Comparison of drift potentials between air induction and conventional nozzles

Heping Zhu
Agricultural Engineer
USDA-ARS Application Technology Research Unit
Wooster, Ohio

Agricultural Research Service
the in-house research arm of the U.S. Department of Agriculture

Co-authors

H. Guler
Post doctoral
The Ohio State University

H. E. Ozkan
Professor
The Ohio State University

R. C. Derksen
Agricultural Engineer
USDA-ARS ATRU

C. R. Krause
Plant Pathologist
USDA-ARS ATRU

Air Induction Nozzles

Previous comparison of air induction and conventional nozzles:

Tip numbers from catalog
but not nozzle orifice size

Consequences:

Not fair comparison
Higher pressure
Higher price

Objective

spray drift reduction potential and other spray characteristics of air induction nozzles could be achieved by conventional hydraulic nozzles with the same orifice size operated at reduced pressure (or same orifice size and flow rate)

Materials and Methods

Dimensions of nozzle orifices

Nozzle Group	Nozzle Type	Orifice Length (mm)	Orifice Width (mm)	Orifice Area (mm^2)
Small	AI 110015	2.33	0.58	1.13
Small	XR 11004	2.31	0.60	1.18
Medium	AI 11003	3.03	0.83	2.09
Medium	XR 11008	3.23	0.88	2.31
Large	AI 11008	4.59	1.46	5.33
Large	XR 11015	4.41	1.21	4.28

Operating pressure and flow rate

Nozzle Group	Nozzle Type	Pressure (psi)	Flow Rate (gal/m)
Small	AI 110015	100	0.25
Small	XR 11004	15	0.25
Medium	AI 11003	85	0.45
Medium	XR 11008	11	0.45
Large	AI 11008	120	1.25
Large	XR 11015	27	1.25

Experiments

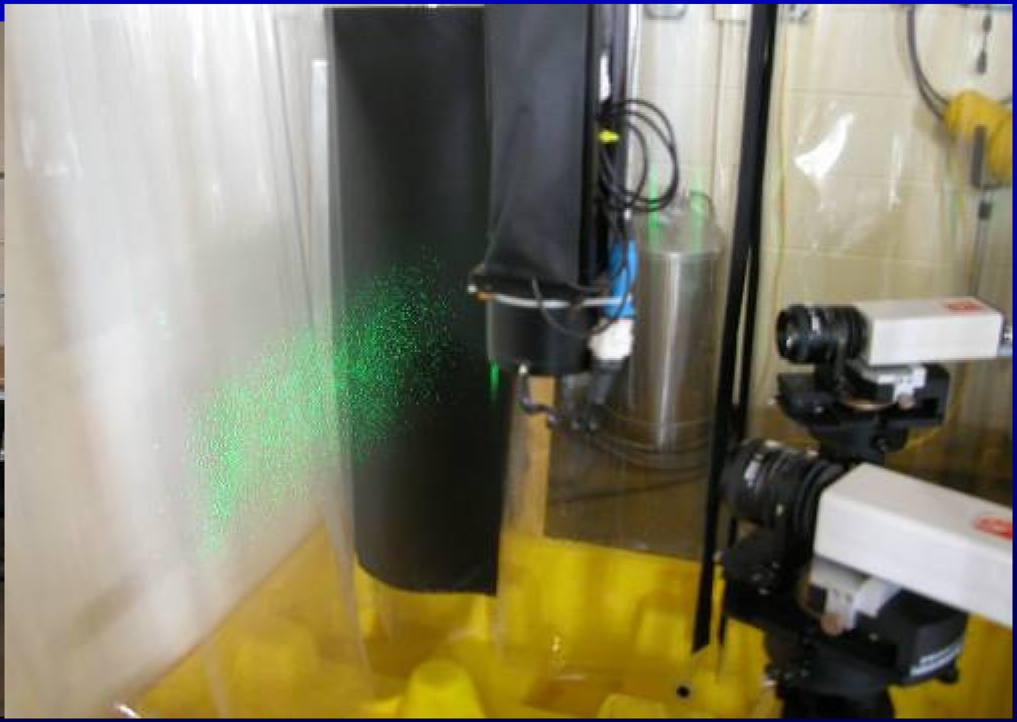
Droplet size and velocity

Spray pattern width

spray coverage

Airborne and ground deposits

Droplet sizes and velocities were measured with a laser imaging system



The spray pattern width was measured with a portable spray pattern analyzing system

Spray coverage on water sensitive papers

Ground and airborne spray deposits were measured in a wind tunnel at two wind velocities (2.5 and 5 m/s)

Results

Droplet sizes, velocities and spray pattern widths for large, medium and small nozzle groups

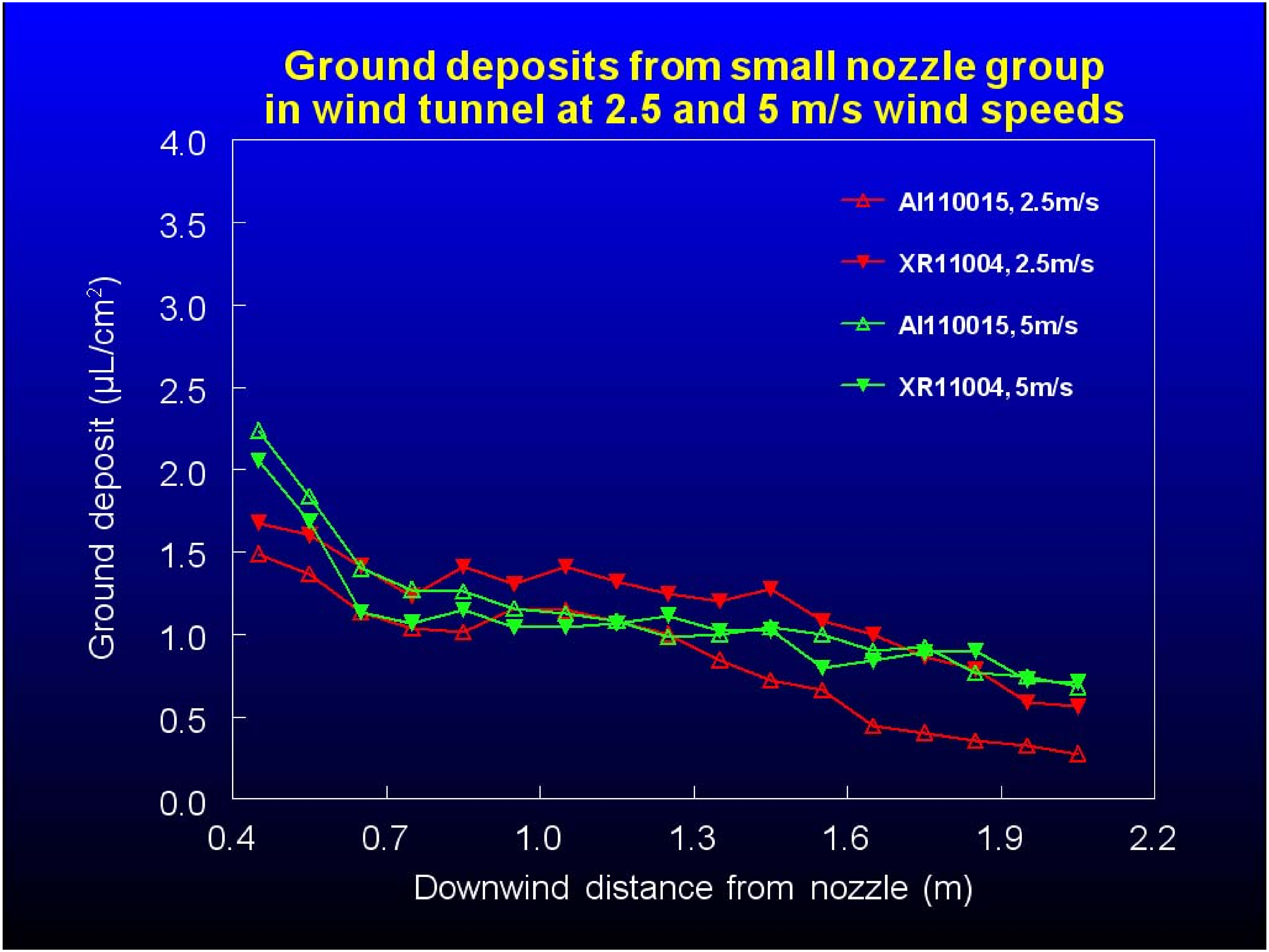
Nozzle group	Nozzle type	$D_{V0.5}$ (µm)	% < 200µm	Average droplet velocity (m/s)	Pattern width[y] (cm)
Small	AI-110015	263e	33.9f	4.1f	122
Small	XR-11004	254e	35.0f	4.2f	116
Medium	AI-11003	319c	27.5e	5.9e	122
Medium	XR11008	353d	18.1d	4.5d	112
Large	AI-11008	401a[z]	21.3c	7.7b	120
Large	XR-11015	417a	18.4b	6.6a	124

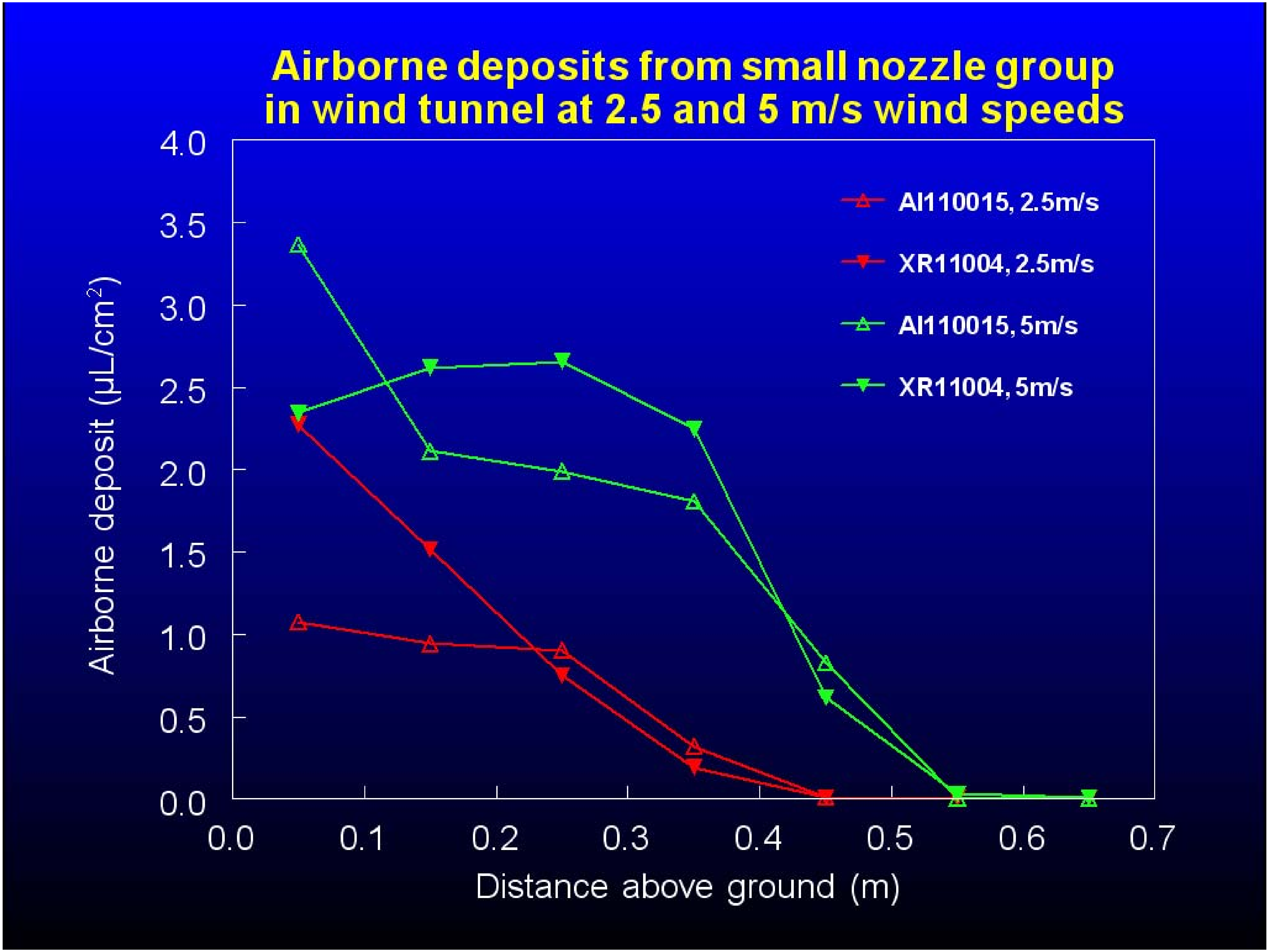
[y] Pattern width represents 99% volume range
[z] Values in the same column fallowed by the same letter are not significantly different at the 0.05 level

Percent of spray coverage on WSP at 50 cm and 70 cm below the AI and XR nozzles tested in greenhouse

Nozzle Group	Nozzle Type	Spray coverage (%)	
		50 cm	70 cm
Small	AI-110015	14.9 (1.9)	14.0 (2.1)
Small	XR-11004	22.7 (1.5)	20.1 (3.0)
Medium	AI-11003	29.0 (3.0)	20.9 (3.6)
Medium	XR11008	29.4 (2.7)	21.7 (3.4)
Large	AI-11008	>70	>70
Large	XR-11015	>70	>70

Standard deviations are given in parentheses


Ground deposits from small nozzle group
in wind tunnel at 2.5 and 5 m/s wind speeds
AI110015, 2.5m/s
XR11004, 2.5m/s
AI110015, 5m/s
XR11004, 5m/s
Ground deposit (µL/cm²)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.4
0.7
1.0
1.3
1.6
1.9
2.2
Downwind distance from nozzle (m)

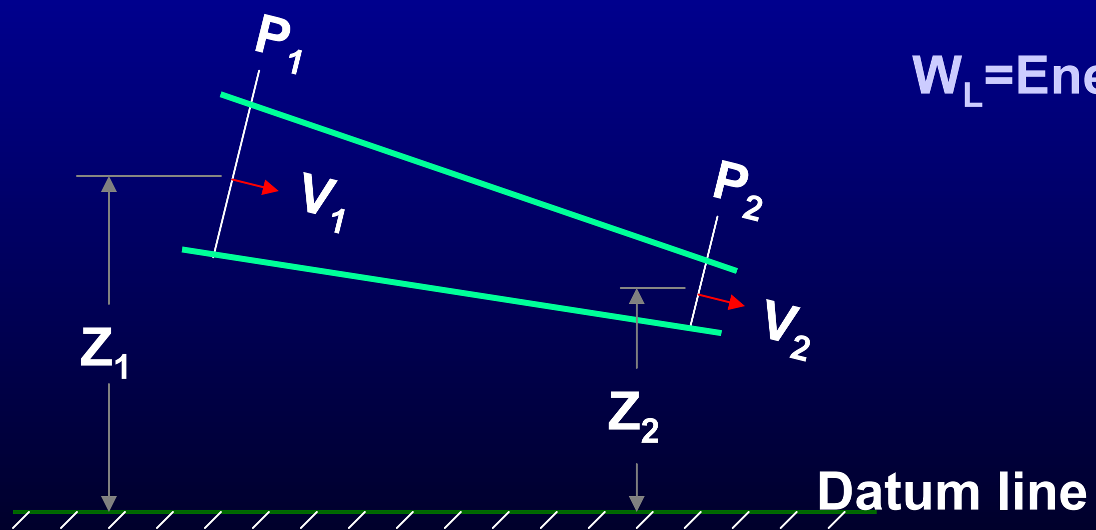

Airborne deposits from small nozzle group
in wind tunnel at 2.5 and 5 m/s wind speeds
Airborne deposit (µL/cm2)
Distance above ground (m)
AI110015, 2.5m/s
XR11004, 2.5m/s
AI110015, 5m/s
XR11004, 5m/s
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

Discussion

Bernoulli's equation

(Rule of conservation of hydraulic energy)

$$\frac{P_1}{\rho} + g\,Z_1 + \frac{V_1^2}{2} = \frac{P_2}{\rho} + g\,Z_2 + \frac{V_2^2}{2} + W_L$$



W_L=Energy loss

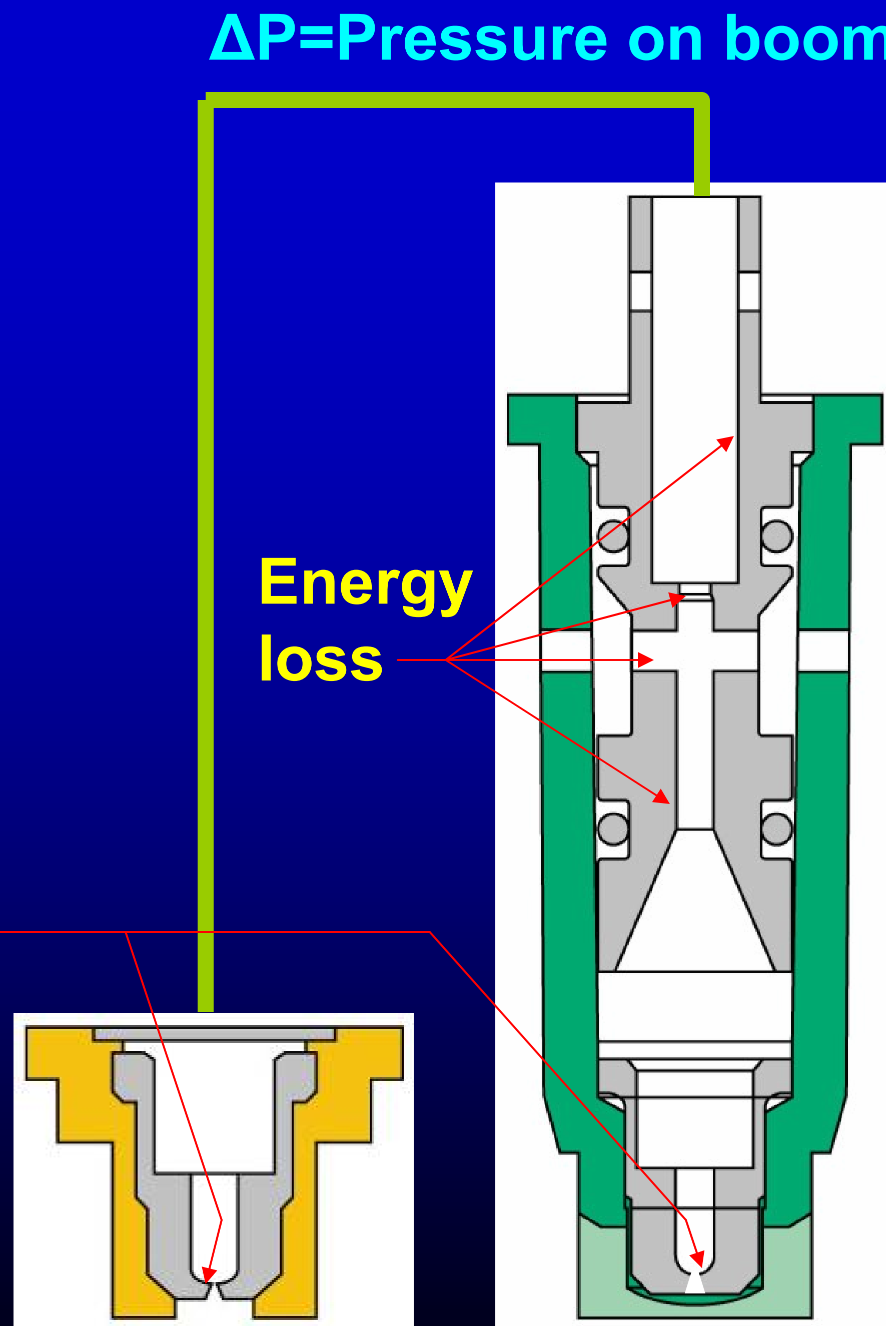
$$V = \sqrt{2(\Delta P - \rho W_L)/\rho}$$

$Q = \pi d^2 V/4$

$$Q = Cd^2\sqrt{P}$$

Q = nozzle flow rate

P = Pressure
on nozzle orifice

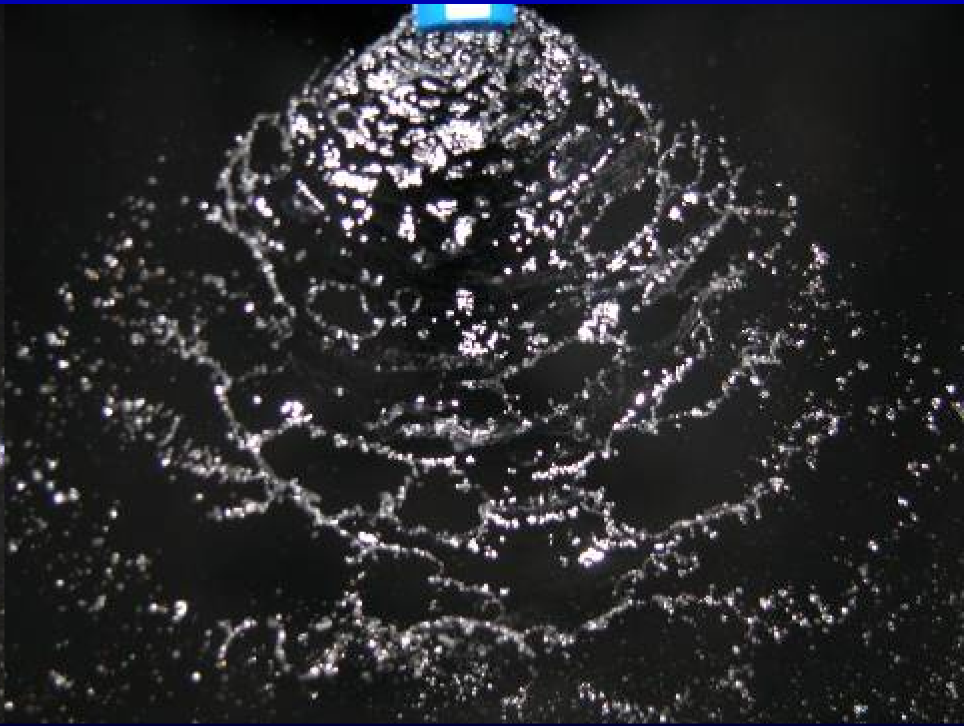


The assumption that droplets from AI nozzles contain air bubbles does not follow engineering principles

Unplugged air holes

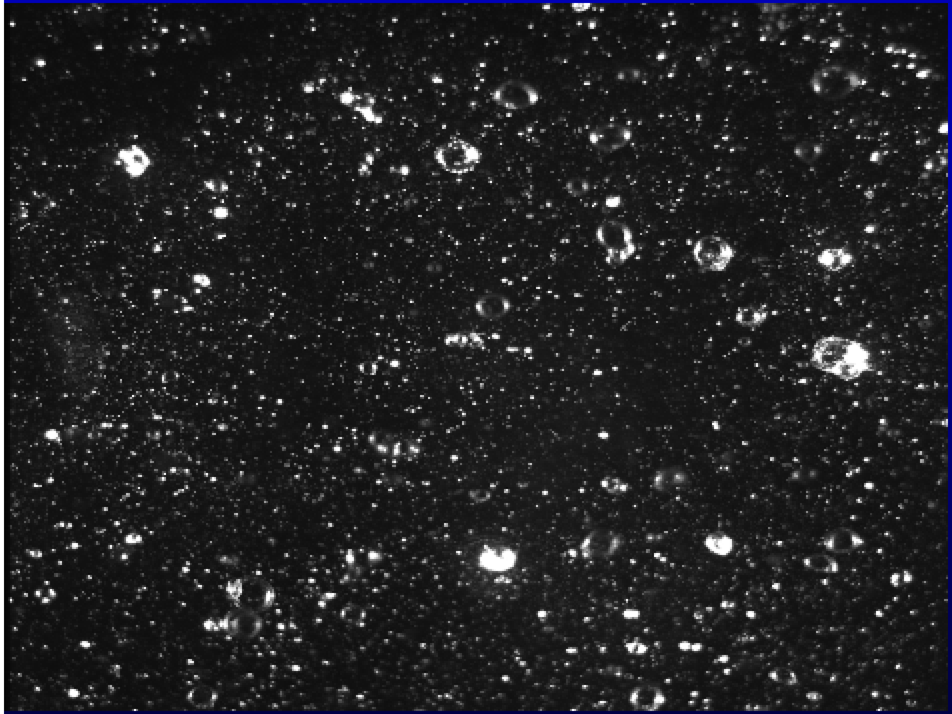
Smaller spray sheet

Plugged air holes

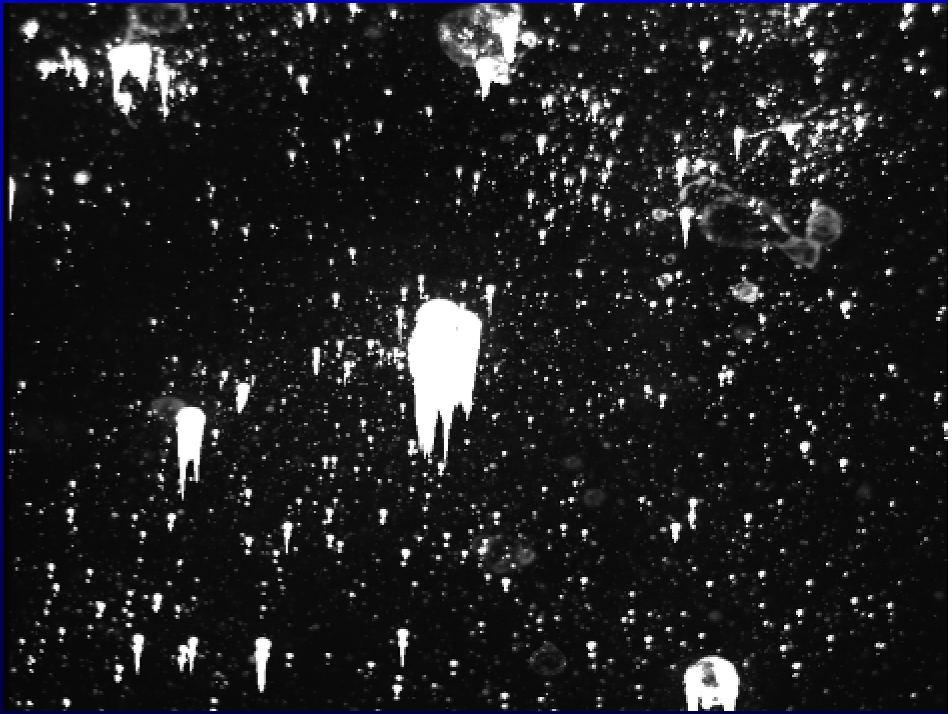


Larger spray sheet

XR 11004



Al 110015



Conclusions

Drift reduction potentials and spray characteristics of AI nozzles could be achieved by conventional nozzles with the same orifice sizes at reduced pressures.

With the same tip number (or same nominal capacity), AI nozzles had at least twice orifice area of XR nozzles.

Because pesticide spray practice is already complicated, the many types of nozzles are unnecessary and have further confused applicators. The number of nozzle types can and should be reduced for pesticide spray applications.

Also, there are many ways to minimize drift potentials, but applicators aren’t aware that they exist. To solve this problem, increased funding for extension education will ensure applicators are properly trained.

Questions?

Thank you!