The Effect of a Herbicide and Additives on Spray Particle Sizes and Size Distribution

Robert N. Klein
WCREC/Agronomy Department, University of Nebraska, North Platte, NE 69101

Abstract

The American Society of Agricultural Engineers Pest Control and Fertilizer Committee developed ASAE S572, Spray Nozzle Classification by Droplet Spectra. This standard defines droplet spectrum categories for the classification of spray nozzles, relative to specified reference fan nozzles discharging spray into static air or so that no stream of air enhances atomization. The droplet spectra produced by single elliptical orifice reference nozzles with specified: liquid mixture (water), liquid flow rates, operating pressures, and spray angles. All of which are specified by the standard, establish the threshold of division between nozzle classification categories. Generally the standard is based on spraying water through the reference nozzles and nozzles to be classified. However, spray liquid properties may affect droplet sizes. Most if not all classification of nozzles have been done with water. Research was accomplished with a Helos/Vario-KF Analyzer with R6 lens, which by laser light diffraction, can determine particle size from 0.5 to 1770 microns. This paper will discuss the effects on spray particle size and spray particle size distribution that Roundup Weather Max with ammonium sulfate has with and without Array, Border and Placement with water compared to water. The nozzles used were Spraying Systems Extended Range, Turbo TeeJet, Turbo Flood and Air Induction. Both the herbicide and additives affected particle size and particle size distribution. Some nozzles are affected more than others and would result in the nozzle receiving a different droplet spectra classification.

Introduction

Most spray nozzle tips used in the application of pesticides produce a distribution of droplet sizes. Droplet size refers to the diameter of an individual spray droplet. The nozzle tip spray pattern is then made up of numerous spray droplets of varying sizes.

Spray nozzle classification by droplet spectrum in the U.S. was developed and approved by the American Society of Agricultural Engineers (ASAE) in August of 1999. This Standard, S-572, defines droplet spectrum categories for the classification of spray nozzles, relative to specified reference fan nozzles discharging spray into static air or so that to stream of air enhances atomization. This provides a means for relative nozzle comparisons based on droplet size only. Other spray drift and application efficacy factors (e.g. droplet discharge trajectory, height, and velocity; air bubble inclusion; droplet evaporation; and impaction on target) are not addressed. The Standard is based on spraying water through the reference nozzles and nozzles to be classified. However, spray liquid properties may affect droplet sizes and should be considered by the end user.

Reference flow rate and operating pressures are specified for each reference nozzle because droplet size spectra from pressure atomizers are affected by flow rate and operating pressure. The classification category thresholds, nozzle spray angles, nominal rated flow ratings at 276 kPa (40 psi), reference flow ratings, and reference operating pressures are shown in Table 1.

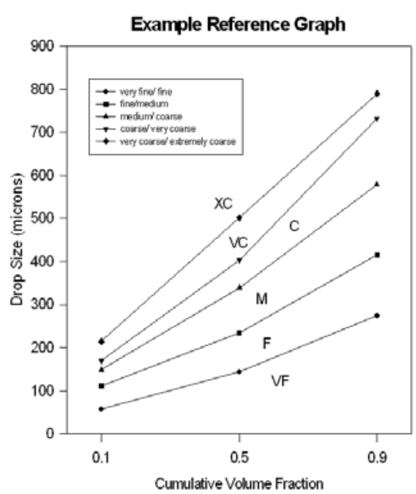
Table 1. Classification category threshold values for flat spray nozzles.

Classification category threshold	Nozzle spray angle (°)	Nominal rate flow rate[1] (L/min)	(gpm)	Reference flow rate (L/Min)	(gpm)	Reference operating pressure (kPa)	(Psi)
VF/F	110	0.38	0.10	0.48	0.13	450	65.3
F/M	110	1.14	0.30	1.18	0.31	300	43.5
M/C	110	2.27	0.60	1.93	0.51	200	29.0
C/VC	80	3.03	0.80	2.88	0.76	250	36.3
VC/XC	65	3.78	1.00	3.22	0.85	200	29.0

[1]Nominal rate flow rate is at 276 kPa (40 psi) and is for nozzles size selection only.

A reference graph for nozzle classification shall be established from droplet size spectra measurements obtained for all of the reference nozzles. Droplet diameter (microns) is plotted versus the cumulative spray value (fraction or percent) (ordinate) for the five reference nozzles as a reference graph. An example reference graph developed from measurements averaged from three types of laser instruments is shown in figure 1.

Figure 1. Sample reference graph developed from measurements average from three types of laser instruments.



Research by Feng *et al.* (2003) on the effect of droplet size on retention, absorption, and translocation of C-glyphosate was studied in glyphosate-resistant corn. Fine, medium, and coarse spray droplets were studied using a track-sprayer equipped with commercially available nozzles. Glyphosate-resistant corn was used to obtain measurements at field use rates in the absence of phytotoxicity. Spray retention on corn leaves was calculated based on recovered glyphosate per leaf area, and retention was higher with application of fine droplets (47%) than with application of coarse (38%) and medium (37%) droplets. Absorption in corn leaves was directly correlated with droplet size and reached a plateau 1 day after treatment (DAT) for all droplet sizes. Based on glyphosate recovered 3 DAT, coarse droplets showed the highest absorption (49%), followed by medium (35%) and fine (30%) droplets. Percentage of translocation also increased with droplet size, and translocation was primarily toward strong sink tissues such as roots and young leaves. The results showed that large droplets have slightly reduced retention in corn but have increased absorption resulting in increased translocation of glyphosate to growing sink tissues. See Table 2 and Figure 2.

Table 2. Comparison of spray retention in glyphosate-resistant corn from fine, medium, and coarse droplets.[a] (Feng 2003)

Droplet size	Plant leaf area (∀SE) cm^2	Maximal retention cm^{-ab}	Expected plant retention (∀SE)[c]	Actual plant retention (∀SE)[d]	% Retention (Actual/expected)
		------------------------------	ml	------------------------------	
Fine	160 ∀ 7	2.5	395 ∀ 18	187 ∀ 16	47 ∀ 2
Medium	162 ∀ 6	2.2	362 ∀ 14	133 ∀ 22	37 ∀ 7
Coarse	150 ∀ 6	3.1	461 ∀ 19	172 ∀ 18	38 ∀ 4

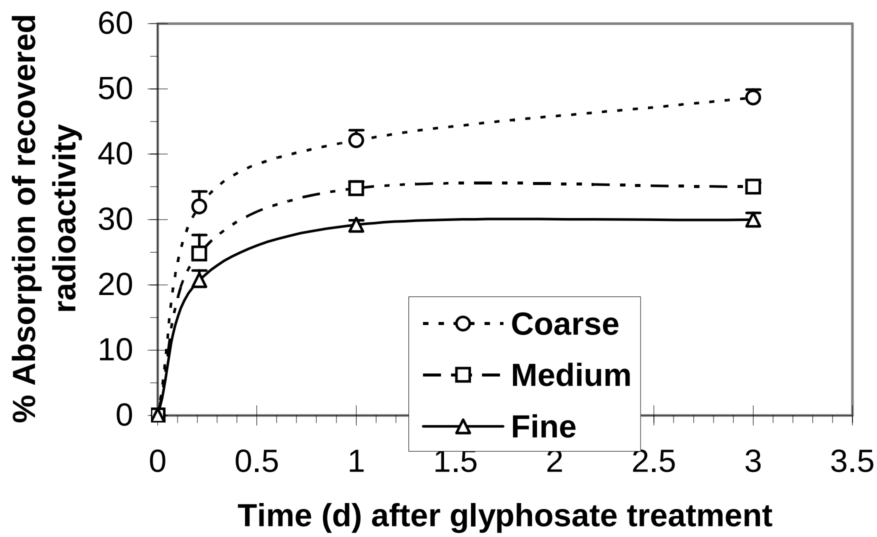
a Glyphosate at 0.84 kg ae ha^{-1} was spike with ^{14}C-glyphosate and applied with a track-sprayer (234 kPa and 187 L ha^{-1}) positioned 46 cm above the canopy. Data represents the mean of four replicates with standard errors (SEs).

[b] Maximal retention per square centimeter was measured from application to filter disks.

[c] Expected retention volume per plant was calculated by multiplying plant foliage area and maximal retention per square centimeter.

[d] Actual retention volume per plant was measured from radioactivity in leaf wash at 0 days after treatment.

Figure 2. The effect of droplet size on time course of glyphosate absorption in glyphosate-resistant corn. (Feng 2003)



Materials and Methods

A Sympatec Laser particle analyzer which is composed of •5 mw Helium-neon laser, •Adjustable measuring zone, •31 ring multi element detector, •Auto alignment system, •High speed fiber optic data transfer cable, and •Computer with Windox 4 operating software for control and operation of the Helos central unit is being used at the West Central Research and Extension Center in North Platte, NE to evaluate particle sizes of nozzle tips. The analyzer is capable of detecting micron sizes in a range from 0.5 to 1750 microns. The width of the spray plume is analyzed by moving the nozzle across the laser by means of a linear actuator. Software with the system generates reports and charts the results to user specifications. Droplet characteristics such as volume median diameter and percent of volume 210 microns and less can be obtained. Particle size analysis will assist in interpreting plot data and correlating it with applications made by nozzles commonly used on farms and by commercial applicators.

The nozzle tips used in the study were Spraying Systems Extended Range XR11004, Turbo TeeJet TT11004, Turbo Flood TF2, and Air Induction AI11003. They were used at 276 kPa for all but the Air Induction which was used at 483 kPa. Roundup WeatherMax was used at 1.6 liters per hectare in 93.5 liter per hectare of spray solution (water was used to make up the difference). Also included in the treatment was spray grade ammonium sulfate at 2% weight/weight. The additives used were Array at 4.1 kg/378.5 L, Border at 0.28 kg/378.5 L, and Placement at 0.156 kg/378.5 L.

Table 3 lists the volume medium diameter for the four nozzle tips with water, with Roundup WeatherMax + AMS with and without the three additives. Note how some nozzle tips are affected more by the addition of the herbicides and additives.

Table 3. Volume median diameter (VMD) as determined with Sympatec Laser.

Treatment	11004XR 276 kPa	11004TT 276 kPa	TF 2 276 kPa	11003AI 483 kPa
		Microns		
Water	250	369	432	484
Roundup WeatherMax + 2% AMS	208	309	400	378
WeatherMax + 1% AMS + Array	285	451	444	343
WeatherMax + 2% AMS + Border	278	439	487	350
WeatherMax + 2% AMS + Placement	225	320	374	387

WeatherMax = 1.6 L/ha; Array = 4.1 kg/378.5 L; Border = 0.28 kg/378.5 L;
Placement = 0.156 kg/378.5 L; carrier volume was 95.5 L/ha.

Table 4 lists the percent of spray volume less than 210 microns. Note how the percent changes, especially with some nozzle tips. Array and Border which reduced the percent of spray volume less than 210 microns with the XR, TT and TF nozzle tips but increase the amount of the spray volume with spray particle sizes less than 210 microns with the air induction nozzle tip.

Table 4. Percent of spray volume less than 210 microns as determined with Sympatec Laser.

Treatment	11004XR 276 kPa	11004TT 276 kPa	TF 2 276 kPa	11003AI 483 kPa
		%		
Water	37	23	19	10
Roundup WeatherMax + 2% AMS	51	30	22	17
WeatherMax + 1% AMS + Array	36	14	14	29
WeatherMax + 2% AMS + Border	35	15	13	29
WeatherMax + 2% AMS + Placement	45	26	22	15

WeatherMax = 1.6 L/ha; Array = 4.1 kg/378.5 L; Border = 0.28 kg/378.5 L;
Placement = 0.156 kg/378.5 L; carrier volume was 95.5 L/ha.

Table 5. shows the classification of the spray nozzle tips with water as they are now classified by Spraying Systems, and how we would classify them with water and herbicides and additives (with Roundup WeatherMax at 1.6 L and 2% AMS to make up 95.5L).

Table 5. Nozzle classifications.

Nozzle	Pressure kPa	Spraying System	Classification	
			Water	Roundup WeatherMax[a]
11004 XR	276	Medium	Medium	Fine
11004 TT	276	Coarse	Coarse	Medium
TF 2	276	Extremely Coarse	Coarse	Coarse
11003 AI	483	Very Coarse	Very Coarse to Extremely Coarse	Medium

[a]1.6 L + 2% AMS w/w in 95.5 total carrier.

Conclusion

Both herbicides and additives affected particle size and distribution. Some nozzles are affected more than others and would result in a different droplet spectra classification. More research needs to be accomplished to study the effect of more herbicides and additives on spray particle size and distribution. This needs to be followed up with research to determine the effect that spray particle size and distribution has on particle efficacy and spray drift.