Do "low-drift" nozzles work — an update

By Erdal Ozkan

The spray drift problem goes back nearly 50 years when pesticides were invented. It has become a more serious concern in recent years mostly because of the new genetically modified plants that are resistant to certain pesticides. A small amount of such pesticides drifting from the genetically modified crop field to the adjacent field of regular crop can cause serious damage.

Drift can never be completely eliminated, however, it can be reduced to minimum if pesticides are applied under favorable weather conditions and by adopting some of the many proven drift reduction strategies. One of these strategies is switching to new low-drift nozzles. The question we often hear when we make this recommendation is: "Do they really work?"

The answer is yes, if your goal is to reduce drift. Droplet size measurements and wind tunnel tests here in Ohio and elsewhere show that low-drift nozzles significantly reduce drift. However, their impact on pesticide efficacy is still not well documented. Following is a review of what these low-drift nozzles are, and what makes them more effective in reducing drift than conventional nozzles.

Wind speed aside, spray droplet size is the next most important factor affecting drift. Droplet size where drift potential becomes insignificant depends on wind speeds, but research has shown that drift is far less likely to be a problem when the spray is made up of droplets 200 microns and larger in size.

Unfortunately all conventional nozzles in use today do produce droplets in a wide range of sizes. With some popular conventional nozzles, the proportion of small, drift-prone droplets is large. Selecting a nozzle with an orifice that is several times larger may solve the drift problem, but we may not be able to achieve a satisfactory pest control because we are using too large droplets.

One of the advantages of these low-drift nozzles is we reduce the number very small droplets without affecting the proportion of very large droplets significantly. These nozzles are designed to create larger droplets at the same flow rate and operating pressure than comparable standard flat-fan nozzles. This has been accomplished by adding a pre-orifice to the nozzle tip assembly just ahead of the conventional discharge orifice. The pre-orifice reduces pressure at the exit orifice creating larger droplets to reduce drift significantly. A schematic of these nozzles is shown below.

We have completed extensive tests in Ohio to determine the differences in droplet sizes between conventional nozzles and low-drift nozzles. Several other university researchers have also conducted similar tests. All of these studies indicate that low drift nozzles reduce the number of drift-prone droplets. For example, results from our studies indicated that volume of spray contained in drift-prone droplets (smaller than 150 microns) was reduced by 87% when a 0.2 gal/min flow rate capacity Low-Drift nozzle was operated at 40 psi compared to a comparable size Standard flat-fan nozzle operated at the same pressure.

The figure attached shows the percent of spray volume contained in droplets smaller than 100 micron in diameter for a conventional and three low-drift nozzles. Droplets smaller than 100 micron are likely to drift in most cases of spraying. Therefore, one can interpret the graph as percent of spray volume lost when using a conventional XR Flat-fan nozzle versus low-drift nozzles (Turbo TeeJet, TurboDrop and AI TeeJet) with two different flow rates (0.2 and 0.4 gpm at 40 psi). (TurboDrop and AI TeeJet nozzles are air induction nozzles).

As shown on the figure below, when using 0.2 gpm size nozzles, one can reduce drift (or loss) of spray volume from 25% (with the conventional XR nozzle) to about 2.5% with any of the two air induction nozzles (TurboDrop or AI Teejet). This is a 10-fold reduction in drift potential.

TT (Turbo TeeJet) nozzle is the least expensive of the low-drift nozzles available in the market at this time. As shown on the figure above, they are not as effective as the air induction nozzles for a given size and pressure. It is possible to achieve better performance simply by selecting one size larger nozzle and operating it at a lower pressure. For example, operating a 0.3 gpm size nozzle at 25 psi will give the same flow rate as a 0.2 gpm nozzle running at 40 psi. The difference is in the percent of the drift prone droplets which will be reduced by about 2/3 by choosing a larger size nozzle and operating it at a lower pressure.

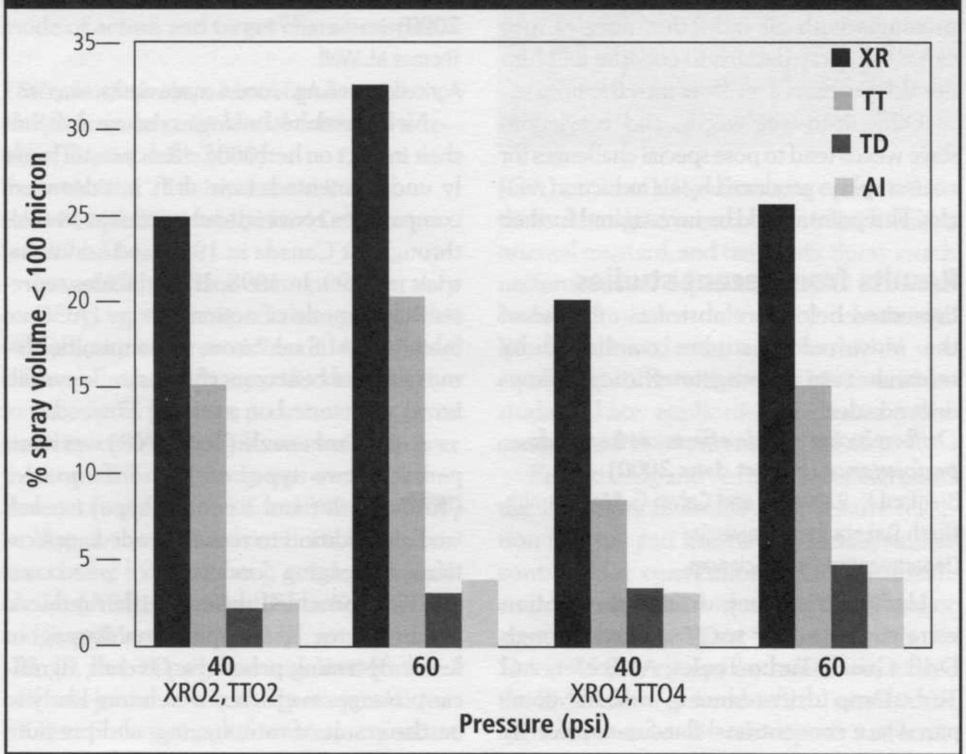
Leaving the wind speed aside, spray droplet size is the next most important factor affecting drift.

How about pest control?

There is limited data on performance of low-drift nozzles in achieving biological efficacy from pesticides.

Only in the last two years researchers in several universities have conducted research to evaluate low-drift nozzles for pesticide efficacy. Unfortunately, it is difficult to draw solid conclusions from these

FIGURE 1. % SPRAY VOLUME < 100 MICRON FROM CONVENTIONAL (XR), TURBO TEEJET (TT), TURBODROP (TD), AND AL TEEJET NOZZLES (FOR SIZES 11002 AND 11004)



limited studies because they are only based on one or two years' data and the test procedures are not uniform (different pesticides, different rates, different climate etc.). However, it is possible to draw following general conclusions from this limited data:

In most cases, air induction and turbo flat-fan tips performed equally well or better than the extended range conventional flat-fan tips.

Overall, significant changes in efficacy were more likely to be the result of rate, staging, and pressure changes than of nozzle choice.

When low-drift nozzles perform less than satisfactory, it is not known whether efficacy reductions are due to poor spray patterns, poor coverage, or an inability to target small weeds.

It appears that Turbo TeeJet and air induction nozzles are suitable for use with glyphosate.

Although most air induction nozzles can be operated at minimum pressures of 25 to 30 psi, they provide better efficacy if they are operated at 60 to 80 psi. Under higher pressures, air-inclusion becomes more pronounced, with relatively minor changes in spray drift potential.

Using lower than the recommended pressures with air induction nozzles may cause the spray pattern to collapse and hinder the process of air flow into the nozzle.

Difficult-to-wet weeds, and cotyledon-stage weeds tend to pose special challenges for coarser sprays produced by air induction nozzles. This point should be investigated further.

Results from recent studies

Presented below are abstracts of some of the most recent studies conducted by researchers to investigate efficacy of low-drift nozzles.

***Drift-reducing nozzle effects on herbicide performance* (Report date: 2000)**

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Herbicide efficacy, drift, and retention were evaluated for spray applied through Drift Guard, Turbo TeeJet, AI TeeJet, and TurbuDrop drift-reducing nozzles compared to a conventional flat-fan nozzle. By reducing the amount of spray in fine droplets, the Turbo TeeJet, AI TeeJet, and TurboDrop sprayer nozzles reduced spray drift more than Drift Guard or conventional nozzles. Total spray coverage detected on water-sensitive cards was greatest for conventional and Drift Guard nozzles compared to Turbo TeeJet, AI TeeJet, and TurboDrop nozzles.

Retention of spray mixtures without adjuvants on weeds was greater for treatments applied with conventional and Drift Guard nozzles compared to Turbo TeeJet, AI TeeJet, and TurboDrop nozzles. However, spray retention with adjuvants was similar among all nozzle types when averaged over spray adjuvant and two weed species. Total spray retention was greatest at 20 gal/acre, but herbicide retention was greatest for spray applied at 5 or 10 gal/acre than at 20 gal/acre. Consequently, herbicide efficacy may be greater for spray applied at 5 or 10 gal/acre as well.

Paraquat and glyphosate efficacy, representing contact and translocated herbicides respectively, was not influenced by changes in nozzle type regardless of spray volume.

***Should we recommend use of low drift nozzles with herbicides?* (Report date: 2000)**

Thomas M. Wolf
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New nozzle technologies reduce drift, but their impact on herbicide efficacy is still largely undocumented. Low drift nozzles were compared to conventional nozzles in 34 trials throughout Canada in 1998, and additional trials in 1999. In 1998, 19 herbicides representing 6 mode of action groups (ACCase inhibitors, ALS inhibitors, auxin mimics, bromoxynil and bentazon, glyphosate, bipyridiliums) were tested on a total of 27 weeds.

A standard nozzle (TeeJet XR) was compared to two types of low drift nozzles (Turbo TeeJet and a venturi-type) in each trial. In addition to recommended application, challenging conditions for weed control were provided through either reduced product rates, later application staging, or lower operating pressures. Overall, significant changes in efficacy were more likely to be the result of rate, staging, and pressure changes than of nozzle choice. When nozzle choice had an impact, low-drift nozzles most often performed less well than the standard, although changes in weed control were rarely greater than 10%. ACCase inhibitors showed the most sensitivity to nozzle choice, with significant loss of control with low-drift nozzles in 60% of cases.

The remaining products were less sensitive, responding to nozzle choice in approximately 12% of cases. Low-drift nozzles performed equally well compared to the standard under challenging conditions for ALS inhibitors, auxin mimics, and the EPSPS inhibitor. For ACCase inhibitors and bromoxynil and bentazon, challenging conditions provided a disadvantage to the low-drift nozzles. Difficult-to-wet weeds were usually, but not always, implicated in instances of reduced control.

Higher spray pressure generally improved graminicide performance without significantly increasing drift potential. However, overall lower performance was still apparent for the coarsest venturi sprays. These results suggest that the successful implementation of low-drift technologies will depend on proper nozzle selection and operation, with reference to herbicide mode of action and target characteristics.

OVERALL STRATEGIES TO REDUCE DRIFT

Using low-drift nozzles is only one of the many options available to us to reduce drift. Here is a list of drift reduction strategies which one can adopt to keep drift under control:

- Use nozzles that produce coarser droplets when applying pesticides on targets that do not require small, uniformly distributed droplets.
- Keep spray volume up, and use nozzles with larger orifices. Most manufacturers now sell what they call low-drift nozzles. Switch to these nozzles the next time you are buying new nozzles. Keep more than one size and type of nozzle on the boom ready to switch when the need arises.
- Follow recent changes in equipment and technology such as air-assisted and electrostatic sprayers that are developed for drift reduction in mind. Adopt some of these technologies when you feel it is time to do so.
- Keep the boom closer to the spray target. Nozzles with wider spray angle will allow you to do that.
- Keep spray pressure down, and make sure pressure gauges are accurate.
- Follow label recommendations to avoid drift with highly volatile pesticides.
- Avoid spraying on extremely hot, dry and windy days, especially if sensitive vegetation is nearby. Try spraying in mornings and late afternoons. Although is may not be practical, from the drift reduction aspect, the best time to spray is at night.
- Avoid spraying near sensitive crops that are downwind. Leave a buffer strip of 50 to 100 feet, and spray the strip later when the wind shifts.
- If you don't already have one, get yourself a reliable wind speed meters. Only then can you find out how high the wind speed is.

The role of spray pressure and nozzle choice in weed control with low-drift nozzles. **(Report date: 2000)**

Thomas M. Wolf*, Eric Johnson, and Brian C. Caldwell, Agriculture and Agri-Food Canada, Saskatoon, SK.

Low-drift nozzles can produce very coarse sprays that may result in poor herbicide efficacy under some conditions. It is not known whether efficacy reductions are due to poor spray patterns, poor coverage, or an inability to target small weeds. To answer these questions, a study was conducted as Saskatoon and Scott, SK in 1999 and 2000, looking at the interactive effects of application timing [early vs. late]; nozzle [Air Bubble Jet (ABJ), Greenleaf TurboDrop (TD), and SprayMaster Ultra (SM)]; spray pressure [20, 40, and 75 psi]; herbicide rate [full and half rate]; and herbicide [paraquat/diquat (PD) at Saskatoon, glufosinate-ammonium (GA) at Scott]. Results were evaluated on three simulated weeds: tame buckwheat, oriental mustard, and tame oats. Spray swath uniformity and deposited droplet size were evaluated under laboratory conditions. Results showed that each herbicide was equally sensitive to the application variables studied. Late application increased weed control for PD, but reduced it for GA.

Early timing and reduced rates increased the sensitivity to nozzle and pressure selection for oats and mustard. Overall, similar control to a conventional flat fan nozzle could be achieved with the ABJ at 40 psi or greater, with the TD at 75 psi, or with the SM at 75 psi, except on tame oats, where the SM had lower weed control event at the highest pressure. Swath deposit uniformi-

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ty, as measured by Coefficient of Variation (CV) was best with the TD (10%), intermediate for the ABJ (23%) and worst for the SM (28%). Increased pressure increased uniformity, except for the SM, where the intermediate pressure had the best uniformity (CV=20%). Spray coverage on water sensitive paper was similar for all nozzles (about 19%), and did not increase with pressure. Deposited Volume Median Diameter (VMD) was lowest for the ABJ, and highest for the SM, and decreased with pressure, although they were always higher than a conventional flat fan nozzle at 40 psi.

Weed control was related to swath deposit uniformity, but this alone was not a consistent predictor. Multiple regression demonstrated that effects of deposit CV and droplet density interacted, and together could predict between 62 and 80% of weed control variation for GA.

***Weed control in herbicide tolerant canola with low-drift nozzles* (Report date: 1999)**

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Coarser sprays are a proven means of reducing herbicide spray drift. To verify the biological performance of these nozzles, efficacy and retention studies were conducted at Saskatoon, SK. Glyphosate and glufosinate-ammonium sprays were applied to simulated weeds in 10 gpa using five different application methods: (a) a conventional spray (TeeJet XR8002), (b) a drift-reducing adjuvant spray, (c) low drift nozzle #1 (Turbo TeeJet TT11002), (d) low drift nozzle #2 (TurboDrop TD110015 'venturi' nozzle), and (e) a twin fluid nozzle (AirJet).

In additional experiments, eight different 'venturi' tips were compared to a standard flat fan nozzle. 'Venturi' tips with an 015 flow rate were operated at approximately 60 psi, whereas a flat fan nozzle with an 02 flow rate was operated at 35 psi. Overall, glyphosate efficacy was similar on broadleaf and grass species for all nozzles.

Glufosinate-ammonium performance was not affected by nozzles for broadleaf species, but some reductions occurred on grass species, particularly with the coarsest sprays. Increasing spray pressure ameliorated the reductions in glufosinate-ammonium efficacy for some, but not all, nozzles. Efficacy was not always related to spray retention *per se*, but also depended on deposit uniformity. According to these data, it appears that most low-drift or venturi tips are suitable for use with glyphosate. Coarser sprays may cause efficacy reductions with glufosinate-ammonium on grassy weeds, particularly if applied at low pressures.

***Flat fan nozzle selection and spacing on sprayers.* (Report date: 1995)**

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Postemergence herbicides require adequate and uniform coverage. Preplant incorporated herbicides require the least coverage, therefore large spray droplets could be used. Nozzles which produce large spray droplets, such as Spraying Systems new turbo floods, could be used effectively for preplant soil incorporated herbicides.

Research by the University of Nebraska has shown that at ten gpa or less the turbo flood nozzles did not give adequate coverage with a paraquat and atrazine tank mix (at 0.31 and 0.5 lb/a, respectively plus a nonionic surfactant at 0.25% v/v) for postemergence applications. Two other nozzles types (XR and Drift Guard) at three gallonages (10, 7.5 and 5 gpa) showed acceptable to excellent weed control.

Dr. Erdal Ozkan is a Professor at Food Agricultural and Biological Engineering Department at the Ohio State University. He was at Iowa State University for six years before joining OSU in November 1985. He received his Masters and Doctorate degrees in Agricultural Engineering at University of Missouri. In Ohio, he provides leadership in development and implementation of Extension educational programs related to new developments in pesticide application technology. He is the author or co-author of 39 journal articles, four book chapters, 48 Extension publications, 16 software and has made over 60 technical presentations at national and international conferences.