Evaluation of the Watchdog Weather Station to Reduce Drift from MDOT Spray Trucks

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SS262

September 2015

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/MS-DOT-RD-15-262		

4. Title and Subtitle
Evaluation of the Watchdog Weather Station to Reduce Drift from MDOT Spray Trucks

5. Report Date
September 2015

6. Performing Organization Code

7. Author(s)
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8. Performing Organization Report No.
MS-DOT-RD-15-262

9. Performing Organization Name and Address
Department of Plant & Soil Sciences
Department of GeoSciences
Mississippi State University

10. Work Unit No. (TRAIS)

11. Contract or Grant No.
SS262

12. Sponsoring Agency Name and Address
Mississippi Department of Transportation
PO Box 1850
Jackson, MS 39215-1850

13. Type Report and Period Covered
Final Report

14. Sponsoring Agency Code

15. Supplementary Notes
This report was done in cooperation with the US Department of Transportation Federal Highway Administration (FHWA). MDOT final research reports are available at http://mdot.ms.gov/portal/research.aspx?open=Reports.

16. Abstract

Wind speed data collected with the Spectrum Watchdog Sprayer Station were compared to data recorded with a Young 05103-5 anemometer at the Rodney R. Foil Plant Science Research Center on the Mississippi State University campus June and July, 2014 and 2015. The manufacturer's specifications advertise the Sprayer Station wind speed accuracy for wind speeds less than 12 mph is $\pm$1.1 mph and wind speeds greater than 12 mph is $\pm$2.3 mph. While the wind speed data recorded by the Watchdog Sprayer Station followed the same trend as the data recorded with the Young anemometer, variations in wind speed both above and below that recorded by the Young anemometer indicate the Watchdog precision is not sufficiently reliable of the actual wind speed. Wind speed data recorded by the Young anemometer and Watchdog Sprayer Stations were poorly correlated at 0.61 and 0.49 for collection periods in 2014 and 2015, respectively. These data indicate the Watchdog Sprayer Station does not measure wind speed with sufficient reliability to provide a MDOT spray truck driver, a true indication when wind speeds are above or below safe parameters for spray applications to avoid drift.

17. Key Words
Vegetation management, herbicide application, wind, drift, pesticide, spray truck

18. Distribution Statement
Unclassified

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	*(Insert number of pages)*	

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Author Acknowledgments

The author wishes to thank the Mississippi Department of Transportation for funding this research. Thanks are also extended to Drs. Bill Cooke, Mike Brown, Jamie Dyer and Graduate Students Zoe Schroder and former Graduate Student Kelly Boyd.

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Executive Summary

Wind speed data recorded by the Watchdog Sprayer Station followed the same trend as the data recorded with the Young Model 05103-5 anemometer. However, variations in wind speed both above and below that recorded by the Young anemometer indicate the precision of the Watchdog Sprayer Station is not sufficiently reliable of the actual wind speed to provide guidance for spray truck operators. Data recorded by the Young anemometer and Watchdog Sprayer Stations were poorly correlated at 0.61 and 0.49 for collection periods in 2014 and 2015, respectively. In 2015, the Watchdog Sprayer Station recorded 14 wind speed measurements above 10 mph and 11 wind speed measurements below 2 mph during the same testing interval the Young anemometer measured 1 occurrence outside the recommended safe zone of >2 but < 10 mph.

Introduction and Literature Search

Applied under the wrong conditions, all pesticides drift. However, because herbicides are the group of pesticides that kill plants, most complaints and subsequent investigations focus around this group of pesticides. Four factors contribute to pesticide drift: droplet size, boom height, and wind speed and direction (Jordan et. al 2009), but scientists do not agree on which factor is most versus least important.

Nozzle selection controls droplet size. Nozzles are designed to break the pesticide solution into small droplets to uniformly cover the target for optimal weed control and facilitate dispersal of a small volume of pesticide over a large area. Breaking the spray solution into many small drops results in better target coverage, but because smaller drop move farther in wind, manufacturers must balance droplet size to maximize coverage, yet minimize drift. Nozzles that produce large spray droplets may not provide sufficient target coverage for acceptable weed control. Nozzles that produce large droplets less likely to move off target also produce higher application rates, so fewer acres are covered with each tank of spray solution.

Boom height above target also influences drift (Jordan et. al 2009). The farther a drop must fall, the greater the potential for that drop to move out of a straight line plane toward the target. Department of Transportation application equipment is typically operated at the manufacturer’s suggested height range to provide proper target coverage and swath width, although there will typically be some variation from the ideal height because of changes in topography along the right of way.

Wind speed and wind direction contribute to pesticide drift (Jordan et. al 2009). Strong winds have more force to move large droplets as they exit the nozzle body out of the straight plane toward the target and outside the target treatment area. Strong winds also move small drops farther away from the treatment zone into nontarget sites. Bode et al. (1976) concluded after 30 tests of pesticide drift that wind speed, air temperature, and boom height were the most significant factors of spray drift. Smith et al. (1982) found after completing nearly 100 experiments on drift that wind speed and boom height were the two factors that most significantly contributed to off-target movement. Wind direction away from or parallel to the line of spray would reduce the potential for off-target movement. However, wind direction is often variable and roads are not straight, so the risk of wind blowing toward a sensitive crop exists on many miles of Mississippi highway. Smith and Lopez (2006) concluded in another study that weather stations more than 2.5 miles from the application site could not be used to reliably predict wind speed and direction. Both scientists agreed that wind speed and boom height are two of the most important factors to minimize off-target pesticide movement. Spray vehicle operators can easily monitor boom height, but wind speed can be difficult to accurately assess from a moving vehicle.

Smith et al. (1974) concluded no real difference existed in drift potential for pesticide applications made in May to June or July to August. However, he reported the least potential for drift occurred when pesticides were applied at night, rather than during the day. The practicality of pesticide applications at night may exist with some of the precision guidance systems that exist for large farm operations, but the potential liability of spraying highway rights of way at night is much higher than the risk of drift if weather conditions are closely monitored.

Weather conditions that cause drift may develop at any time during the application. Experienced applicators may not be aware the probability of drift is high. Smith and Lopez (2006) stated “What is of greater need for aerial applications is a system that can measure the wind speed and direction while the plane is over a given field and record those results.”

Herbicide manufacturers place the responsibility of drift prevention on applicators. Therefore, many herbicide labels state that drift can be minimized if applications are made when wind speed is more than 2, but less than 10 mph. Some also state it is the responsibility of the applicator to know the local wind patterns and the effects on drift.

Methodology

Wind speed was recorded with both a Watchdog Sprayer Station and R.M. Young anemometer, model 05103-5. The Young anemometer, serial number WM 129652 was calibrated from the factory. Devices recorded wind speed and direction June 3, July 16, and August 3 in 2014 at various times of day and July 7, 8, 13, 14, and 15 in 2015. The Young anemometer was mounted on a tripod 98 inches above the soil surface. The Watchdog Sprayer Station was attached to the magnetic mount and placed on a front-end loader bucket to position two devices at the same height (Figure 1). Another sprayer station was positioned on the roof of a Honda car (65 inches above the soil surface, Figure 2) and a third device was placed on the roof of a Kubota RTV900 (88 inches above the soil surface, Figure 3).

Data from all devices were downloaded to a computer for statistical analysis. Wind direction data from 2014 were analyzed by t-tests. Wind speed data for both years were analyzed by Pearson’s linear correlation indices. A significance level of $p<0.05$ was used for all analyses.

Discussion

Wind direction data were only collected in 2014. Statistical analysis of the wind direction data showed that the Watchdog Sprayer Stations and the Young anemometer were not statistically different only 55% of the time (Table 1). In all other cases, the two types of instruments differed in the wind direction recorded.

Analysis of the wind speed data collected in 2014 is presented in Table 2. Statistical analysis of these data indicated the two types of devices recorded data that followed similar trends with respect to increasing and decreasing wind speed. However, the actual wind speed recorded by the two types of devices was poorly correlated at 0.61. Data collected in 2015 is presented in Figure 4. These data had a lower correlation than data collected in 2014 at 0.49. The graphic presentation of the 2015 data more clearly visualizes the differences in wind speed measured by these two devices.

It is clearly evident from the graphic presentation of the data, the Watchdog Sprayer Station measured wind speed above that recorded by the Young anemometer as well as below that recorded by the Young anemometer. In the 2015 data, the Young anemometer measured only one wind gust above the 10 mph speed when spray application should be stopped (x value 397) compared to 14 measurements by the Watchdog Sprayer Station of wind speed in excess of 10 mph during the same testing periods. During the same testing interval, the Watchdog Sprayer Station recorded 11 occurrences of wind speed below 2 mph compared to none measured by the Young anemometer.

The graphic presentation of 2015 data were emailed to Spectrum Technology to show these research findings and question the validity of company advertising claims. Technical literature of the Watchdog Sprayer Station indicate the device accurately measures wind speeds below 12 mph $\pm$ 1.1 mph or wind speeds above 12 mph $\pm$ 2.3 mph. Spectrum personnel responded by stating the Young Model 05103-5 anemometer is a mechanical rather than ultrasonic anemometer and testing these two types of devices was an invalid comparison. However, since most NOAA and USDA weather stations in Mississippi continue to use mechanical anemometers to measure wind speed, any investigation on off-target herbicide movement by the Bureau of Plant Industry would involve data measured by a mechanical anemometer from weather stations in the proximity of the claim.

Conclusions

Many right of way herbicide labels recommend spray applications should be made when wind speed is between 2 and 10 mph. The Watchdog Sprayer Station recorded 14 measurements of wind speed above 10 mph during the same testing interval that a Young Model 05103-5 anemometer recorded only 1 occurrence of wind speed above 10 mph. A similar result occurred with wind speed below 2 mph. The Watchdog Sprayer Station recorded 11 wind speed occurrences below 2 mph compared to none measured by the Young anemometer. Since mechanical anemometers are used by NOAA and USDA weather stations to record wind speed, and thus, provide the data used by regulatory agencies in Mississippi that investigate drift complaints, the comparison of these types of measuring devices are valid. The Watchdog Sprayer Station is not a tool that would help MDOT spray truck operators reliably measure wind speed and direction with sufficient accuracy to reduce off-target herbicide movement.

Figures 1, 2, 3. Initial stationary testing of Watchdog Sprayer Station and Young anemometer, June 3, July 16, and August 3, 2014, respectively, at the Rodney R. Foil Plant Science Research Center.

Table 1. Summary of difference-of-means t-test results for console and Young wind direction measurements. Mean and circular variance were calculated using a trigonometric approach.

Wind Direction Test	Console A Mean (rad)	Console A Variance (rad)	Young Mean (rad)	Young Variance (rad)	n	df	t score	p-value	Null Hypothesis	Directions Different?
6/3/2014	1.68258	0.79577	1.9957	0.8449	31	30	-1.502	0.071775	Accept	No
7/16/2014	-0.30147	0.97567	0.1543	0.90259	48	47	-2.376	0.010815	Reject	Yes
8/3/2014	-1.50963	0.33337	-0.4272	0.508689	35	34	-10.53	0.000000	Reject	Yes

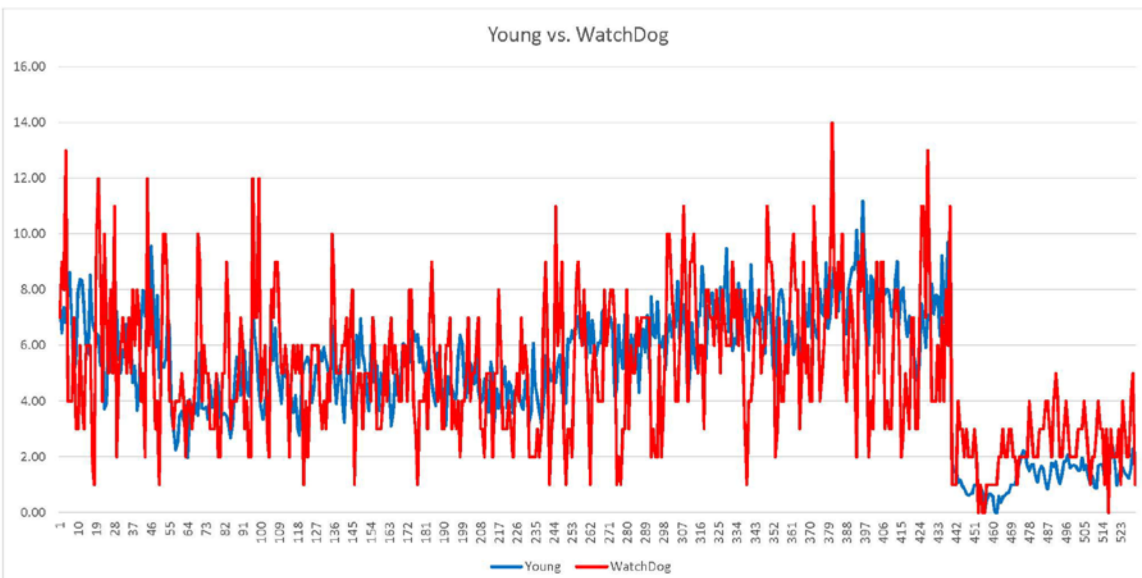
Wind Direction Test	Console B Mean (rad)	Console B Variance (rad)	Young Mean (rad)	Young Variance (rad)	n	df	t score	p-value	Null Hypothesis	Directions Different?
6/3/2014	1.6272	0.94452	1.702518	0.748638	53	52	-0.455	0.325502	Accept	No
7/16/2014	-0.117	0.95602	0.103652	0.965775	61	60	-1.268	0.104848	Accept	No
8/3/2014	0.263	0.96990	-0.48159	0.917218	64	63	4.4623	0.000000	Reject	Yes
8/14/2014	1.1719	0.89530	1.867563	0.955477	34	33	-3.098	0.001982	Reject	Yes

Wind Direction Test	Console C Mean (rad)	Console C Variance (rad)	Young Mean (rad)	Young Variance (rad)	n	df	t score	p-value	Result	Directions Different?
6/3/2014	1.15653	0.63375	1.568496	0.801049	30	29	-2.209	0.017615	Reject	Yes
7/16/2014	0.06583	0.85179	0.265726	0.879192	42	41	-1.058	0.148125	Accept	No
8/3/2014	0.16499	0.89446	-0.33313	0.913861	33	32	2.2377	0.016165	Reject	Yes
8/14/2014	1.56800	0.82033	1.885488	0.961213	31	30	-1.399	0.086034	Accept	No

Table 2. Pearson's linear correlation indices (*r*-value) for console and Young wind speed observations. Values in bold are statistically significant ($p < 0.05$).

	Trial 1	Trial 2	Trial 3
A and Young	**0.483**	**0.777**	0.000
B and Young	**0.635**	**0.665**	**0.484**
C and Young	**0.621**	**0.609**	-0.043

Figure 4. Graph of wind speed data collected on the Rodney R. Foil Plant Science Research Center July 2015.



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