Pesticides – Minimizing Spray Drift

INTRODUCTION

One of the enduring challenges with pesticides is the reduction of spray drift. This is becoming more important each year, for several reasons:

- Pesticides are commonly found in surface, ground and precipitation water.
- Many of our fungicides and insecticides can very toxic to birds, fish, or their food.
- The use of 2,4-D ester and other volatile formulations remains high and new weed control products often contain these in a tank mix.
- The public is scrutinizing the use of pesticides and human exposure.
- The Pest Management Regulatory Agency (PMRA) is regulating pesticide use based on concerns about the environment.

This document will cover aspects relating to the drift of pesticides, what can be done to minimize it and what the implications for pesticide efficacy are.

FACTORS THAT GOVERN DRIFT RISK

Several factors are important in determining how much spray will drift, and these primarily involve weather conditions and sprayer setup. The best way to prevent drift is to spray only in the correct conditions with a properly adjusted sprayer. It is therefore important for an operator to have some understanding of how these are interrelated.

Weather Conditions

The most important weather factors are wind speed and atmospheric stability. Temperature and relative humidity play a role for aerial application.

Wind Speed:

All other things remaining constant, spray drift increases linearly with increasing wind speed. For example, an 8001 tip applying 50 L/ha will lose about three per cent drift at a 10 km/h wind speed, seven per cent at 20 km/h, and 11 per cent at 30 km/h. This doesn't mean that calm conditions are ideal for spraying. At very low wind speeds, the drift cloud can move in an unpredictable direction and cause damage. As a result, spraying is best done when there is some wind, and when the operator can be sure that wind direction has stabilized.

The effect of wind speed is a function of spray quality. For example, coarse sprays are less sensitive to increased wind speeds than fine sprays. But even with good drift reducing technologies, drift will still occur, and there are always maximum wind speeds above which no spraying should be done. Operators must use their judgment and be aware of downwind effects at all times.

Atmospheric Stability:

Under normal sunny daytime conditions, the atmosphere is said to be "unstable". This means that air near the ground is much warmer than air above. Under these conditions, there is considerable turbulence in the atmosphere, and adjacent air layers mix readily with each other.

So if the air contains some drift, this drift is quickly dispersed upward and downward, diluting it with clean air and reducing its impact (Figure 1).

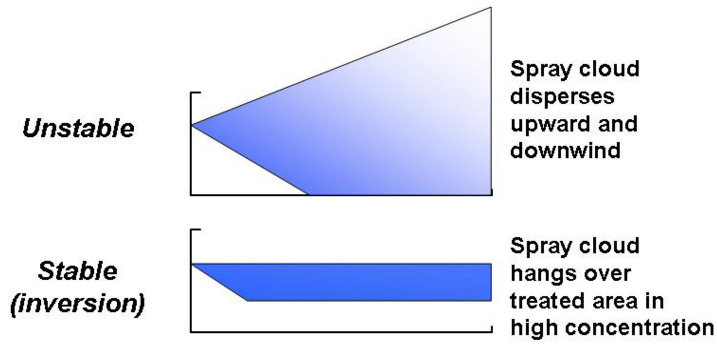

Figure 1: Fate of a spray cloud under unstable and stable (inversion) conditions

The opposite of an unstable atmosphere is a "stable" atmosphere ("temperature inversion"). Inversions occur when air near the ground is cooler than air above it, typically at nights with limited cloud cover and light to no wind. Under inversion conditions, turbulence is suppressed and suspended spray may hang over the treated area in a concentrated cloud for a long time. Winds after an inversion are very slow and unpredictable in direction and when they occur, a concentrated spray drift cloud is moved off the treated area and can cause considerable damage at its destination. For this reason, drift potential is high during a temperature inversion. Fine sprays are particularly sensitive to inversion drift. Applicators should avoid spraying during temperature inversions, regardless of the application method. Most serious drift complaints involve spraying under inversion conditions.

Air Temperature and Relative Humidity

Table 1: Summary of atmospheric conditions and consequences for spray drift.

Unstable Conditions	Stable Conditions (inversions)
• sunny days • some wind • predictable wind direction • disperse spray	• nights • no or little wind • unpredictable wind direction • keep spray concentrated

Small water droplets can rapidly evaporate to a smaller size, predisposing themselves to drift. Temperature and relative humidity affect how quickly droplets evaporate. For example, under warm and humid conditions (20º C and 80 per cent relative humidity), a 100 μm droplet evaporates completely in 57 seconds. Under hotter, dry conditions (30º C and 50 per cent relative humidity), the same droplet is evaporated in 16 seconds. A 50 μm droplet would last only four seconds under the hot and dry conditions, enough time to fall only 15 cm. From a drift perspective, droplets large enough to withstand drift may evaporate down to a size which makes them drift-prone in the time they spend between the nozzle and the target plant.

Sprayer Settings

For all sprayers, drift reducing methods focus on three approaches:

- reducing the proportion of small droplets in the spray cloud (spray quality);
- protecting the spray from wind (boom height and shrouding);
- diluting the spray solution (carrier volume).

Spray Quality

The most effective way to reduce drift potential is to apply coarse sprays that minimize the proportional contribution of small droplets (<150 µm). Droplet size can be varied in a number of ways. Nozzle and spray pressure selection are the most important parameters.

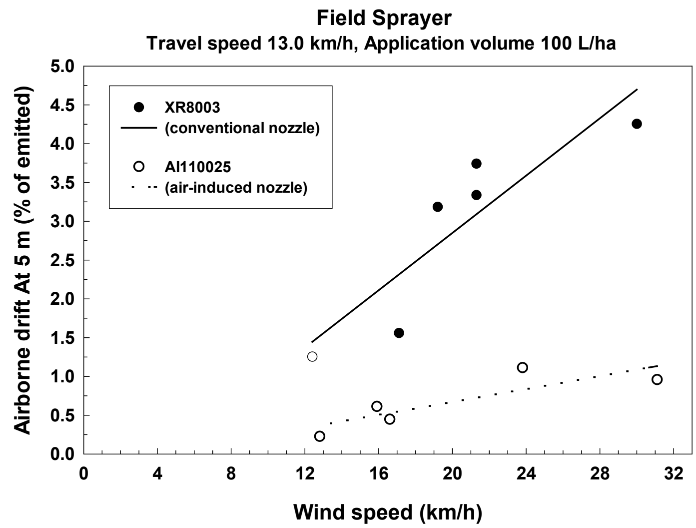

Figure 2: Effect of droplet size on off-target spray drift. Boom height was 60 cm.

- **Nozzle Types:** Conventional flat fan nozzles or hollow cone nozzles can be quite drift prone. Low-drift nozzles are available from many manufacturers. These use a combination of pressure and flow rate to produce a spray that can reduce drift from 50 to 95 per cent for a given flow rate (Figure 2). Many of these nozzles can be operated at higher pressures without increasing drift potential significantly. This is one of the most important and widely used means of drift reduction for ground application, and will be discussed in more detail at the end of this presentation.
- **Pressure:** For any given nozzle, lower pressures result in coarser sprays. Drift potential can vary by a factor of three within a nozzle's recommended pressure range. The lowest recommended pressure will minimize drift risk. Operators should ensure that spray patterns remain uniform at the lower pressures.
- **Flow Rate:** For any given nozzle, a larger orifice (nominal flow rating) will produce a coarser spray.
- **Nozzle Fan Angle:** With most nozzle types, narrower fan angles produce larger droplets. If wider fan angles are used, booms should be lowered to compensate.
- **Carrier Volume:** Most herbicides work equally well between 50 and 200 L/ha. Use of higher carrier volumes is a very effective way of reducing drift, for two reasons. First, if travel speed is maintained, a larger nozzle is used to apply the higher volumes. This results in a coarser, less drift-prone spray. Second, the spray solution is more dilute at the higher volume. This means that drift will contain less active ingredient, and therefore have less potential for causing damage.

Travel Speed

Herbicides have historically been applied primarily by tractor-drawn sprayers with outrigger wheels. These sprayers travel eight to 10 km/h, and are able to maintain a constant height along the width of the boom. Recently, the use of faster self-propelled high clearance sprayers has increased. Faster travel speeds have three main effects on how spray behaves after it leaves the nozzle:

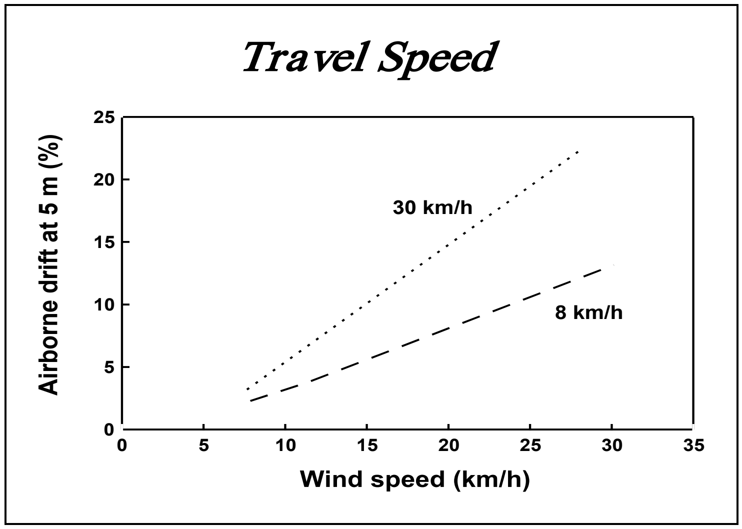

Figure 3: Effect of travel speed on spray drift. 30 km/h travel speed conducted using XR11002 tips applying 30 L/ha. 8 km/h travel speed done using XR8001 tips applying 50 L/ha.

- Faster travel speeds cause increased air shear on the spray sheet emerging from a nozzle. This increases sheet breakup and causes a finer, more drift-prone spray to be produced.
- Faster speed causes the spray to stay aloft longer because it gets swept back due to air resistance.
- Faster speeds often require higher boom heights on uneven ground. On the other hand, when maintaining a constant carrier volume and pressure, faster travel speeds require the use of larger flow-rate nozzles, which produce coarser sprays, reducing drift potential. The net effect of travel speed changes are still not clear, but some evidence suggests that drift is increased (Figure 3).

Boom Height

Spray can be protected from wind by lowering the boom to the minimum recommended setting. For 80º fan angles, this is 45 cm, and for 110 degree fan angles, 35 cm. Nozzles with 110 degree fan angles create finer sprays than the same nozzle type with an 80 degree angle, so the ability to lower them closer to the ground doesn't really afford much more drift protection. Also remember that suspended booms of self-propelled sprayers are likely to sway during operation, so booms need to be high enough to compensate for that. Automatic boom levellers can help keep booms at the correct height. By orienting the spray forward or backward, boom height can be reduced as long as the nozzle to target distance is maintained at the minimum recommended in the direction the nozzle is oriented. Low-drift sprays require greater overlap than finer sprays, and boom heights resulting in 100 per cent overlap are recommended for these. 100 per cent overlap is achieved when the edge of a spray pattern reaches the centre of the adjacent nozzle pattern.

Shrouds

Shrouds reduce drift. In field testing, shrouds were able to reduce drift from an 8001 tip applying 50 L/ha by about 75 per cent (Figure 4). Drift from the finer spray produced by 11001 tips was not as easily prevented. Some booms may not be able to accommodate shrouds, in those cases cones may be appropriate. Cones allow greater ground clearance for suspended booms, and won't contaminate susceptible crops with spray residue on the shielding material. Protective cones have been shown to reduce drift by 30 to 50 per cent. We don't yet know how these shrouds perform on high clearance sprayers moving at faster travel speeds. An operator should expect shrouds to become less effective with higher booms and travel speeds. A combination of shrouds and low-drift tips, although not yet tested under field conditions, would provide the best overall drift protection, better than shrouds or low-drift tips alone.

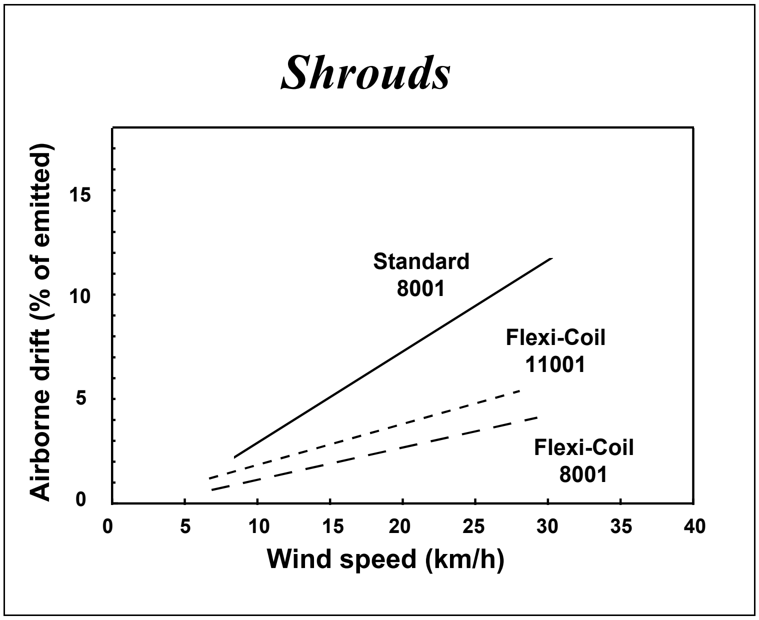

Figure 4: Reduction of drift with shrouds. Application volume was 50 L/ha.

Air Assist

The use of air assist to reduce drift is sound in principle, but more difficult to put into practice. In principle, a fast-moving droplet is more drift-resistant than a slow-moving droplet of equal size. The idea behind air assist is to use an air stream to carry the emitted spray downward toward the target, imparting speed and preventing it from hanging in the air and being exposed to wind (Figure 5). It is important to set the direction and velocity of the airblast to match the prevailing atmospheric and crop canopy conditions. For example, too strong an airblast into a small crop canopy, such as seedling wheat, can result in the airblast rebounding off the ground. Any spray not intercepted by the canopy will return upward into the airstream and is prone to drift. Tests have shown that drift will increase if the airblast is too strong. When spraying into a dense canopy, for example to desiccate a pulse or apply fungicide to canola, a strong airblast is more appropriate to obtain better canopy penetration. Ultimately, air assist must be adjustable to be useful and requires an experienced operator for maximum benefits.

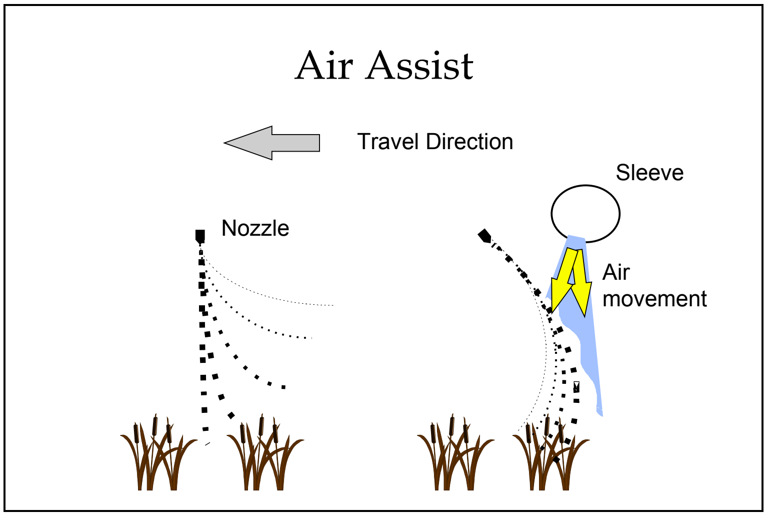

Figure 5: Air assist carries drift-prone droplets to their intended target.

The Importance of Active Ingredient

Vapour Drift

Some herbicides and insecticides are prone to vapour drift and can seriously damage plants, animals and humans. If the active ingredient is volatile, vapour drift can occur even when there is no particle (droplet) drift, and even dry spray deposits can send vapours into the atmosphere.

Vapour drift increases with air temperature, therefore the application of volatile products should be avoided on, or just preceding, hot days. Total losses depend on temperature, soil and leaf moisture, and the vapour pressure of the active ingredient.

Buffer Zones

The actual amount of droplet spray drift leaving a treated area and settling out downwind is very small. Some studies report that only 1 per cent or less of the applied amount deposits a significant distance downwind under unstable (daytime) conditions. How much damage can such a small amount cause? That depends on the potency of the active ingredient and the plant susceptibility. For example, sulfonylurea herbicides, phenoxies, and glyphosate are very potent and can damage susceptible plants at very small doses. Extra care must be taken when applying these products. Most other herbicides are less active, and small quantities have no noticeable effect on plants. However, many insecticides and fungicides are very harmful to aquatic or avian species, and drift or run-off into water must be avoided.

Buffer zones, defined as the downwind distance from the edge of the spray swath to the upwind side of a sensitive area, can be used to reduce the impact of a pesticide spray. Buffer zones from sensitive terrestrial or aquatic areas are indicated on product labels. Applicator-calculated changes to buffer zones that reflect low-drift application conditions are now being considered by the Pest Management Regulatory Agency.

What to Do Before Spraying

The most important thing to do in any spraying situation is to keep people informed. Prior to spraying near a residence, inform its inhabitants about your plans to spray. This way they realize that you are concerned and want to avoid problems. Let them know what you're spraying, what precautions you're taking, and that you'll be watching the wind speed and direction. If drift damage does occur, this will at least minimize antagonism later. Make sure you know what's growing on nearby sites and gardens, and have an idea about how these might be affected by your active ingredient. Take special care near sensitive areas like yards, ponds, sloughs or shelterbelts. It may be a good idea to apply a higher volume with the first tank, and take care of the outside rounds and other sensitive areas first.

What Can Be Done to Avoid Drift Complaints?

- Know your surroundings. Are there sensitive crops nearby? Shelterbelts? Does the family in the nearby yard know you're spraying?
- Measure wind speed and wind direction using a proper anemometer and compass before spraying. Record this and other weather conditions (sunny, air temperature) in a log book. It will come in handy if there's a complaint.
- Make sure the wind is blowing away from sensitive areas.
- Don't spray under high wind speeds or dead-calm conditions. At night, temperature inversions, usually associated with calm conditions, allow the spray cloud to "hang" for a long time. This cloud can do a lot of damage once winds come up.

- Use low-drift technology whenever possible. Recognize its limits and stop spraying when it gets too windy.
- Drive as slowly as your schedule allows.
- Keep boom height as low as possible. Consider getting automatic boom height adjustment.
- Lower spray pressure near sensitive areas.
- Avoid spraying volatile products on or immediately before hot days. Even dried spray deposits can volatilize and drift.
- Get trained and updated regularly.
- Be professional and courteous and respect the concerns of others.
- Phone an expert if you're not sure what to do.

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