: air-blast sprayers, nozzles, buffers, the environment, simulation models, adjuvants, and miscellaneous (ex. reports and Extension publications).

Strategies and Practices Supporting Spray Drift Minimization

The following drift-reducing considerations are derived from information taken from a recent review of the drift literature for ground sprayer applications. They are summary statements based on the best judgment of the author. Each statement contains a reference (in parentheses) to the citation in the corresponding section of the literature review. The reader may then refer to the original article for more information. For full citations of the documents cited here, see "References" in "A Review of the Spray Drift Literature for Ground Applications."

Not all reviewed documents are referenced below; others are referenced multiple times. The statements in each section appear in reverse chronological order: most recent to oldest.

Section 1 – Air-Blast Sprayers

- Making variable-rate applications using a laser scanner that can detect the presence or lack of foliage, then controlling when and where the spray occurs, is more efficient and reduces drift (Chen et al., 2011).
- When compared to conventional nozzles and a sprinkler application system, low-drift nozzles result in more deposition with less coverage variability when spraying in dwarf apple orchards (Panneton and Phillion, 2011).
- Tunnel sprayers equipped with a recovery/recycling system reduce spray loss (Jamar et al., 2010).
- Traditional ATR hollow-cone nozzles outperformed drift-mitigating TVI air-induction hollow-cone nozzles when spraying apple trees (Jamar et al., 2010).
- Low-drift nozzles used to spray fruit orchards reduced drift (Behmer et al., 2010).
- Low pressure (500 kPa compared to 1,800 kPa) with conventional air-blast sprayers was beneficial for reducing drift (Di Prinzio et al., 2010).
- Adjusting dosage rates in vineyards to vary with season, different row widths, variety, and trellis designs will reduce drift (Zhou and Landers, 2010).
- Infrared sensors on a vineyard canopy sprayer that can monitor canopy growth and make adjustments in airflow into the canopy will reduce drift (Larzelere and Landers, 2010).
- Designs that provide a more directed spray into the tree canopy while regulating airflow speed will reduce drift (Landers, 2010).
- Deposition and canopy penetration increase with the increase of air volumetric flow (Garcia-Ramos et al., 2009).
- Vertical and horizontal air curtains added to the rear and lower booms of a recycling sprayer reduced drift (Baldoin et al., 2008).
- Adapting a conventional air-blast sprayer (Wanner) with reflective shields was a useful drift-reducing technique (Wenneker and van de Zande, 2008).
- Reflective shields on a Wanner sprayer in combination with air-injection nozzles also reduced spray drift (Wenneker and van de Zande, 2008).
- A recycling sprayer with wrap-around booms and nozzles mounted in air spouts equipped with a centrifugal fan reduced drift during vineyard applications (Baldoin et al., 2008).
- When using air-blast sprayers, matching sprayer parameters (airspeed, direction of airflow, application volume, droplet spectra, and application speed) to tree size, shape, and density will reduce spray drift in orchards (Fox et al., 2008).
- Low-drift nozzles in fruit crop spraying reduced drift (Van de Zande et al., 2008).
- A surrounding sprayer reduced drift and runoff in orchard and vineyard applications when compared to a conventional fan sprayer (Geva and Broday, 2008).

- The use of an electromechanical system to adjust the air output from an air-blast sprayer can reduce drift in orchard spraying (Pai et al., 2008).
- When compared to conventional hollow-cone nozzles, the Turbodrop XL (air-induction) nozzle had less drift when spraying in orchards (Derksen et al., 2007).
- Sprayer inspection could benefit the pesticide application process (Gil, 2007).
- Spraying techniques to reduce or avoid leaf runoff reduce the amount of pesticide on the ground (Ade et al., 2007).
- A mechanical (deflector) system added to a sprayer to adjust air output based on foliage density and to better position airflow into the canopy reduced drift (Landers and Gil, 2006).
- Sprayers designed with a cross-flow airstream resulted in less variation in deposits across multiple tree rows (Derksen et al., 2006).
- Cross-flow airstream design with reduced fan speed increased nearest row deposition (Derksen et al., 2006).
- Using reduced spray volumes and speed settings improved efficiency when spraying in orchards (Derksen et al., 2006).
- Large-capacity nozzles are not needed on top of air-blast sprayers when spraying dwarf trees (Zhu et al., 2006).
- A recovery sprayer designed for apple orchard applications was effective in reducing drift in vineyard applications (Panneton and Lacasse, 2006).
- A tunnel sprayer equipped with an air-circulation system is more efficient and has less drift than a conventional air-blast sprayer (Ade et al., 2005).

Section 2 – Nozzles

- A wind tunnel and a phase Doppler particle analyzer are suitable as indirect methods to assess spray drift (Nuyttens et al., 2010).
- Larger droplet sizes correspond to higher droplet velocities (Nuyttens et al., 2009a).
- Flat-fan nozzles have higher droplet velocities than similar-sized air inclusion/induction nozzles (Nuyttens et al., 2009a).
- Droplet velocities are affected by preorifice and venturi designs (Nuyttens et al., 2009a).
- Drift-reduction nozzle designs have lower drift potential compared to conventional (flat-fan) nozzles (Nuyttens et al., 2009b).
- Drift is decreased when spraying into higher leaf density canopies in strawberry (Bjugstad and Hermansen, 2009).
- ASABE Standard S572.1 for droplet spectra establishes an eight-category nozzle classification system to assess drift potential from a given nozzle (American Society of Agricultural and Biological Engineers, 2009).
- Spinning disc atomizers drift much more than similar-sized flat-fan nozzles (Qi et al., 2008).
- Lower speeds, reduced boom heights, larger nozzle orifice sizes, and lower spray pressures reduce drift (Nuyttens et al., 2007).

- Spray characteristics of air-induction nozzles can be achieved using conventional nozzles with an equivalent orifice size operated at a lower pressure (Guler et al., 2007).
- Improving canopy penetration with a mechanical canopy opener may reduce drift (Zhu et al., 2006).
- Higher-volume applications have less drift than lower-volume ones (Wolf, 2005).
- Conventional flat-fan nozzles create more drift than those with drift-reducing designs (Wolf, 2005).

Section 3 – <u>Buffers</u>

- Hedgerows (windbreaks) reduced drift below the height of the hedge (de Schampherleire et al., 2009).
- Drift distance and amount beyond windbreaks is affected by the strength of the wind (de Schampherleire et al., 2009).
- The use of tree rows in front of a body of water downwind from the application reduced spray drift (Vischetti et al., 2008).
- The use of narrow, unsprayed buffer zones reduces drift (de Jong et al., 2008).
- Hedgerows 7 to 8 m high reduce drift (Lazzaro et al., 2008).
- A double hedgerow does not change the amount of drift reduction compared to a single hedgerow (Lazzaro et al., 2008).

Section 4 – The <u>Environment</u>

- Applicators should not spray during temperature inversions. Inversions are most common between 6:00 p.m. and 6:00 a.m. but may occur as early as 4:00 p.m. This condition is most critical when wind speeds are below 2 m/sec (Fritz et al., 2008).

Section 5 – <u>Simulation Models</u>

- AGDISP can now be used for ground boom drift simulations and is feasible for orchard air-blast sprayers. It is currently being used for simulations beyond nearby deposits (Teske et al., 2011).
- Recent data indicates that the high boom scenario data in AgDrift Tier I may not be as accurate as once thought (Teske and Thistle, 2011).
- A model predicting tree canopy deposition showed that spray canopy distance, spray volume rate, and canopy density contributed significantly to deposition. The model would be a good predictor for planning more effective on-target applications to trees (Labri and Salyani, 2010).
- A model developed in the United Kingdom is being used successfully in the United States to predict spray drift or surface water deposits up to 200 m (Ellis and Miller, 2010a).
- AGDISP is influenced by humidity of the spray cloud. Adjusting the AGDISP model for humidity makes it a better drift predictor (Teske and Thistle, 2010).

- Researchers have combined a global positioning system with DRIFTSIM to obtain two-dimensional drift predictions from ground sprayers (Kruckenberg et al., 2010).
- DepositScan, a portable scanner and software, is available to evaluate droplet characteristics on location (Zhu et al., 2010).
- A computational fluid dynamics (CFD) model for orchards that allows the simulation of the spraying process for different sprayers can evaluate several spray parameters (Endalew et al., 2010).
- A computer model developed in the United Kingdom has been improved to include the effects of multiple nozzles and a forward speed (Ellis and Miller, 2010b).
- AGDISP can now be used for ground boom drift simulations (Teske et al., 2009b).
- Recent upgrades in AGDISP allow for evaporation impacts on droplet size and for behavior of the integration time step (Teske et al., 2009a).
- Linear multiple regression and fuzzy logic inference models combined with math models can be used to evaluate air pollution and spray drift (Gil et al., 2008).
- The IMAG Drift Calculator overestimates drift at close distances (2 to 3 m) (Wolters et al., 2008).
- A model to quantify spray drift and to study the influence of several application variables on the amount of pesticide released into the atmosphere during air-assisted spraying is suitable for evaluating spray drift (Gil et al., 2007).
- Boom movements have a significant impact on drift (Baetens et al., 2007).
- Small variations in driving speed have little impact on drift (Baetens et al., 2007).
- Using a test bench to evaluate drift was more reliable than using a field test (Balsari et al., 2007).
- AGDISP can predict drift based on crop canopy height and closure, but it may be less accurate for ground boom sprayers close to the canopy (Hoffman et al., 2007).
- The closer a spray boom is to a water body, the greater the likelihood of drift (Garratt and Kennedy, 2006).
- A CFD model was developed to predict spray drift from nozzles (Nuyttens et al., 2006).
- Light detection and ranging (lidar) imaging is an accurate and efficient way to estimate spray transport models by viewing spray plumes (Hiscox et al., 2006).
- DRIFTSIM, a tool to predict drift up to 200 m, can rapidly estimate horizontal drift distances. The Windows software factors in temperature, release height, droplet velocity, relative humidity, wind speed, and droplet size (Zhu et al., 2005).

Section 6 – Adjuvants

- As solution temperatures increase, dynamic surface tension and viscosity decrease, resulting in smaller droplets. However, solution temperatures are unlikely to vary enough to affect the drift risk of an application (Hoffmann et al., 2011).

- Extremely low concentrations of polymers can increase droplet size dramatically (Williams et al., 2008).
- Surfactants increase droplet wetted area and reduce evaporation time (Zhu et al., 2008).
- Drift retardants increase evaporation time and decrease droplet coverage area (Zhu et al., 2008).
- The addition of drift-control adjuvants decreased the percentage of small-diameter droplets but did not affect field efficacy (Jones et al., 2007).
- Solution and/or formulation may affect droplet size. For example, an emulsifiable concentrate formulation of phenmedipham resulted in smaller volume median diameters than the suspension concentrate formulation (Stainer et al., 2006).
- High operating pressure (1,655 kPa) in an air-blast sprayer with a polyacrylamide polymer drift retardant resulted in more airborne and ground drift potential (Guler et al., 2006).

Section 7 – Miscellaneous (ex. reports and Extension publications)

- Using reduced-angle (80º compared to 110º) flat-fan nozzles will lower drift risk (Miller et al., 2011).
- Hand sprayers can be adapted to use drift-control nozzles to improve deposition and reduce spray drift (Wolf, 2010).
- The greatest challenge facing pesticide applicators is the need to balance effective and efficient pest control with reduced drift. This goal must also accommodate conditions (ex. wind speed) that may influence the outcome (Wolf, 2009).
- Higher temperatures and lower humidity levels will increase evaporation speed, resulting in smaller droplet sizes and increased drift potential (Hanna and Schaefer, 2009b).
- The DRIFTSIM model incorporates temperature and humidity; it can calculate droplet size and off-target movement distance (Hanna and Schaefer, 2009b).
- Adding drift-retardant materials into a spray solution can reduce drift (Hanna and Schaefer, 2009b).
- Selecting a nozzle orifice size to match the label-required droplet spectra can help reduce drift as well as maintain proper efficacy (Wolf and Bretthauer, 2009).
- Applicators should select nozzles based not only on orifice size but also on droplet size and pressure (Hipkins et al., 2009).
- Single boomless nozzles used for roadside and pasture herbicide applications can be highly influenced by wind, which may affect pattern quality, swath width, efficacy, and drift potential (Wolf et al., 2009).
- A summary of drift studies indicates that wind speed, boom height, and distance downwind affect drift the most (Klein, 2009).
- Increasing droplet size is critical for reducing drift (Hanna and Schaefer, 2009a).
- Lower application pressure, larger orifice size, lower boom height, low-drift (air induction/inclusion) nozzles, and driving at slower speeds all contribute to less drift (Hanna and Schaefer, 2009a).

- Avoid drifting onto sensitive crops by using DriftWatch, an online Google Maps interface designed to inform applicators of the locations of these crops (Antony et al., 2008).
- Select nozzles based on their efficacy as well as for better drift control (Wilson et al., 2008).
- Drift-reduction strategies should emphasize compliance without excessive costs (Blaine et al., 2008).
- Five field experiments compared the primary drift of 10 herbicides. Drift deposits were common with all equipment used. Differences reported were attributed to different droplet sizes, wind velocities, formulations, and the filtering effect of vegetation (Carlsen et al., 2006).
- Evaporation speed of different tank mixes is a factor influencing drift (Carlsen et al., 2006).
- A detailed listing of general best management practices for boom spraying contains recommendations to reduce spray drift (Ozkan and Womac, 2005).

Summary and Conclusions

This publication comprises a list of 97 strategies and practices that have been shown to reduce spray drift. Each item is supported by research data. The goal of this publication was to provide applicators with a collection of best management practices to better manage spray drift.

The challenge in formulating such a list is that much of the reported research is not applicable outside of the research realm. Data acquired through research may not be accurate or relevant for many of the scenarios that applicators face each day. Also, it is very difficult to compare studies. Control factors and experimental designs vary, making it hard to analyze the amounts of drift reduction associated with various treatments. Nonetheless, the findings in this review contain some good, workable practices.

Applicators need more detailed information to make responsible choices fitting their application scenarios. Currently, those details are often not available. For instance, it is common knowledge that larger droplets will reduce drift. But how large should they be? How much efficacy must be sacrificed to safeguard human and environmental safety? Currently, there is much concern about hard-to-control and resistant weeds. Good application practices are just as critical to resolving that issue as are debates about the safety of the pesticide product.

A new era of application is before us as we begin using herbicide-tolerant cropping systems. The author believes that a similar intensive review of the pesticide efficacy literature is needed to put drift-reduction and efficacy databases together. These combined resources may help applicators make better decisions about how to manage spray treatments responsibly and effectively. Unfortunately, much of the efficacy data reported in the past does not include key equipment setup factors. Unless more attention is given to these factors, we are again left to speculate on recommendations for best practices.

Fortunately, there is a growing interest across the industry in supporting research regarding the influence of chemistry, adjuvants, and nozzle type on droplet size and how that relates to efficacy as well as drift control. These results are being coupled with field efficacy trials that should provide more useful guidance for minimizing spray drift while maintaining good pest control.

Drift-reduction research is ongoing, providing opportunities for new information on reducing spray drift. In fact, several new research studies have been reported since this review ended (September 1, 2011). Also, new efforts to evaluate the influence of different tank-mix solutions using “live” tank mixes in wind tunnels are underway. A new high- and low-speed wind-tunnel facility came online in January 2012 at the West Central Research and Extension Center of the University of Nebraska – Lincoln for this purpose.

One conclusion from this data review is that an expanded effort to provide usable drift-prediction models looks very promising. Many studies have supported the reliability of these models. Models are often a more economical approach to evaluating drift-reducing technologies than are complicated and weather-dependent field studies. These models will need to be simple to use and available as smartphone applications to make use of current technology.

Acknowledgments

I would like to thank Crop Life America for financially supporting this project, helping to guide the process, and providing editorial assistance in the development of the final document.