Precision Herbicide Spray and Foam

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Most herbicide spray technologies have been adapted from agriculture.
For spraying crops precision has not been a primary concern.

Drift – yes – but not the precise targeting of weeds.
For example, it is less critical if a sprayed herbicide contacts genetically-modified, herbicide-resistant corn.
Native area management is different.
Native plants are not herbicide resistant.
Native plants are valuable:
• Forbs can live 3-25 years
• Grasses can live 5-39 years

Laurenroth et al. 2008.
For native area management

"Transfer efficiency" is key:

1. target **just** the weed.
2. Keep the herbicide **on** the weed.
3. **in the best** form for absorption.
Compare transfer efficiency between:

• Agricultural herbicide spray techniques

• Green Shoots technology:
  • Foam herbicide
  • Ultra-low pressure spray
“Transfer efficiency”:

1. target just the weed.

2. Keep the herbicide on the weed.

3. in the best form for absorption.
Agricultural Model Uses High Pressure Spray
As Pressure Increases

Drop Size Decreases

“A simple rule that holds for all nozzles.” Bete Fog Nozzle, Inc.
Well known: small drops are drift prone and reduce ability to target.
But, in addition, high pressure affects other things such as *spray coverage* – sometimes in unforeseen ways.
This is an illustration similar to ones in technical guides for nozzles.
It’s often used for nozzle spacing. Because of the effects of gravity on spray drops, the technical guides recommend farmers overlap broadcast spray patterns to ensure full coverage.
But what about drops beyond the “theoretical spray coverage area”?
This is critical for maintaining the precision of a directed spray application.
To explore spray coverage, we did indoor tests where we sprayed colored water onto white paper.
The nozzle was held at a constant height of 10 in.
Pressure was at 5 to 30 psi.

Measured this distance.
At 30 psi, many drops are deposited well beyond the “theoretical spray coverage area.”
At 35 in., circles mark some of the tiny spray drops. There are many more that aren’t circled.
At 30 psi, the “shadow spray coverage” extends more than 35 in. from the center line.

Nozzle: Hypro VP-110-015.
Why is there “shadow” spray coverage – even in no wind conditions?
Hypothesis: the spray pattern is affected by the ground or other objects.

Smaller lower velocity drops
Regardless how it is created, this big, largely invisible, “shadow” spray coverage area may put nearby desirable plants at risk.
You may think you are avoiding the desirable plant in the middle.
Given the potential for off-target harm. . .

Why are high pressure and the resultant small drops preferred for agricultural spraying?
Why preferred for agriculture?

Knoche’s research attempts to isolate this variable.
Knoche’s research essentially means a number of small drops will perform better than the same volume of large drops.
Why might small drops perform better?
Agricultural Spray Technology

“Transfer efficiency”:

1. target just the weed.

2. Keep the herbicide on the weed.

3. in the best form for absorption.
Small drops are generally retained better on leaves.

Yao et al. 2014.
“Transfer efficiency”:

1. target **just** the weed.

2. Keep the herbicide on the weed.

3. in the best form for absorption.
Absorption depends on three factors:

- Coverage
- Wetted Time
- Herbicide Solution
“300 μm diameter droplets had longer evaporation times per droplet volume and greater wetted area per droplet volume than the 600 μm diameter droplets.”

Xu et al. 2010.
Xu et al. 2010 suggests that cumulatively coverage and wetted time may improve with smaller drops created by high pressure.
Herbicide solution is more complicated

• Herbicide
• Carrier – e.g., water
• Adjuvants such as surfactants

Surfactants are not typically included in herbicide efficacy trials even today. See, e.g., Butts et al. 2018. Surfactants, however, can have a big effect as discussed below.
For transfer efficiency with traditional agricultural methods:

1. target *just* the weed.
2. Keep the herbicide on the weed.
3. in the best form for absorption.
Green Shoots products use foam and spray technology to increase “transfer efficiency.”
Precision Electronic Dispenser for Foam and Spray
Custom Backpack Frame
Ultra-low pressure

• **Pressure range**: 1.5 psi to 12 psi.
  
  • **Foam**: 1.5 to 10 psi.
  
  • **Foliar spray**: 5 to 12 psi.
  
  • **Basal spray**: below 5 psi.
  
• **Increments of 0.2 psi.**
Manual Foam Herbicide Dispensers
“Transfer efficiency”:

1. target **just** the weed.
2. Keep the herbicide on the weed.
3. in the best form for absorption.
First, you can target just the weed with a low-volume-high-concentration application.

12 days later.
Low-volume-high-concentration applications:

• Low carrier volume

• High concentration of herbicide (typically above 2% a.i.)
Application to cut-stump of thistle using the Small Dispenser.
Foam herbicide applied to a cut tree stem.

1 Year Later.
Electronic Dispenser with mesh brush attachment
Mesh brush with Large Handheld Dispenser
Stump applications using Electronic Dispenser and mesh brush
Prototype of the Rollable Cage – wiping from bottom to top of plant
Excellent for tall grasses and other weeds
“Transfer efficiency”:

1. target just the weed.
2. Keep the herbicide on the weed.
3. in the best form for absorption.
10 days later.

Foam can really keep herbicide on the weed.
Foam Herbicide Technology

“Transfer efficiency”:

1. target just the weed.

2. Keep the herbicide on the weed.

3. in the best form for absorption.
Foam emphasizes these two factors.

Coverage

Herbicide Solution

Wetted Time
18 days later.

Minimal coverage, but application can be very effective because:
- Glyphosate concentration is higher
- Surfactant
- Foam remains in aqueous state longer than sprays.
Even a tiny amount of glyphosate can do the job even though coverage is limited.
How can this be in light of Knoche?

- **Glyphosate is different.** Low-volume-high-concentration applications have been found more effective. Cranmer et al. 1991; Feng et al. 1994.

- **Other low-volume-high-concentration application methods have been found highly effective using a variety of herbicides.**
  - **Drizzle technique:**
    - DiTomaso 2016 (“drizzle” technique using concentrated triclopyr ester and surfactant).
    - Motooka et al. 2002 (Hawaii weed control guide including “drizzle” technique)
  - **Splatter technique:**
    - Brooks et al. 2014 (aminopyralid/fluroxypyr, fluroxypyr and metsulfuron-methyl to Siam weed).
  - **Herbicide Wiping:**
    - Harrington et al. 2016. (“Despite huge potential . . . only limited research.”)

- **Surfactants:** Surfactants can improve results, potentially even for herbicides other than glyphosate as DiTomaso suggests.
For transfer efficiency using foam herbicide:

1. target just the weed.
2. Keep the herbicide on the weed.
3. in the best form for absorption.
What about an application system that can be faster?
Ultra-Low Pressure Spray Technology
“Transfer efficiency”:

1. target **just** the weed.

2. Keep the herbicide on the weed.

3. in the best form for absorption.
10 psi

30 psi

Smaller shadow spray coverage area mean less off-target spray.
Bigger drops mean less drift.
Ultra Low-Pressure Spray Technology

“Transfer efficiency”:

1. target **just** the weed.

2. Keep the herbicide on the weed.

3. in the best form for absorption.
First, reducing the velocity of drops improves retention. Yao et al. 2014.
Second, surfactants will help larger drops stick better to leaves.
Instead of bouncing off the leaf . . .
The drop sticks with added surfactant.
A 306 micron drop bounced off a leaf more than 50% of the time when pure water was used and bounced 0% when a surfactant concentration of 0.75% was used.

Dong et al. 2015.
“Transfer efficiency”:

1. target just the weed.

2. Keep the herbicide on the weed.

3. in the best form for absorption.
Low pressure can emphasize these two factors.
5 psi – Glyphosate 4% ai; no surfactant; Hypro® 30HCX8 nozzle tip

30 psi – Glyphosate 4% ai; no surfactant; Hypro® 30HCX8 nozzle tip

Given how glyphosate performs, the application at left might perform better than the one at right.
But . . . let’s assume you want better coverage than this.
Coverage can be adjusted to the desired level using surfactants.
Using surfactants to adjust coverage:

Coverage — Herbicide Solution — Wetted Time
No surfactant.
With Surfactant – 0.5% a.i. alkyl polyglucoside (no anti-foam)
For transfer efficiency using ultra-low-pressure spray:

1. target just the weed.
2. Keep the herbicide on the weed.
3. in the best form for absorption.
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