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Innovative research by the USDA-ARS Aerial Application Technology Group keeps aerial applicators on the cutting edge

The Industry Loses a Legend: Leland Snow 1930–2011

FACTS TO THE FUTURE

Innovative research by the USDA-ARS Aerial Application Technology Group keeps aerial applicators on the cutting edge

By Scott Bretthauer, Ph.D.
University of Illinois, Application Technology Extension Specialist

The Aerial Application Technology Group's Clint Hoffmann and Brad Fritz secure fishing line in an Illinois cornfield for an in-canopy swath analysis they are conducting with Scott Bretthauer, author of this article. The fishing line is used to measure multiple swath deposition patterns in corn.

Over the years as an Operation S.A.F.E. analyst, member of the PAASS Program Development Committee and a researcher involved with aerial application, I have developed a deep appreciation for the USDA-ARS Aerial Application Technology Group (AAT). They conduct a variety of research projects related to aerial application and provide valuable information to the industry. They also provide unbiased information that can be used to defend the aerial application industry against those who seek to regulate it more heavily. As United States agriculture continues to deal with various pest problems, it is critical for growers to have agricultural aviation available as the solution to their pest management problems. No other application method can provide the timely, effective and safe applications that agricultural aviation can.

Based in College Station, Texas, the Aerial Application Technology Group is part of the USDA Agricultural Research Service's Areawide Pest Management Research Unit. It is the largest aerial application research group in the country and has access to resources that no other research group has available. As AAT's lead

scientist, Dr. Clint Hoffmann leads a team of scientists, engineers and support personal committed to finding solutions to challenges facing the aerial application industry and agriculture as a whole.

The information supplied by AAT is used for three important purposes. First, it is used directly by aerial applicators to improve the quality of their applications. Second, it serves as an unbiased source that can be used by government regulatory agencies to assist them in developing reasonable regulations for our industry. Third, the data can be used to show growers who might use aerial application and the general public that aerial applications are both extremely effective and safe.

Since 2001, AAT has played a prominent role in dispelling the notion that agricultural aircraft could be used as a terrorist weapon to dispense biological weapons. While those of us in the industry recognize this is an impossible scenario, having AAT verify to the federal government that agricultural aircraft cannot be used as terrorist weapons has prevented the aerial application industry from being heavily scrutinized and subjected to additional security regulations.

The speed and effectiveness of aerial application means it is the only viable option for treating the outbreak of rapidly spreading destructive pests, particularly those invading from other parts of the world, such as soybean rust. Ensuring agricultural aviation remains a pest control option in the future is vital for United States agriculture. AAT provides the information that ensures it will be. In this article I would like to highlight research from AAT related to two topics important for the future of aerial application: reducing drift and improving the effectiveness of aerial applications.

USDA-ARS Aerial Spray Nozzle Models

One of the biggest and most important projects completed by the AAT group was the creation of the Aerial Spray Nozzle Models, which were completed in 2004. These models, which are available for download at http://apmru.usda.gov/downloads/downloads.htm, serve two very important purposes. First, they assist aerial applicators in selecting and setting up nozzles on their aircraft to achieve a droplet spectrum that will provide sufficient coverage for the product they are applying while also minimizing the risk of drift. Second, it provides irrefutable evidence to pesticide manufacturers, regulators and others as to the high quality of spray possible from aerial applications.

Developing the models was a complicated project. To begin the project, the USDA worked with NAAA to poll aerial applicators across the nation to determine the most commonly used nozzle types for aerial applications. These nozzles were then selected for evaluation. To simulate the high speeds used in aerial applications, a high speed wind tunnel was used to generate suitable airspeeds. An agricultural surfactant was used to mimic the spray solution characteristics of agricultural spray mixes. Each of the nozzles to be tested was then mounted at the outlet of the wind tunnel and operated at various orifice sizes, pressures, deflection angles and airspeeds. A laser diffraction instrument was used to measure the spray droplet size throughout the spray plume created by the nozzle.

The spray droplet models were then created using data from these tests. They allow an aerial applicator to select the nozzle type they are interested in using, the airspeed at which they intend to operate, the orifice size and pressure for their application, and the nozzle deflection angle. The model will then provide droplet size data for that particular setup. If the droplet size generated by the models is undesirable for the application, the applicator can quickly change various parameters until a more suitable droplet size is generated. This is a huge advantage, because the aerial applicator can quickly and conveniently test multiple nozzle types and settings right from the computer.

Information provided by the models includes spray droplet characteristics and the ASABE droplet spectra classifications. An example of the nozzle model output can be seen in table 1.What does all this mean to an aerial applicator? It means you can accurately assess how well you're

A number of pesticide labels approved by the EPA have mandatory buffer zones on all sides of the application site, downwind and upwind, for certain applications. Having AAT provide scientific proof that this is unnecessary is critical when working with the EPA to help them understand that upwind buffer zones provide no additional safety, and thus only serve to restrict agricultural production.

targeting the ideal droplet size for the product and pest (Dv0.5), what your risk of drift is (Dv0.1, % volume <100 microns and <200 microns), whether you are wasting spray in very large droplets (Dv0.9), and how wide your droplet spectrum is (relative span). There is not currently a comparable tool for ground applicators that provides the same level of detail as the aerial spray nozzle models.

When the EPA assesses the risk of drift from aerial applications for various pesticides being registered or re-registered, it often uses a fine droplet spectrum for its models. Using the USDA-ARS Aerial Spray Nozzle Models, it can be shown that many nozzle setups on agricultural aircraft produce a medium or coarse droplet spectrum when classified using the Dv0.1 value, which represents the portion of the spray volume at risk for drift. This means the EPA can run more realistic models when determining the risk of drift from aerial applications. Without the nozzle models, it would be difficult to prove to the EPA that using a fine droplet spectrum for their models is not realistic. NAAA is urging the EPA to use these types of third-party, scientifically valid models when it does its risk assessments on aerial drift of pesticide products.

40-DEGREE FLAT FAN NOZZLE (LARGE ORIFICE)
FOR USE ON FIXED-WING AIRCRAFT
AERIAL APPLICATORS SPRAY NOZZLE HANDBOOK
USDA ARS AH-726
I. W. Kirk, Agricultural Engineer, Areawide Pest Management Research Unit,
Southern Plains Agricultural Research Center, Agricultural Research Service, U. S. Department of Agriculture, 2771 F&B Road, College Station, TX 77845-4966, USA.

Directions: Enter 40 DEGREE FLAT FAN nozzle settings, pressure, and airspeed in the cells highlighted below.
(Atomization parameters are valid only with nozzle and operational settings specified in the Acceptable Range.)

	Nozzle Tip Size, (Enter 15 for 4015, etc.)	Nozzle Angle, degrees	Pressure, psi	Airspeed, mph
Acceptable Range:	10 to 30	0 to 90	20 to 60	100 to 160
	15	23	40	140

Atomization parameters are displayed in the box below.

CAUTION: Do not enter or clear data in the cells in this box!

$D_{V0.1}$ =	174 µm	= Droplet size such that 10% of the spray volume is in droplets smaller than $D_{V0.1}$.
$D_{V0.5}$ =	303 µm	= Volume median diameter
$D_{V0.9}$ =	465 µm	= Droplet size such that 90% of the spray volume is in droplets smaller than $D_{V0.9}$.
RS =	0.96	= Relative Span
%V<100µm =	4.21 %	= Percentage of spray volume in droplets smaller than 100 µm diameter.
%V<200µm =	12.33 %	= Percentage of spray volume in droplets smaller than 200 µm diameter.
$DSC_{V0.1}$ =	COARSE	= Droplet Spectra Classification based on $D_{V0.1}$.
$DSC_{V0.5}$ =	MEDIUM	= Droplet Spectra Classification based on $D_{V0.5}$.
$DSC_{V0.9}$ =	FINE	= Droplet Spectra Classification based on $D_{V0.9}$.
DSC =	FINE	= ASAE S572 AUG99 Droplet Spectra Classification

Table 1. An example spray nozzle model from the USDA-ARS Aerial Application Technology Group. This model is for a 40-degree flat fan with a size 15 orifice setup with 23-degree deflection and operated at 40 psi and 140 mph. This setup would provide a good balance between coverage and drift reduction. Note that while the overall droplet spectrum is classified as fine, the classification for the Dv0.1 value (the portion of the droplet spectrum that represents the risk for drift) is coarse. Many nozzle manufacturers use these models on their website to assist aerial applicators when choosing their nozzles.

The AAT group is currently planning on expanding their droplet size database even more. They intend to test pesticide formulations and adjuvants to determine the impact these products have on the droplet size. Recent studies along these lines found that glyphosate and foliar fungicides reduce the droplet size. Understanding how pesticide formulations and adjuvants impact droplet size will help aerial applicators set up their aircraft more accurately and better select and use adjuvants. In addition to testing actual pesticide products, AAT has tested several products in effort to find a "blank" that can be safely used at Operation S.A.F.E. fly-ins to mimic the impact that pesticide formulations have on droplet size and spray patterns. The goal is to use these blanks to improve the accuracy of pattern and droplet size testing at fly-ins.

The Aerial Application Technology Group's new high speed wind tunnel and droplet sizing system is capable of airspeeds over 200 mph.

AAT also recently installed a new high speed wind tunnel capable of generating even higher airspeeds so the models can be expanded to include speeds commonly used with larger, faster turbine aircraft. This new wind tunnel was used to answer a common question from aerial applicators: should I be using air-induction nozzles? AAT provided an answer in Savannah at the NAAA Convention—in a word, no (*see pg. 25*). As the additional research is completed with various pesticides and adjuvants and at higher airspeeds,

aerial applicators can expect updated and easier to use nozzle models.

Other Drift Reduction Projects

Other projects dealing with drift included examinations of drift reduction additives using both laboratory and field trials. The goal of using any drift reduction adjuvant is to reduce the risk of drift by reducing the formation of small, drift-prone droplets. One concern is that the drift reduction additive increases the overall droplet size, which can have a negative impact on coverage and application effectiveness. The AAT group has conducted field trials to measure how well various drift reduction adjuvants reduce the downwind deposition of sprays. Evaluating these products in their high speed wind tunnel then allows them to evaluate how the products change the overall droplet size so that aerial applicators can be sure they chose a drift reduction adjuvant that lowers their risk of drift but does not reduce the effectiveness of their application. Additional work with drift reduction adjuvants will also likely be a part of future research plans.

The Aerial Application Technology Group consists of five scientists and six support personnel, including, from left to right: Phil Jank, Dr. Juan Lopez, Curtis Hubbard, Dr. Dan Martin, AAT pilot Lee Denham, lead scientist Dr. Clint Hoffmann, Charlie Harris, Dr. Yubin Lan, Chris Parker, Dr. Brad Fritz and Dr. Mohamed Latheef.

Pest and crop-specific projects that AAT conducts provide two benefits. For aerial applicators, they provide useful information on nozzle selection, aircraft setup and operation for achieving the best pest control. For others, they provide proof that aerial applications, and in particular low volume applications, are very effective for controlling pests.

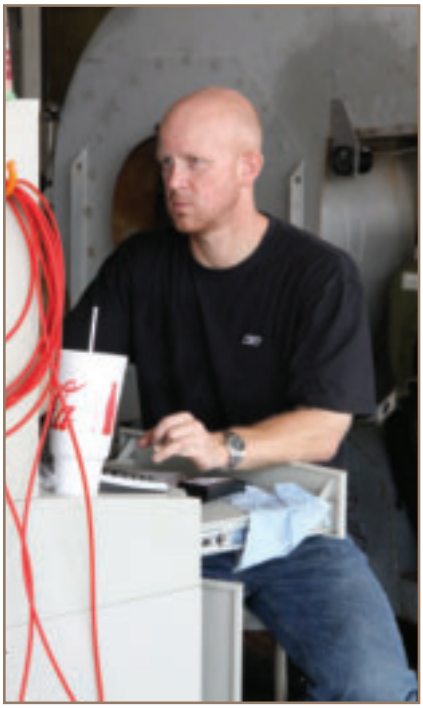
The AAT group also conducts research related to weather conditions and drift. In recent years they have focused on inversions in order to help aerial applicators better understand how drift occurs when applications are made during an inversion. Results from these projects have been used in the PAASS program in order to better educate aerial applicators about how to identify inversions so that applications can be avoided when they occur.

Establishing reasonable buffer zones is another issue affecting the industry. One important paper where the lead author was a member of the AAT group deals with the use of buffer zones during aerial applications. The article reviewed research and models related to drift to examine whether upwind buffers zones are needed for aerial applications. The authors concluded that a review of the research does not support the need for upwind buffers zone for aerial applications carried out in wind speeds greater than 3 miles per hour. In fact, the only time upwind drift is possible is when the upwind vortex from the aircraft exceeds the force of the wind. Even in these situations, the material deposited upwind of the upwind edge of the swath and the upwind distance it is carried is very slight. Since aerial applicators are taught, through the PAASS Program and other pesticide education programs, to avoid applications when wind speeds are less than 3 mph, it can be concluded that upwind buffer zones are not necessary. While this may seem obvious, it is important to remember that a number of pesticide labels approved by the EPA have mandatory buffer zones on all sides of the application site, downwind and upwind, for certain applications. Having AAT provide scientific proof that this is unnecessary is critical when working with the EPA to help them understand that upwind buffer zones provide no additional safety, and thus only serve to restrict agricultural production.

The AAT group is also involved with the EPA's Drift Reduction Technology (DRT) Program. The concept of the DRT program is to provide an incentive to all applicators, not just aerial, to use technology proven to reduce the risk of drift during pesticide applications. The use of DRTs, according to EPA's draft policy,

can result in reduced buffer zone distances for applicators making an application. AAT is working with the EPA to develop testing procedures to evaluate DRTs, which can include nozzle type, setup, drift reduction adjuvants and operation parameters. The testing procedures involve the use of multiple samplers placed downwind of the application, both on the ground and on towers. Deposition on these downwind samplers from the various DRTs is compared with deposition from a reference application setup. This comparison is then used to calculate how much each individual DRT reduced drift. A preliminary study showed that the use of an aerial flat-fan nozzle reduced drift between 70 percent and 84 percent, depending on the airspeed, from that of the reference spray system. *[Editor's Note: See pg. 26 for further information about that study.]*

NAAREF relies heavily on AAT to prepare the drift mitigation module for the PAASS Program. Data from their research projects are often used within the modules, which are presented to approximately 1,700 ag pilots and operators nationwide. AAT's research engineers readily allow themselves to be filmed explaining various points about drift reduction, and they serve on the Program Development Committee offering their expertise for the module's content. The PAASS Program is recognized by both the FAA and EPA as an outstanding safety education program, and since its inception, the number of ag aviation related accidents and drift complaints have gone down. Because of the substance of the PAASS Program and proven results in strengthening the industry's stewardship—thanks to the quality of the curriculum as developed by the AAT group and other ag scientists—insurance companies offer many ag pilots and operators that participate in the program a reduction in insurance costs.



Brad Fritz enters data into the Aerial Application Technology Group's droplet sizing system.

AAT Application Efficacy Research

In addition to drift reduction research projects, the AAT group conducts various projects examining the effectiveness of aerial application scenarios. AAT researchers have undertaken a wide range of projects to determine the optimum nozzle type, setup and spray volume for different pests. These projects have included studies to examine the best method for controlling fusarium head blight, a major disease pest of wheat and barley. AAT has also played a key role in determining the best spray setup for making low volume foliar applications of fungicide on corn. Applying glyphosate at low volumes has also been investigated by AAT. These pest and crop-specific projects provide two benefits to the aerial application industry. For aerial applicators, they provide useful information on nozzle selection, aircraft setup and operation for achieving the best pest control. For others, they provide proof that aerial applications, and in particular low volume applications, are very effective for controlling pests.

Future work will continue to deal with drift reduction and improving application efficacy. In addition, AAT is working to develop new equipment for use at Operation S.A.F.E. pattern testing fly-ins. The group's facilities also serve as a location for calculating spread factors, which are used to calculate droplet size and deposition from water sensitive and Kromekote papers. Without the correct spread factor, the exact droplet size cannot be measured. This allows Operation S.A.F.E. analysts and researchers to evaluate the impact of various spray formulations on the spray pattern and droplet size in the field.

The importance of the work conducted by the AAT group cannot be overstated. Besides the information they provide to aerial applicators to help them improve the safety and efficacy of their applications, the ability to dispute false claims from those unfamiliar with agricultural aviation is invaluable. I have personally stopped more than one conversation with those opposed to aerial application by providing data from AAT, in particular the Aerial Spray Nozzle Models. AAT provides the aerial application industry with an unbiased source of information that can be used to improve the accuracy of aerial applications, develop reasonable regulations for our industry and prove to our customers the quality of our work. These facts will help ensure a positive future for aerial application. ■