Reducing Herbicide Use in a No-Till Dairy Cropping System

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Northeast SARE Sustainable Dairy Cropping Systems Project at Penn State University

As the need to protect water quality has become necessary and the benefits of conservation tillage have been recognized, many farms have adopted no-till practices. The Penn State **Sustainable Dairy Cropping Systems Experiment** is a multi-disciplinary systems experiment that began in 2010. The experiment consists of three distinct crop rotations that produce the feed, forage, and some fuel, needed to sustain a 65-cow dairy herd.

Herbicides are used for weed control in no-till systems, but have the undesirable consequences of potentially impacting water quality and selecting for herbicide resistant weeds. **The objective of this research is to evaluate the efficacy of an integrated weed management program (Fig.1) that uses less herbicide in combination with other management tactics.** Weed management strategies are being tested in corn (*Zea mays* L.) , soybean (*Glycine max* L.), and establishment-year alfalfa (*Medicago sativa* L.).

The Sustainable Dairy Cropping Systems Experiment is being conducted at The Pennsylvania State University's Russell E. Larson Agricultural Research Station in central Pennsylvania.

Research Questions

We are comparing two suites of weed management practices to answer the following questions:

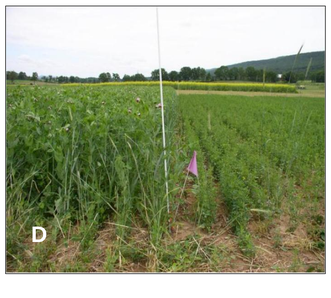
1. Can "Reduced Herbicide" management corn, soybeans, and alfalfa effectively control weeds in these crops?
2. Will "Reduced Herbicide" management result in lower yields of corn, soybean, and establishment-year alfalfa, as compared with "Standard Herbicide" management?

Hypotheses

- Using a winter rye (*Secale cereale* L.) cover crop mulch, banding herbicide over the crop row, and supplementing with high-residue cultivation between crop rows can provide equivalent weed management to an herbicide-based management program in corn and soybean (Table 1). Weed density, biomass, and crop yields will be equivalent between the two treatments.
- The annual companion crops triticale (*x Triticosecale*) and pea (*Pisum sativum* L.) plus orchardgrass (*Dactylis glomerata* L.) will provide equivalent weed suppression to herbicide control of weeds in establishment-year alfalfa.

Table 1. Weed management treatments being tested in no-till corn, soybean, and alfalfa.

Crop	Standard Herbicide	Reduced Herbicide
Corn	• Rye cover crop • 76-cm spacing • PRE herbicide: pendimethalin + s-metolachlor • POST herbicide: dicamba + diflufenzopyr + isoxadifen	• Rye cover crop • 76-cm spacing • PRE herbicide: BANDED pendimethalin + s-metolachor + mesotrione • POST: high residue cultivation
Soybean	• Rye cover crop • 19-cm spacing • PRE herbicide: flumioxazin + chlorimuron • POST herbicide: glyphosate	• Rye cover crop • Roller-crimper • 76-cm spacing • PRE herbicide: BANDED flumioxazin + chlorimuron + s-metolachlor • POST: high residue cultivation
Alfalfa	• POST herbicide: 2,4-DB ± clethodim	• Companion crops: orchardgrass, triticale, pea



Photos to right: Reduced herbicide management tactics. A winter rye cover crop was sprayed and rolled with a roller-crimper before no-till soybeans. The residue serves as a weed-suppressant mulch. **B.** A no-till planter used to simultaneously plant the crop and apply a 25 cm herbicide band over crop row. **C.** Following herbicide banding, high-residue cultivation was used to remove weeds between crop rows. **D**. "Reduced Herbicide" (left) using companion crops to control weeds, and "Standard Herbicide" (right) alfalfa in establishment year.

Dairy production remains one of Pennsylvania's largest agricultural sectors. Many dairy farms in Pennsylvania are small to mid-sized family farms that produce much of their required forage and some grain. Photo: Virginia Ishler.

Methods

- Added supplemental weed seeds to "subplots" to better test treatments
- Sampled weed density & biomass in cash crops & cover crops
- Separated weeds & forages to determine percent weed composition
- Measured crop yield and quality

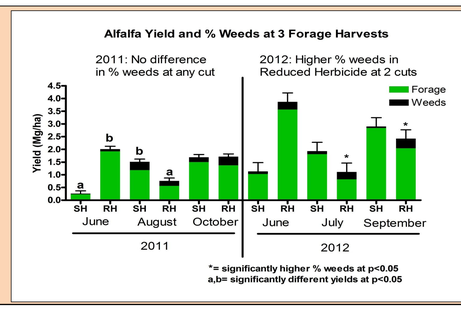
- Full-entry design, with each crop present every year
- Randomized nested split-split plot design with four replications
- Analyzed using PROC MIXED in SAS: weed management and crop as fixed effects and block as a random effect
- Repeated measures function used in forage analysis
- Tukey's test performed for means separation ($p < 0.05$)

Table 2. Effect of Reduced and Standard Herbicide Weed Management on Weed Biomass or Proportion of Weed and Crop Yield

Crop	Weed Biomass g m^{-2}		Crop Yield Mg*ha^{-1}
Corn	**2011** Reduced: 20.1 b Standard: 0.2 a	**2012** Reduced: 15.7 Standard: 0.3 *SE=6.1*	**2011:** Reduced: 13.0 Standard: 12.6 (15.5% moisture; n/s, SE= 0.25)
Soybean	**2011** Reduced: 89.0 b Standard: 0.4 a	**2012** Reduced: 1.2 b Standard:0.09 a	**2011:** Reduced: 3.19 a Standard: 3.84 b (13% moisture)

**letters and orange color indicate significant differences at p<0.05*

Alfalfa (SH) vs. Alfalfa + Pea + Triticale + Orchardgrass (RH)



2011	2012
Total forage yield (dry matter in Mg/ha)*	
Reduced: 4.42 b Standard 3.46 a	Reduced: 7.40 b Standard: 5.98 a
* Management by cut interaction: both years	
Forage quality	
Higher NDF in RH at all cuts	Lower CP and higher NDF in RH -June cut

More Weeds, Comparable Yields

1. Reduced Herbicide management in corn and soybeans resulted in:
   - Less use of herbicide active ingredient (56%) in each crop,
   - Higher weed densities & biomass in 2011, higher weed biomass in soybeans in 2012;
   - Lower weed biomass than what is typically considered necessary to impact crop yield (weed biomass < 100 gm^{-2});
   - No corn crop yield difference in 2011;
   - Soybean yield reduced by 17% (0.65 Mg*ha^{-1}) in 2011: different planting dates, row spacing, and differences in population may have contributed to this.
   - Low weed biomass in soybeans in 2012 due to high biomass of rye mulch accumulated in warm spring.

Left: High-residue cultivator navigates thick rye mulch in reduced herbicide soybean.

Right: Coulter for slicing residue, mounted on the high-residue cultivator. This coulter precedes the cultivation sweep, to leave reside in place during cultivation.

2. Reduced Herbicide management in alfalfa:
   - Eliminated one herbicide application;
   - Provided 28% more forage in 2011 and 19% more forage in 2012 than did SH, due to fast growth of companion crops.
   - Had higher neutral detergent fiber (NDF) than pure alfalfa (SH management) in 2011 and at first cut in 2012, most likely due to presence of grasses in mixture. In 2012, crude protein was 12 points higher in SH at first cut.
   - Because most dairies also feed non-lactating cows, this forage was of sufficient quality for the dry cows and heifers and was well-utilized, particularly in 2011, which was a low-yielding year for forage crops.

Future Research

- Determine economic viability of both management strategies and potential soil loss in cultivated treatments.
- Determine if the weed population increases over time under a reduced-herbicide integrated management approach.
- Substitute more reduced-tillage weed management into crop rotation to further reduce herbicide use, and particularly glyphosate.

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