Criteria for Choosing the Right Spray Application Volume on a Diversified Farm

Tom Wolf
Agriculture & Agri-Food Canada
Saskatoon, Saskatchewan
tom.wolf@agr.gc.ca

Introduction

Low water volumes can mean less effort to apply pesticides. But there is a limit to how low water volumes can go before problems appear. To understand the reasons why, and help applicators use the right volume for a given situation, this paper will briefly outline the interaction of the spray cloud and the crop canopy.

Basic Principles

To choose the right water volume, one must first think about droplets in three ways. First, the spray must reach the target to be effective. Second, there must be enough droplets to sufficiently cover the target. Third, the droplets have to be in a form (size and pesticide concentration) that allows the pesticide to be efficiently taken up by the target.

Let's start with the second criteria. The more leaf area to be covered (i.e., the taller the crop canopy), the more droplets will be required. Leaf Area Index (LAI), defined as the total leaf area per unit ground area, is a good indicator of canopy density. To put this in perspective, consider a pre-seed burnoff or an early post-emergent herbicide spray vs. a late season fungicide. In the first case, the canopy can be described as being in a single plane near ground level, with leaf areas of target plants fully exposed and with an LAI of <1. High droplet density on the leaves will be achievable with relatively low volumes (Figure 1). In the second case, the canopy will have more depth, and will contain large leaf areas in each of the lower, mid, and upper canopy regions, with an LAI >>1. Providing the same droplet number to each of the regions in the second case will require more droplets, and therefore more volume.

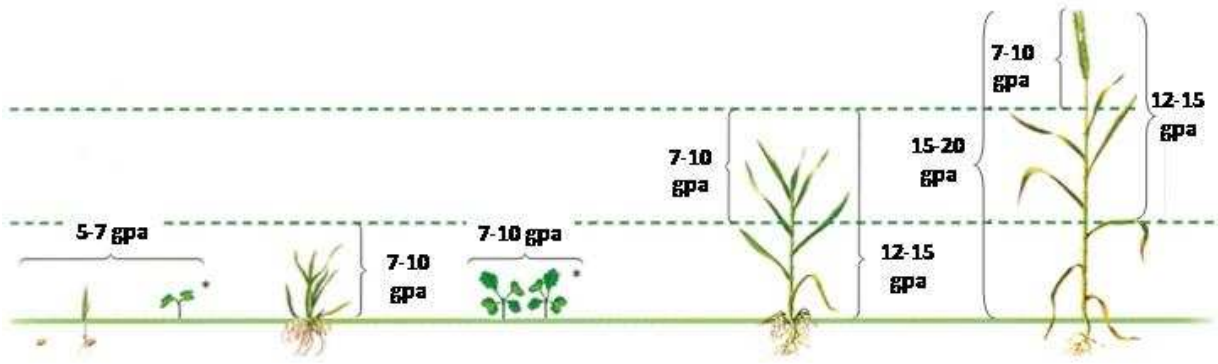

Figure 1. Relationship of water volume, crop stage, and target location.

Greater droplet numbers can be achieved by either using more water or atomizing the available water in finer sprays. The suitability of each of these depends on the weather, target type and the active ingredient. Small droplets, though making better use of available spray volume, may evaporate rapidly on hot, dry days, reducing targeting efficiency. They also tend to be drift

prone, often moving off-target before depositing. When they do deposit, smaller targets such as stems, petioles, and very small leaves tend to capture more small droplets than exposed larger leaves and ears. Finally, while some sprays inherently work better as smaller droplets (i.e., many insecticides), others have greater performance as larger droplets (e.g. glyphosate, Group 2 & 4 herbicides, Table 1). Taken as a whole, the use of finer droplets is often counterproductive except in special circumstances where the above aspects are addressed. Higher water volumes have the advantage of allowing larger average droplet sizes to be maintained, minimizing evaporation, drift, and enhancing deposition.

Table 1. Herbicide modes of action, minimum water volumes with low-drift nozzles, and maximum spray quality

Herbicide Mode of Action Group	***Example Active Ingredients***	***Water Volume***	***Spray Quality***
1	clodinafop, pinoxaden, clethodim, fenoxaprop	7 - 10 US gpa	Medium - Coarse
2	thifensulfuron, tribenuron, imazethapyr, imazamox	7 - 10 US gpa	Coarse – Very Coarse
4	2,4-D, MCPA, diacamba, clopyralid	7 - 10 US gpa	Coarse – Very Coarse
9	glyphosate	4 - 5 US gpa	Coarse
6, 10, 22,	bromoxynil, glufosinate, diquat	9 - 12 US gpa	Medium - Coarse

Before we can talk about coverage, the droplets must reach the target, i.e. they have to possess the right trajectory and force to get to, and deposit, where they're needed. In general terms, finer sprays tend to target smaller objects and those objects that are oriented vertically (think of cotyledons, stems, petioles, first true leaves of grasses). Larger droplets are better suited for larger objects such as broad leaves, fully emerged cereal leaves, and horizontally oriented targets. Larger droplets are also retained more easily by leaf surfaces that are considered "easy to wet", such as most broadleaf weeds.

Finer sprays tend to be more successful at navigating their way through a broadleaf canopy because they tend to flow around larger objects. Larger droplets, on the other hand, are better at impacting on larger leaves near the top of a canopy and navigating through a vertically oriented canopy or open canopy. Larger droplets can also provide a kind of air-assist for smaller droplets in their flight towards the canopy.

In practice, an applicator rarely encounters just one type of targeting situation. Most herbicides are either broad-spectrum, or are tank mixed to target both grass and broadleaf weeds. As a result, the same spray operation has to be effective on grass weeds and broadleaf weeds, some

of which may be near the top of the canopy, or be more mature, whereas others may be just emerging. In these cases, a number of different droplet sizes will be required.

At the risk of oversimplifying, a low-drift nozzle can be used for most such applications, as long as small adjustments are made for specific conditions. Increases in pressure above 60 psi (for finer droplets, Medium to Coarse spray quality) and volume to at least 7 to 10 US gpa (for better penetration) with this nozzle optimizes performance for grassy weeds. Lower pressures (down to 40 psi, Coarse to Very Coarse spray quality) are sufficient for systemic broadleaf products or when additional drift control is necessary. Higher volumes (12 – 15 US gpa) may be needed to obtain good coverage into dense canopies. Always check with nozzle manufacturer information to learn what spray quality is produced by the nozzle you're using – this will vary with nozzle type, flow rate, and spray pressure.

Air Assist

An overlooked tool for droplet delivery is air assist. Forcing sprays into a canopy with fan-forced air is very effective at increasing lower canopy deposition, and can be useful for overcoming drift and deposit problems with finer sprays.

Ordinary sprays also have some built in air assist, and applicators can take advantage of this with volume and speed choices. Droplets moving through space drag air along with them much like a vehicle on a gravel road drags dust along behind. The more liquid is sprayed, or the larger the droplets, the more air is dragged along. Smaller droplets are carried along with this downward airflow. Maximizing this effect through higher water volumes, larger droplets, lower boom heights, or slower travel speeds provides effective means of increasing canopy penetration and deposition.

Putting the Pieces Together

Let's assume we have to cover a large canopy, say a wheat canopy at boot stage, with a foliar fungicide. To protect the plants, the fungicide must cover leaves in both the upper and lower canopy. These leaves are mostly mature and will likely be oriented partly horizontally and partly vertically. It should be obvious that both large and small droplets are required to achieve these goals.

Nozzle Choice

Our main tools for droplet size selection are spray pressure (higher pressure reduces droplet size) or nozzle choice. All nozzles produce a wide variety of droplet sizes ranging from 5 µm to 1000 µm in diameter. The main difference between sprays is the proportion of their volume in any given size fraction, with low-drift sprays having less of their volume in the drift-prone sizes (less than 200 µm, Figure 2). Even low-drift

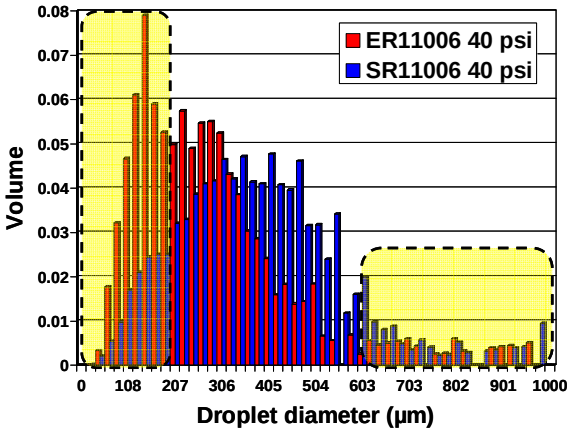

Figure 2: Typical droplet size spectra of a conventional flat fan nozzle (ER11006) and a low-drift nozzle (SR11006)

nozzles produce small droplets, and these provide sufficient coverage in most cases. Low-drift sprays do create more larger droplets, and these do not contribute to coverage due to their relatively low number and poor retention.

Pressure

Higher pressures are sometimes thought to increase canopy penetration because they force the spray into the canopy. This is not true. While higher pressures create faster moving droplets, this quickly diminishes. By the time the spray enters the canopy, the faster velocity is lost, and the only effect that remains is the finer spray. Finer droplets will penetrate many canopies further, but only if they are protected from wind. On a windy day, the finer sprays are more likely to blow downstream, or perhaps evaporate. The main benefit of higher pressure is better operation of the nozzle, especially air-induced nozzles, leading to more uniform patterns and better overall results.

Droplet Size

Although coarser sprays are often thought to have lower efficiencies, they offer certain advantages. One advantage is that a coarser spray tends to provide the air assist mentioned above (dragging air into the canopy, and giving smaller droplets a greater chance of moving where they're needed). Larger droplets also take longer to evaporate, increasing opportunities for uptake and translocation within the plant. Larger droplets are more efficient at targeting the exposed, large leaves of plants requiring disease protection, leading to greater deposition and fungicide performance. Most importantly, coarser sprays produce less drift, enabling application under windier conditions and thus ensuring that the timing of the application with respect to the crop or disease stage can be optimized.

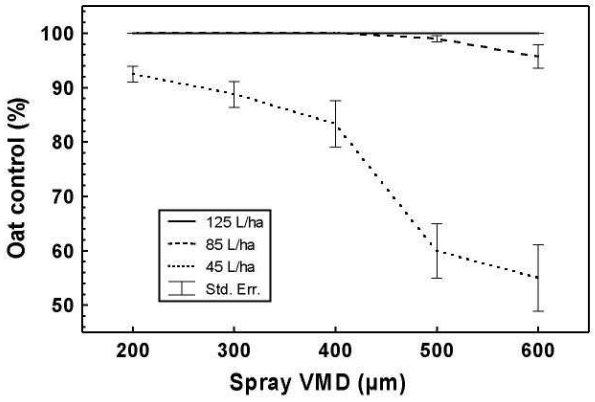

Figure 3: Typical interaction between droplet size and water volume for herbicides

Volume

Higher water volumes are the single most effective way of increasing dense canopy penetration. Higher volumes will deliver a greater number of droplets to the lower canopy, leading to greater performance when lower canopy coverage is of importance. When used in combination with lower travel speeds, the downward air flow created by sprays can provide significant benefits in forcing the smaller droplets further down. Larger volumes also decrease sensitivity to droplet size, permitting coarser sprays that reduce spray drift (Figure 3).

Nozzle Angling

Research has shown that exposed (upper canopy) vertical targets such as heads or stems will benefit from an angled spray (Figure 4). Forward-pointed sprays offer a slight advantage over backward-pointed sprays. Since angled sprays must maintain this trajectory to be useful, it is recommended that coarser spray qualities be used to minimize fine droplet production. Angled fine droplets will quickly deflect from their initial angled path and move with prevailing winds. Canopy penetration has not been shown to be improved with angled sprays.

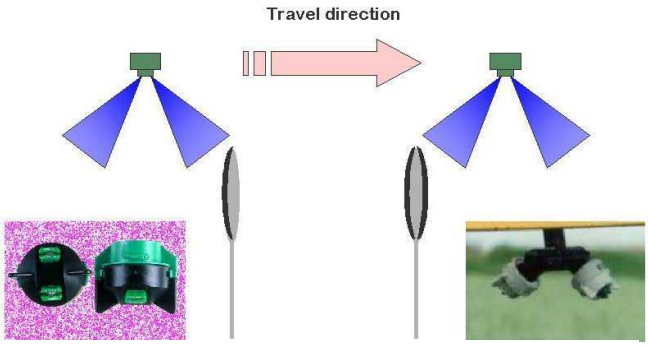

Figure 4: Double nozzles can improve coverage of exposed vertical targets.

Approach

How can an applicator decide the most appropriate water volume and spray quality for a specific application scenario? The following guides should help.

First determine the canopy density and form (broadleaf or grassy), and the target site within it (upper, mid, or lower). If the canopy is dense, but fairly vertical (i.e., a cereal), and a significant portion of it needs to be protected, the best strategy is to apply a higher water volume using a reasonably slow ground speed to allow the spray's built-in air assist to work. If, on the other hand, only the upper layer of leaves, or the heads, are to be targeted, less water can be used. If the water volume is appropriately high for the canopy, larger droplet sizes do not diminish coverage or pesticide performance.

If the canopy is dense but more horizontally oriented (broadleaf crops), similar rules apply for water volume and travel speed, but now the use of a somewhat finer spray may be of benefit. The smaller droplets will be better able to move around and through the leaves to reach deeper into the canopy. Ensuring a downward trajectory of the spray through travel speed and water volume selections will be important.

On the whole, a low-drift nozzle such as the Air Bubble Jet, the Greenleaf AirMix, the Hypro ULD, the Hypro Guardian Air, the TeeJet AIXR, the Hardi MiniDrift, the Lechler IDK, or the ComboJet SR and MR at about 60 psi and 7 to 10 gpa will provide a very good compromise of coverage and drift control for herbicide applications. Lower volumes can be used for systemic early season herbicides, higher volumes should be considered for larger canopies or certain (contact) modes of action. Larger volumes to 12 or 15 gpa should be considered for late-season fungicides and desiccation. Maintaining good spray patterns and overlaps is important to guarantee good pest control – use a wide enough fan angle and high enough pressure and boom height to ensure 100% overlap. Coarser sprays give flexibility in timing the application so that it can be done when the pest is threatening, rather than waiting for better weather (likely beyond the ideal time) with a finer spray.