Weed Technology 2017 31:724–731

Dicamba Spray Drift as Influenced by Wind Speed and Nozzle Type

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With the release of dicamba-resistant crops, it is necessary to understand how technical and environmental conditions affect the application of dicamba. This study sought to evaluate drift from dicamba applications through flat-fan nozzles, under several wind speeds in a wind tunnel. Dicamba applications were performed through two standard (XR and TT) and two air induction (AIXR and TTI) 110015 nozzles at 0.9, 2.2, 3.6 and 4.9 m s^{-1} wind speeds. The applications were made at 276 kPa pressure and the dicamba rate was 561 g ae ha^{-1}. The droplet spectrum was measured using a laser diffraction system. Artificial targets were used as drift collectors, positioned in a wind tunnel from 2 to 12 m downwind from the nozzles. Drift potential was determined using a fluorescent tracer added to solutions, quantified by fluorimetry. The air induction TTI nozzle produced the lowest percentage of dicamba drift at 2.2, 3.6 and 4.9 m s^{-1} wind speeds at all distances. Dicamba spray drift from XR, TT and AIXR nozzles increased exponentially as wind speed increased, whereas from TTI nozzle drift increased linearly as wind speed increased. Drift did not increase linearly as the volume percentage of droplets smaller than 100 μm and wind speed increased.

Nomenclature: Dicamba.
Key words: Air induction nozzles, herbicide application technology, percent fines.

Dicamba is a selective herbicide in the benzoic acid family of chemicals, which has been used to control many broadleaf weeds and woody plants. Farmers will likely increase their use of dicamba in the near future to manage weeds that have become resistant to other herbicides (EPA 2016), given that new dicamba-resistant cotton and soybean varieties are now commercially available. However, there is little research showing how technical and environmental conditions, such as nozzle type and wind speed, could affect dicamba movement during application.

Drift reduction techniques have come to the forefront of application research in the past few years in the United States and other developed countries, including new spray nozzles, sprayer modifications, spray delivery assistance, spray property modifiers (adjuvants), and landscape modifications (Hoffmann et al. 2010). Among these factors, spray droplet size has long been recognized as one of the most important variables to be considered to mitigate spray drift (Bird et al. 1996). Low-drift nozzle selection is fundamental to reducing spray drift (Celen 2010), because low-drift nozzles produce coarser droplets than ordinary flat-fan nozzles (Cooper and Taylor 1999).

Drift management requirements will be specified on the labels of several new dicamba-containing herbicides, including guidelines for boom height, buffer zones, tank-mix partners, nozzle selection, operating pressure, and wind speed and air temperature at time of application (Hewitt 2000). If the applicators do not follow label guidelines, they may be penalized. Therefore, the objective of this research was to evaluate drift from dicamba applications through air induction and non–air induction flat-fan nozzles under several wind speeds in a wind tunnel. From these observations, a drift prediction model was created as a function of driftable fine droplets and wind speed.

DOI: 10.1017/wet.2017.61

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Materials and Methods

This study was conducted at the Pesticide Application Technology Laboratory at the West Central Research and Extension Center of the University of Nebraska–Lincoln in North Platte, NE, in 2015. Four studies were conducted separately, characterized by different wind speeds. However, experimental design and configuration were the same in all studies. The wind speeds used were 0.9, 2.2, 3.6, and 4.9 m s^{-1} (3.2, 7.9, 13.0, and 17.6 km h^{-1}) and were measured using a portable anemometer (Nielsen-Kellerman Inc., Kestrel® 4000, Boothwyn, PA) placed upwind of the boom at the nozzle height. Within each wind speed, the experimental design was a split-plot arranged in a complete randomized design with four replications. Main plots and subplots consisted of four nozzle types and seven downwind distances from the nozzles (2, 3, 4, 5, 6, 7, and 12 m), respectively. These four experiments were conducted twice in time, representing two experimental runs. All conditions (treatments, wind tunnel set up, procedures, etc.) were the same for both runs.

Another study was conducted in a complete randomized factorial scheme with four nozzle types (and different droplet spectrum) and four wind speeds. However, drift was only measured at 12 m downwind from the nozzles. The nozzle types and wind speeds were the same in all studies.

Dicamba (Clarity®, BASF, Research Triangle Park, NC) was applied at 561 g ae ha^{-1} at a rate of 200 L ha^{-1} (0.6% v v^{-1}) through a single static nozzle. In addition, a 1,3,6,8-pyrenetetrasulfonic acid tetrasodium salt (PTSA) fluorescent tracer (Spectra Colors Corp., Kearny, NJ) was added to the solution at 1 g L^{-1} to be detected using fluorimetry (Hoffmann et al. 2014; Roten et al. 2014). Four nozzle types were evaluated: Extended Range (XR), Turbo TeeJet (TT), Air-Induction Extended Range (AIXR), and Turbo TeeJet Induction (TTI) (Spraying Systems Co., Wheaton, IL). All nozzles were 110015 flat-fan nozzles and were evaluated at a pressure of 276 kPa. A digital manometer was fixed next to each nozzle to ensure that the pressure was the same for all nozzles. Each replication consisted of a continuous 10-second application, controlled by a digital auto shut-off timer switch (Intermatic Inc., EI 400C, Spring Grove, IL). All distances were sprayed at the same time and each set was considered one replication.

Determination of Drift Potential. Applications were performed in a low-speed wind tunnel with a working section 1.2 m wide, 1.2 m high, and 15 m long. This wind tunnel used an axial fan (Hartzell Inc., Piqua, OH) to generate and move air flow from the fan into an expansion chamber located in front of the tunnel. Environmental conditions during applications were kept at 20 C (±2 C) and 60% to 70% relative humidity.

Drift was determined in accordance with the ISO 22856 Standard (ISO 2008), with a few modifications. It was calculated as function of the amount of tracer deposited on collectors. Prior to each application, artificial collectors composed of colorless round strings 2 mm in diameter (Blount Inc., Magnum Gatorline™, Portland, OR) and 1.0 m in length were positioned at each distance, parallel and perpendicular to the tunnel floor and its length, respectively.

Collectors and nozzle were placed at 0.1 m and 0.6 m above the tunnel floor and in the longitudinal center of the wind tunnel, respectively. To simulate leaf area, a 1.2- by 0.5-m rug with polyethylene blades 1 cm tall (GrassWorx LLC., St. Louis, MO) was positioned on the sprayed area to absorb droplets. Once the application was performed, strings were collected and placed individually into prelabeled plastic bags and then placed into a dark container to prevent photodegradation of the tracer. Samples were kept in the dark until fluorimetric analysis could be conducted.

In the laboratory, a total of 50 ml of 10:90 isopropyl alcohol:distilled water solution was added to each plastic bag using a bottle top dispenser (LabSciences Inc., 60000-BTR, Reno, NV). Samples were then swirled and shaken to release fluorescent material. After the tracer was suspended in solution, a 1.5 ml aliquot from each sample bag was drawn to fill a glass cuvette. The cuvette was placed in a PTSA module inside a fluorimeter (Turner Designs, Trilogy 7200.000, Sunnyvale, CA) using ultraviolet light to collect fluorescence data. The fluorimeter was initially calibrated to relative fluorescence unit, which was converted into mg L^{-1} using a calibration curve for the tracer. Finally, percentage of drift for each distance was calculated using Equations 1 and 2:

$$\beta_{dep} = \frac{(\rho_{sample} - \rho_{blank}) \times f_{flow} \times f_{conc} \times V_{dil}}{\rho_{spray}}, \text{ and} \quad [1]$$

$$\%\, Drift = \frac{\beta_{dep} \times C_{lenght}}{C_{diameter} \times A_{time} \times R_{flow}} \times 6, \qquad [2]$$

where β_{dep} is spray drift deposit (ml), ρ_{sample} is the fluorimeter reading of the sample (mg L^{-1}), ρ_{blank} is the fluorimeter reading of the blanks (collector plus extractor solution) (mg L^{-1}), ρ_{spray} is the concentration of referential solution (g L^{-1}), f_{flow} is an adjustment factor for flow rate (dimensionless), f_{conc} is an adjustment factor for tracer concentration from spray (dimensionless), V_{dil} is the volume of dilution liquid used to extract the tracer from collector (L), C_{length} is drift collector length (mm), $C_{diameter}$ is drift collector diameter (mm), A_{time} is application time (s), and R_{flow} is flow rate of referential nozzle (L min^{-1}).

Droplet Spectrum. The droplet spectrum produced by each nozzle type was measured using a Sympatec HELOS-VARIO K/R laser diffraction droplet sizing system (Sympatec Inc., Clausthal, Germany) set up with a R7 lens with a dynamic size range of 9 to 3700 µm. This system was integrated into the wind tunnel and the wind speed was maintained at 6.7 m s^{-1} during data acquisition, following methodology proposed by Fritz et al (2014). The pressure was the same used at drift determination, 276 kPa, and the distance from the nozzle tip to the laser was 0.3 m. Three replicate measurements were made for each treatment, with each replication consisting of a complete vertical traverse of the spray plume. Spray parameters of interest were volumetric median diameter (VMD) and volume percentage of droplets smaller than 100 µm, which are also referred to as driftable fine droplets (V_{100}).

Statistical Analysis. Normality of residuals and homogeneity of variance of drift data were analyzed by Kolmogorov-Smirnov and Levene's tests, respectively, using SPSS Statistical Software, version 17.0 (SPSS Inc., Chicago, IL). In cases where the assumptions were significant at $\alpha = 0.01$, data were transformed by arcsine [$(x/100)^{0.5}$] and subjected to a new analysis. The data (original and transformed) were subjected to analysis of variance (ANOVA) using Sisvar Statistical Software, version 5.6 (Ferreira 2011). Nozzles were compared to each other within each distance with Tukey's multiple comparison test, whereas regression analysis was performed for the distances, both at $\alpha = 0.05$. Joint analysis was performed to make comparisons between wind speed experiments and proceeded when the ratio between the greatest and lowest mean square error (MSE) of ANOVA from each experiment was equal or less than 3, as described by Box (1954) and Pimentel-Gomes and Guimarães (1958).

For the study conducted in a factorial scheme, comparisons between nozzles were made using Tukey's test, and regression analysis was applied to wind speed. Percentage of drift at 12 m downwind, which is a result of percent fines and wind speed, was subjected to droplet spectrum analysis and multiple regression analysis. These analyses were made using Statistica Software (Dell Inc., Tulsa, OK), as was as response surface graph based on multiple regression.

Results and Discussion

The VMDs generated by XR, TT, AIXR, and TTI nozzles were 172, 248, 372, and 774 µm, while V_{100} values were 19%, 7%, 2%, and 0.3%, respectively. These four nozzles had a wide range of droplet spectra with a 4.5X difference between the largest and smallest VMD and a 64X difference between the highest and lowest V_{100}. Comparisons between wind speeds were not possible because the ratio between the highest and lowest mean square error was over 3. Joint analysis could not be applied to the data, and therefore the analyses were performed separately within each wind speed.

Across distances, the highest and lowest percentage of drift with dicamba applications at wind speeds over 0.9 m s^{-1} occurred with XR and TTI nozzles, respectively, in both experimental runs (Table 1). At 0.9 m s^{-1}, standard nozzles (non–air induction; XR and TT) produced similar drift at 7 m and 12 m as compared to air induction nozzles. In run 2, air induction nozzles produced similar drift at distances over 5 m. At 12 m, TT, AIXR, and TTI nozzles produced similar drift, varying from 0% to 0.1% in run 1 and from 0.1% to 0.3% in run 2.

At the closest sampling point (2 m), the XR nozzle produced 25 times more drift than the TTI nozzle at 0.9 m s^{-1}, 16 times at 2.2 m s^{-1}, 7 times at 3.6 m s^{-1}, and 4 times at 4.9 m s^{-1}. At 12 m, the differences were 6, 31, 24, and 24 times, respectively. Even under high wind speeds, ultracoarse droplets (produced through the TTI nozzle) had a tendency to be deposited on areas closer to the nozzle. On the other hand, low wind speeds were enough to carry

Table 1. Percentage of drift in dicamba applications at 0.9, 2.2, 3.6, and 4.9 m s^{-1} wind speeds through four flat-fan nozzles in two experimental runs.

	Distance (run 1)[b] m							Distance (run 2) m						
Nozzle[a]	2	3	4	5	6	7	12	2	3	4	5	6	7	12
	%													
	0.9 m s^{-1} wind speed													
XR	10.3 c	3.5 c	2.2 c	1.3 d	0.9 d	0.6 b	0.1 b	18.7 d	6.6 d	3.2 d	1.9 c	1.2 c	0.8 c	0.3 b
TT	9.1 c	3.3 c	1.6 c	0.9 c	0.6 c	0.5 b	0.1 ab	9.5 c	3.5 c	1.7 c	1.2 b	0.7 b	0.5 b	0.3 ab
AIXR	2.8 b	1.3 b	0.6 b	0.3 b	0.2 b	0.1 a	0.0 ab	2.9 b	1.3 b	0.6 b	0.4 a	0.3 a	0.3 a	0.1 ab
TTI	0.5 a	0.3 a	0.1 a	0.1 a	0.1 a	0.1 a	0.0 a	0.6 a	0.3 a	0.2 a	0.2 a	0.2 a	0.1 a	0.2 a
	2.2 m s^{-1} wind speed													
XR	65.9 d	40.4 d	25.3 d	16.6 d	12.1 d	8.9 d	3.0 c	56.1 d	31.7 d	19.3 d	13.0 d	9.3 d	6.5 d	2.0 d
TT	40.1 c	23.3 c	14.0 c	9.6 c	6.9 c	5.3 c	2.7 c	35.8 c	18.8 c	10.7 c	6.6 c	4.3 c	3.4 c	0.9 c
AIXR	15.6 b	8.1 b	4.8 b	3.6 b	2.9 b	2.6 b	1.9 b	14.7 b	6.7 b	3.7 b	2.4 b	1.5 b	1.2 b	0.4 b
TTI	4.5 a	1.8 a	0.8 a	0.5 a	0.3 a	0.2 a	0.1 a	3.3 a	1.2 a	0.8 a	0.5 a	0.4 a	0.4 a	0.1 a
	3.6 m s^{-1} wind speed													
XR	87.4 d	66.0 d	50.4 d	38.6 d	30.1 d	23.9 d	9.3 d	71.4 d	53.7 d	39.7 d	29.9 d	23.4 d	18.5 d	6.8 c
TT	54.0 c	40.6 c	28.7 c	21.1 c	16.4 c	12.4 c	4.4 c	47.3 c	34.8 c	25.5 c	18.3 c	13.8 c	10.7 c	3.7 bc
AIXR	33.3 b	19.9 b	12.6 b	8.6 b	6.3 b	4.5 b	1.6 b	32.3 b	18.7 b	11.5 b	7.8 b	5.4 b	4.1 b	1.3 ab
TTI	12.0 a	6.0 a	3.5 a	1.9 a	1.2 a	0.8 a	0.3 a	10.8 a	5.4 a	3.0 a	1.9 a	1.1 a	0.9 a	0.4 a
	4.9 m s^{-1} wind speed													
XR	71.5 d	59.2 d	47.3 d	40.1 d	33.2 d	28.2 d	13.2 d	70.9 c	59.6 d	49.4 d	41.7 d	34.2 d	29.1 d	13.8 d
TT	51.5 c	42.0 c	32.9 c	26.6 c	21.2 c	17.5 c	6.5 c	48.5 b	40.8 c	32.1 c	25.6 c	20.9 c	16.9 c	6.6 c
AIXR	41.4 b	28.0 b	20.8 b	15.3 b	11.8 b	9.2 b	3.2 b	42.0 b	28.1 b	19.6 b	14.6 b	10.7 b	8.4 b	3.3 b
TTI	18.2 a	11.2 a	6.7 a	4.3 a	2.8 a	2.0 a	0.5 a	17.9 a	10.9 a	6.9 a	4.5 a	3.2 a	2.2 a	0.6 a

[a] Teejet Technologies, Spraying Systems Co., Wheaton, IL 62703.

[b] Averages followed by the same letter in the column, within wind speed, do not differ by Tukey's test at $\alpha = 0.05$.

fine droplets (produced through the XR nozzle) further distances from the nozzle.

Drift decreased exponentially as the downwind distance increased for all nozzle types and wind speeds, except for the TTI nozzle at 0.9 m s^{-1}, where no significant regression model could be calculated (Figure 1; Table 2). All significant regression models for drift data had coefficient of determination values over 99.7% for both experimental runs. For the XR nozzle in run 1, the estimated drift at 4.9 m s^{-1} was less than the estimated drift at 3.6 m s^{-1} until the 4 m distance; however, beyond 5 m, the opposite was observed. This response was not observed in run 2, which suggests that there was an unknown factor causing drift to be overestimated at closer distances in run 1. At lower wind speeds, drift curves generally had larger and narrower numerical curvature angles for non–air induction and air induction nozzles, respectively, at distances of less than 5 m.

At 0.9 m s^{-1}, nozzles produced similar drift at 12 m, varying from 0.1% to 0.2% (Table 3). At 3.6 and 4.9 m s^{-1}, the highest percentage of drift was observed for the XR, followed by the TT, AIXR, and TTI nozzles. At 2.2 m s^{-1}, the TTI nozzle produced the lowest drift (0.1%), while the greatest drift was produced through XR and TT nozzles: 2.5% and 1.8%, respectively. At 2.2 m s^{-1}, the TT produced similar drift when compared with the AIXR, even though the AIXR generated 124 μm coarser VMD than the TT nozzle. These results reinforced the idea that wind speed has a stronger effect on drift than droplet size does.

As expected, when wind speed increased, higher drift was observed across nozzle types (Figure 2). For the XR, TT, and AIXR nozzles, drift increased exponentially, while for the TTI nozzle, the increase was linear (Table 4). The smaller the droplet size, the greater the drift potential. The least drift occurred

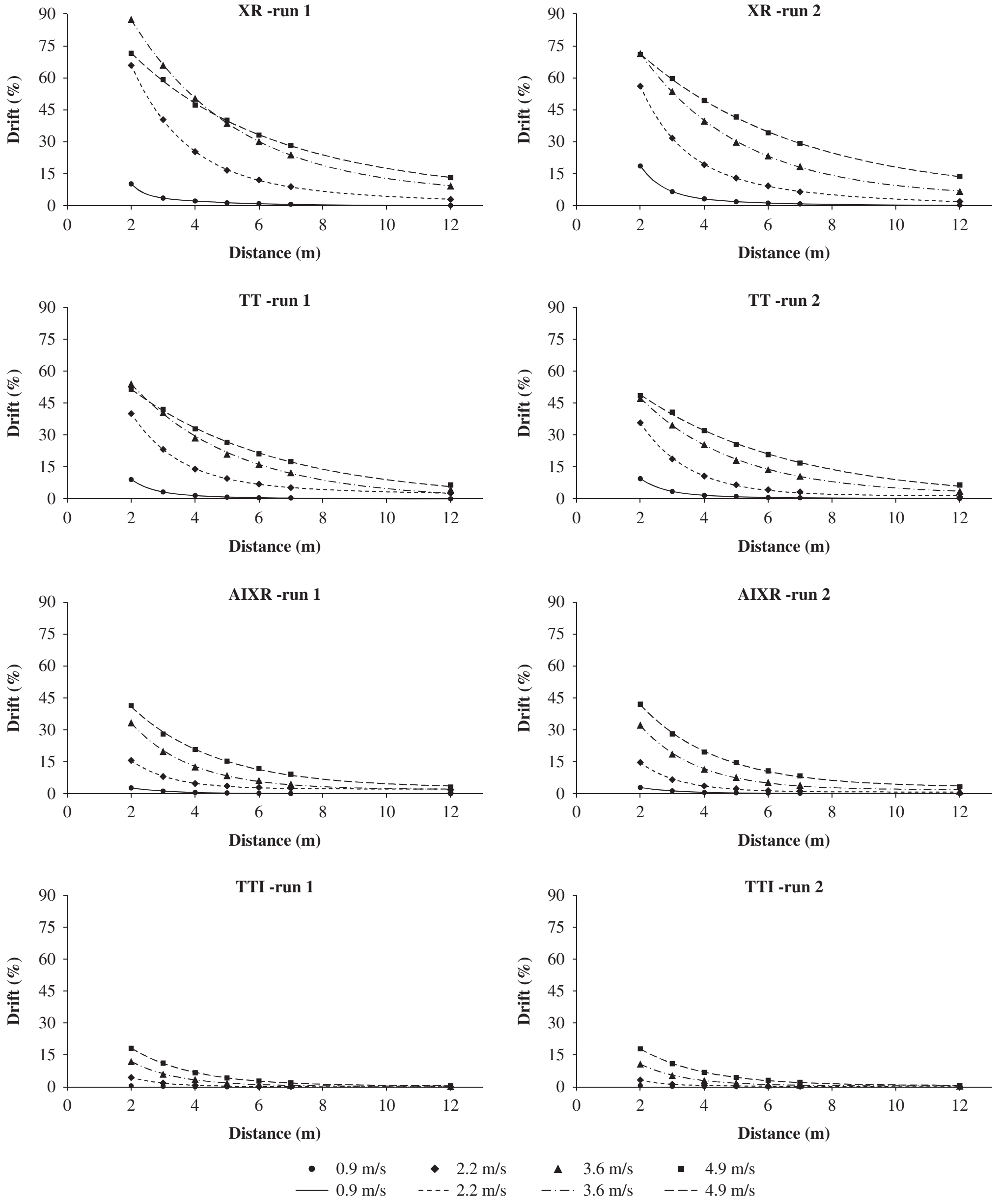


Figure 1. Drift curves from dicamba applications through four flat-fan nozzles in a wind tunnel operating at wind speeds of 0.9, 2.2, 3.6, and 4.9 m s^{-1} in two experimental runs. Shapes and lines were used to represent observed and estimated values, respectively.

with the TTI nozzle. It is expected that the drift at 12 m for this nozzle will be 0.03% higher for each 0.28 m s^{-1} (1 km h^{-1}) increase in wind speed. The difference in drift between nozzle types increased as the wind speed increased, reaching the highest amount of 13.5% at 4.9 m s^{-1} with the XR nozzle (finest droplets).

Percentage of drift at 12 m downwind was expressed as a function of driftable fine droplets and wind speed (Figure 3). Negative values of drift were observed when the highest values of driftable fine droplets were combined with the lowest values of wind speed. In those cases, the drift was considered null. Combellack et al. (1996) also observed that the treatments that created large volumes of small droplets generally produced more drift, which correlates to the relative rankings of our treatments based on droplet size. Antuniassi et al. (2014) and Stainer et al. (2006) correlated drift and droplet spectra and drew similar conclusions.

Table 2. Functions, R^2 and F_c generated by regression analysis of wind speed effect on dicamba drift data collected in an experiment using flat-fan nozzles in two experimental runs.

Nozzle[a]	Wind speed	Run 1 Function ($\hat{y}$ =)	Run 1 R^2	Run 1 F_c [b]	Run 2 Function ($\hat{y}$ =)	Run 2 R^2	Run 2 F_c
	m s^{-1}		%			%	
XR	0.9	$11.19e^{-0.4118x} + 1570.01e^{-2.8373x}$	99	153.1**	$8.65e^{-0.3263x} + 246.29e^{-1.4275x}$	99	823.1**
	2.2	$17.63e^{-0.1488x} + 177.53e^{-0.6057x}$	99	5948.0**	$31.13e^{-0.2320x} + 187.27e^{-0.8173x}$	99	6791.2**
	3.6	$5.26 + 149.16e^{-0.2956x}$	100	3073.4**	$4.03 + 126.39e^{-0.3140x}$	99	445.2**
	4.9	$73.25e^{-0.2861x} + 37.38e^{-0.1030x}$	99	527.7**	$4.39 + 99.32e^{-0.1978x}$	99	884.2**
TT	0.9	$5.60e^{-0.3744x} + 127.56e^{-1.4895x}$	99	126.7**	$2.43e^{-0.2053x} + 99.00e^{-1.2647x}$	99	208.3**
	2.2	$7.84e^{-0.0897x} + 128.41e^{-0.6704x}$	99	2140.8**	$1.52 + 125.28e^{-0.6510x}$	99	4336.5**
	3.6	$98.33e^{-0.3005x}$	99	2559.0**	$2.02 + 88.65e^{-0.3345x}$	99	206.9**
	4.9	$79.66e^{-0.2177x}$	99	1575.8**	$74.60e^{-0.2104x}$	99	978.9**
AIXR	0.9	$0.08 + 13.09e^{-0.7922x}$	99	17.6**	$0.19 + 15.73e^{-0.8700x}$	99	29.2**
	2.2	$2.22 + 65.91e^{-0.7975x}$	99	436.4**	$0.84 + 67.90e^{-0.7990x}$	99	719.3**
	3.6	$1.98 + 89.08e^{-0.5259x}$	99	525.0**	$1.80 + 90.31e^{-0.5578x}$	99	105.3**
	4.9	$2.73 + 79.99e^{-0.3707x}$	99	562.7**	$3.08 + 88.31e^{-0.4134x}$	99	419.0**
TTI	0.9	$1.57e^{-0.5498x}$	-	1.24^{ns}	$1.07e^{-0.3181x}$	-	1.32^{ns}
	2.2	$0.14 + 27.71e^{-0.9303x}$	99	48.8**	$60.88e^{-1.6555x} + 1.69e^{-0.2351x}$	99	23.0**
	3.6	$0.39 + 45.48e^{-0.6832x}$	99	75.9**	$0.54 + 41.92e^{-0.7063x}$	99	12.4**
	4.9	$0.51 + 49.51e^{-0.5136x}$	99	132.5**	$0.70 + 47.09e^{-0.5034x}$	99	87.2**

[a] Teejet Technologies, Spraying Systems Co., Wheaton, IL 62703.

[b] F_c, Calculated F value; ns, nonsignificant, **, significant at $\alpha = 0.01$.

If one knows the amount of driftable fine droplets produced through a given nozzle and the wind speed condition during an application, it is possible to predict drift at 12 m from the nozzle in dicamba applications. Obviously, the highest percentage of drift is expected in conditions of high wind speeds and with nozzles that produce a large amount of driftable fine droplets. Although Holterman et al. (1997) reported that field trials were consistent with model results when field trials were averaged over several replications, further trials are needed to investigate dicamba spray drift in the field under different weather conditions, using nozzles that are recommended on the new dicamba labels.

Table 3. Percentage of drift at 12 m downwind from each nozzle in dicamba applications at different wind speeds using flat-fan nozzles.

Wind speed[c]	Nozzle[a,b] XR	TT	AIXR	TTI
m s^{-1}	%			
0.9	0.2 a	0.2 a	0.1 a	0.1 a
2.2	2.5 c	1.8 bc	1.1 b	0.1 a
3.6	8.0 d	4.1 c	1.5 b	0.3 a
4.9	13.5 d	6.6 c	3.2 b	0.6 a
CV	26.48%			
LSD	0.9			
$F_{ws \times noz}$[d]	94.6**			

[a] Averages followed by the same letter in each row do not differ by Tukey's test at $\alpha = 0.05$.

[b] Teejet Technologies, Spraying Systems Co., Wheaton, IL 62703.

[c] Abbreviations: CV, coefficient of variation; LSD, least significant difference.

[d] $F_{ws \times noz}$, calculated F value for interaction between wind speed and nozzle; **, significant at $\alpha = 0.01$.

Overall, air induction TTI nozzle produced the lowest percentage of dicamba spray drift at 2.2, 3.6,

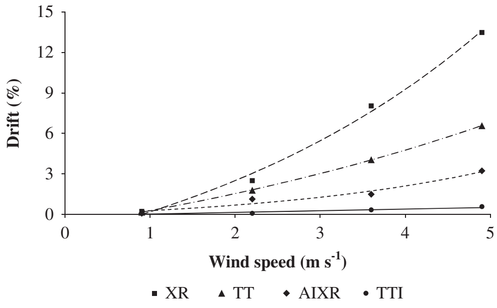


Figure 2. Effect of wind speed on dicamba drift collected 12 m downwind from applications made through different nozzle types in a wind tunnel. Shapes and lines were used to represent observed and estimated values, respectively.

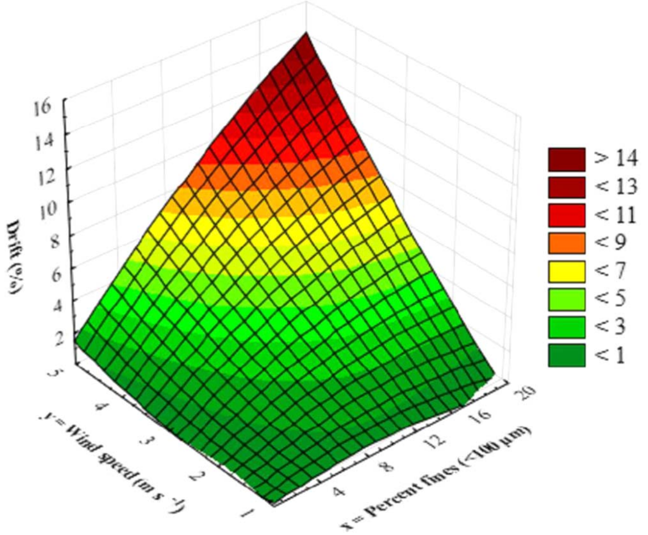
Table 4. Functions R^2 and F_c generated by regression analysis of wind speed effect on dicamba drift collected 12 m downwind from flat-fan nozzles.

Nozzle[a]	Function	R^2	F_c[b]
		%	
XR	$\hat{y} = -1.5930 + 1.57^{*}(e^{0.2511x}-1)/0.2511$	99	99.9**
TT	$\hat{y} = -0.8036 + 0.99^{*}(e^{0.1585x}-1)/0.1585$	99	22.1**
AIXR	$\hat{y} = -0.0119 + 1.57^{*}(e^{0.2389x}-1)/0.2389$	95	4.6*
TTI	$\hat{y} = -0.1019 + 0.1239x$	91	2.3*

[a] Teejet Technologies, Spraying Systems Co., Wheaton, IL 62703.

[b] F_c, Calculated F value; *, significant at $\alpha = 0.05$; **, significant at $\alpha = 0.01$.

and 4.9 m s^{-1} wind speeds at downwind distances from 2- to 12-m. Drift decreased exponentially as distance from nozzle increased across nozzle type and wind speed, except for the TTI nozzle at 0.9 m s^{-1}. Increasing wind speeds resulted in exponential increases in dicamba spray drift for the XR, TT, and AIXR nozzles, whereas drift from the TTI nozzle increased linearly. Dicamba spray drift was adjusted by a multiple regression as a function of percentage of droplets smaller than 100 µm and wind speed, increasing nonlinearly as these two parameters increased.



$$\text{Drift (\%)} = 0.5867 - 0.0007x - 0.7503y + 0.1655xy - 0.0093x^2 + 0.1774y^2$$

$$R^2 = 98.52\%;\ Fc = 133.5^{**}$$

Figure 3. Graphic representation of dicamba drift collected at 12 m downwind from nozzle, as a result of combination between percent fines and wind speed. F_c, calculated F value; **, significant at $\alpha = 0.01$.

Acknowledgements

The authors would like to thank the Coordination for the Improvement of Higher Education Personnel and the research group of the Pesticide Application Technology Laboratory at University of Nebraska–Lincoln for their assistance, especially Chandra Hawley, Annah Geyer and Jeff Golus.

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Received February 21, 2017, and approved June 16, 2017.

Associate Editor for this Paper: Kevin Bradley, University of Missouri