Using ‘DropletScan™’ to Analyze Spray Quality

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Introduction

Specific knowledge about crop protection product performance for each target with different nozzles will be necessary information for future application decisions. Droplet size and spectrum has been identified as the one variable that most affects drift (SDTF, 1997). Droplet size produced by the nozzle is the controlling factor in gallonage per acre, target deposition, uniformity of coverage, efficacy, off-target movement, and resulting exposure. Many forces impinge on droplet size, but it is still the drop size that must be manipulated to optimize performance and eliminate associated undesirable results (Williams, et. al., 1999).

Over the last several years there has been an increased interest by nozzle manufactures to engineer nozzles that will effectively reduce the volume of driftable fines found in spray droplet spectrums. This is being successfully accomplished with the use of a preorifice and also with turbulation chambers (R. Wolf, 2000). Now, there is a new trend with spray nozzle design to incorporate a ‘venturi’ that includes the spray droplet in air to lessen the drift potential while still maintaining adequate efficacy. Several nozzle manufacturers are including this new design as a part of a marketing campaign for drift control. Early research would indicate that the venturi nozzle is producing larger spray droplets (Womac, 1997; Ozkan, 1998; R. Wolf, et.al., 1999). Some would contend that the increased droplet size may reduce the effect of the crop protectant product used. For some targets that are hard-to-wet, a finer spray may be required. This would suggest using a higher pressure with venturi nozzles to achieve good coverage (T. Wolf, 1999; R. Wolf, et.al., 1999). A major focus for field research with the venturi nozzle design is to determine if in fact, while reducing drift, a desired level of efficacy can be obtained. Detailed droplet information will be important to equipment manufactures, chemical company representatives, university research and extension personnel, crop consultants, and private and commercial applicators.

DropletScan™ System

DropletScan™ is a software program that will allow accurate and rapid measure of spray droplet impressions on water-sensitive paper. This program may also be used with any other material that provides a good color contrast (i.e. white surfaces and dark dyes). The process can be used to determine several useful spray drop statistics. For example, the percent coverage, the spray deposition rate (GPA), drift profile, single swath pattern width, and multiple pass uniformity are all easily determined. Droplet statistics such as VMD ($V_{(0.5)}$, Volume Median Diameter), $V_{(0.1)}$, and $V_{(0.9)}$ are automatically calculated for each drop card scanned. A printout with a histogram of the drop sizes (by droplet number and percent of spray volume in each category) along with a graphic record (in color when a color printer is used) of the spot cards are provided by the software (see appendix A).

The system was designed after a software program developed by Devore Systems, Inc., Kansas State University, and is modeled after a software program, Crumb

Scan, which can evaluate the flour effects of bread. Crumb Scan is used in a similar fashion to determine the hole sizes in slices of bread (Whitney, 1997).

Elaborate testing has been conducted to determine the accuracy of the DropletScan™ system. Comparisons against known sizes have been verified through controlled droplet applications by using a microscope for analysis. Droplets were also tested against a camera and digitizing system at the KSU Wind Erosion laboratory using standard USDA software for digitizing. The drop diameters from all three methods (microscope, digitizing, and droplet scan) compared favorably with and R^2 of 0.85 or better. Algorithms have been written to help analyze droplets of various sizes and shapes including the ability to accommodate drops that hit the card and smear into teardrops to touch each other (Whitney, 1997).

The resolution of the scanner is such that stains as small as 50 microns or smaller in diameter can be measured. Drops that size are too small to be seen without the use of magnification. Since the smaller droplet portion of the spray spectrum is important to consider for drift management, then this software system can provide valuable information relative to drift potential. The droplet size data measured and recorded using the DropletScan™ system accurately represents the drop sizes that actually impact a target rather than the droplet sizes that are being released from the nozzle (Whitney, 1997)

Franz, 1993, found that using water-sensitive cards and a handheld scanner to monitor spray distribution in field situations was very operator sensitive, especially in field situations where variations in humidity levels existed. On card and card to card contrast was not easily maintained. However, he summarizes that water-sensitive cards subjected to varying humidity conditions can be analyzed for relative comparisons using a scanner and software.

In work with aerial application nozzles, Williams, et. al., 1999, found a close linear relationship in droplet spectra information comparing the DropletScan™ system of analysis to a wind tunnel analysis model developed by I.W. Kirk with the USDA in Texas (figure 1).

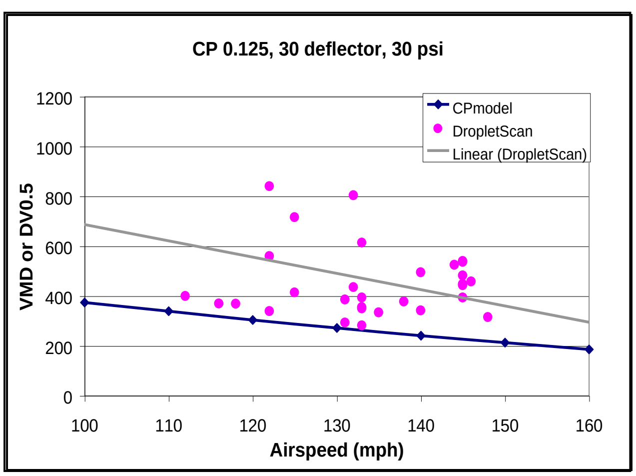

Figure 1

Williams also reported that the stains measured using DropletScan™ are very sensitive to spread factor. The droplet spread factor is very hard to determine for each material and collection material. This problem is more pronounced with larger droplets and should not pose a large error with driftable fine measurements.

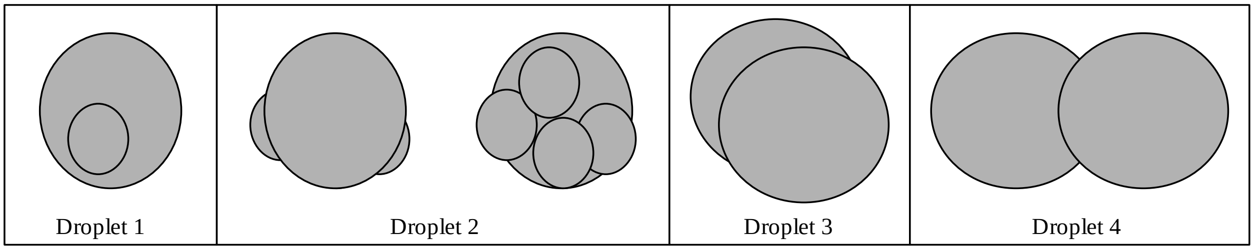

Figure 2.

Sometimes though, a small droplet can be completely masked by larger droplets. For example, Droplet 1of Figure 2 has a small droplet which is completely masked by the larger droplet, thus the VMD would be greater for this drop image since the image is made from the liquid of two separate droplets. Droplet 2 is a large droplet and depending on how DropletScan™ recognizes the curvature, it might be recognized as one large droplet and two smaller ones. But, it is revealed that the large droplet in fact is composed of one large droplet and four smaller ones. To understand the curvature look at Droplet 3. It has a small curvature and might be recognized as one very large droplet instead of two droplets as seen in Droplet 4. DropletScan™ must be able to recognize at least half of the droplet to correctly identify it. Droplet masking is most severe with heavier application rates.

Wind is another issue that is known to increase the deposition on the collection cards. High winds sometimes result in application rate estimates greater than 100% of the application rate. Orientation of the collector is another important concern. For the most accurate representation on the card orient the collector perpendicular to the spray. At heavier application volumes be careful not to have the card in an extreme vertical position. This may result in the bigger droplets running after impacting on the card causing an error in the reading.

System Requirements and Processes

Basic System Requirements

The DropletScan™ system requires and IBM compatible PC based on a 486 or higher microprocessor with a math coprocessor, running in windows 95, 98, or NT, and a high resolution HP ScanJet flatbed scanner. The latest version of the software has been written to operate with a HP ScanJet 6200Cse. The equipment in use to evaluate this software program is a Gateway 9100XL notebook computer (366 MHz), HP ScanJet 6200Cse flatbed scanner with USB port, and either an HP DeskJet 890C color printer or an HP LaserJet 2100 black and white printer.

Basic System Processes

The main process involves the acquiring of images from the water-sensitive paper, or other collector with dyes or a means of developing a color contrast, that has been placed on the scan bed. A two-step acquisition occurs. The first scan pass is low-resolution and is used to locate the spot card position and provide a preview image to the computer screen. The number of spot cards shown must equal the number of cards on the scanner bed. The spacing and ordering of the cards is critical. If the cards are too close together the scanner may interpret two cards as one. The second pass follows the display of the preview scan and is taken from a predetermined area within each spot card. (see figure 3). The region to be scanned should not be on the spot card edge and should avoid any unusual drops. The software allows for adjustments to the scanned area. The information taken is from the area inside the marked boxes.

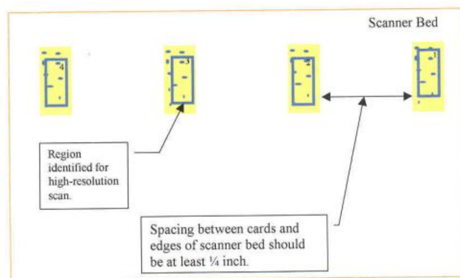

Figure 3

The operator can enter data and comments regarding the collection including weather and other critical spray pass information to be recorded on the final printouts. A visual example is found in appendix A. Several different report options are available. Typical reports will include coverage (percent area), deposition (Volume/area), histograms, images of cards, calculated best swath, minimum swath, and vertical and horizontal drift or swath displacement.

The Collection Procedure

The DropletScan™ system can be used to collect droplets under the boom representing the on-target deposition as well as being used to measure swath displacement or the off-target movement. For under the boom collections evenly space the cards along the boom at the target height making sure to avoid the wheel tracks. Previous measurements would indicate that the most accurate depositions are made on the cards angled at about 45 degrees (figure 4) to the ground with the higher end of the card pointed in the direction of travel. Figure 5 and 6 shows the detail of the card setup for an under boom swath analysis. For collecting basic droplet statistics a centerline and positive and negative distance are not critical. For this purpose cards could be spaced evenly and numbered in order across the boom width.

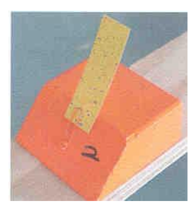
Figure 4

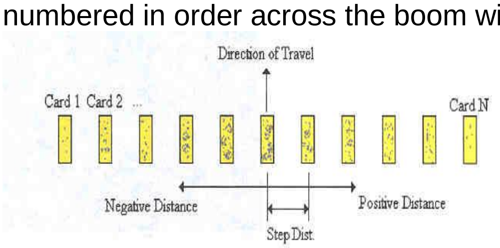

Figure 5


Figure 6

The collection of drift is also quite easy with this system. An example of a collection setup is shown in figure 7. For swath displacement collections the collector should be placed perpendicular to the wind direction positioning the cards for a distance off the end of the boom, oriented at 45 degrees with the higher tip of the card directed away from the boom. A vertical tower can be used to determine the amount of vertical off-target movement. The exact parameters of vertical and horizontal distances are still being researched. The number of cards and the increment distance for each card is recorded.

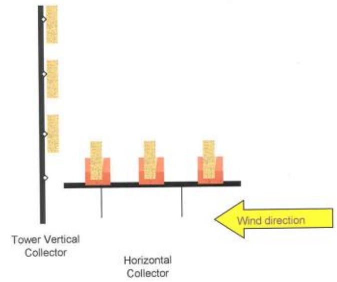

Figure 7

It is advisable to mark all cards on the backside prior to placing them on the collector. Record the pass information or treatment number so that no mistakes will occur later during the scanning process. Premarking prevents unnecessary smearing of the card after the spray pass. Also, remember that the water-sensitive cards are sensitive to the moisture on your fingers. Avoid placing a fingerprint on the card. Touch only on the edges. After the collections are finished it is necessary to preserve the quality of the cards and to prevent further moisture from depositing on them. Allow the droplets ample time to dry before placing them in a lock and seal plastic bag. The bags should be properly identified for each pass. This will allow the cards to remain as they were when collected and can be kept for an indefinite amount of time. A separate bag for the under the boom cards and the drift cards should be used. They will need to be analyzed in different parts of the software program.

The final stage of the analysis involves the scanning process. For each treatment place the cards droplets down on the scanner bed beginning with the number 1 positioned card in the upper left hand corner of the scan bed. You can begin the analysis of the cards after all the application information is entered into the program. Refer back to the previous section on the system process for more detail on the scanning activity.

CONCLUSIONS

This paper represents some information and procedures for using the WRK DropletScan™ system to analyze the spray quality from field application nozzles at field rates. The evaluation involved the use of the WRK DropletScan™ system to evaluate under boom droplet statistics and off-target droplet movement while spraying with several different nozzles under various application parameters. A purpose was to evaluate the WRK DropletScan™ system as a tool to gain information about each nozzle under the studied parameters to enable the application industry to make better application decisions specific to individual targets, crop protection products, and while attaining adequate efficacy, minimizing off-target movement of materials.

The use of the WRK DropletScan™ system to analyze field developed droplet spectrums may proof to be very useful to the application industry. The ease of using the system and the feedback information available in the report could provide a good basis for making sound application decisions for increasing the efficacy and reducing the drift potential. As more data of this type is analyzed then better information will be available about individual nozzle types as it relates to various crop protection products. Additional research using the WRK DropletScan™ system will help determine how effective the system will be to analyze various application scenarios and will bolster the value of the this measurement technology to quickly evaluate spray characteristics of different nozzle types under many different operating parameters.

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