# FALL MANURE AND COVER CROPS: WHO WINS, WHO LOSES?

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## Introduction

Over 1 million acres of corn silage is grown in Wisconsin. When harvested in late summer, there is a clear opportunity for cover crops to be planted. In addition, it is likely that manure will be applied after corn silage harvest allowing cover crops to provide both soil and nutrient conservation benefits. However, growers in Wisconsin climates may have concerns about trade-offs with management such as extra field work in the spring, competetion for soil water and nutrients, and other associated costs that can only be addressed through coordinated research and extension efforts across the state. The potential for yield loss is a real concern of Wisconsin farmers and there are quantified examples of corn yield reductions following a rye cover crop (e.g., 13 bu/ac decrease reported by Stute et al., 2009). The objectives of this study were to determine the performance of fall seeded cover crops in a corn silage/fall manure application production system in different regions of Wisconsin and to quantify effects (yield and optimal N rate) on subsequent corn crop yield. Two cover crops were evaluated winter rye (which required termination in the spring) and spring barley (which winterkills).

## Materials and Methods

The study was conducted at three locations in Wisconsin across two growing seasons: the 2015 and 2016 corn growing seasons (Tables 1 and 2). Study sites included Arlington Agricultural Research Station (ARL) in south-central Wisconsin, Lancaster Agricultural Research Station (LANC) in south-west WI, and Marshfield Agricultural Research Station (MARS) in north-central Wisconsin. All field sites were preceded by corn silage and manure was applied at a target rate of 10,000 gallons/ac. Exact rates and nutrient content is presented in Table 4. First year availability of nitrogen (N) from manure was around 100 lb/ac at each site except Marshfield, where low percent solids in the liquid dairy manure resulted in a much lower nutrient contribution. Following manure application, cover crop seed was drilled at target rates of 90 lb/ac pure live seed (PLS) for winter rye and 80 lb/ac PLS for spring barley. Cover crops were sampled immediately prior to winterkill of spring barley and again in spring before chemical termination. The subsequent spring corn was planted with a no-till drill and split plot treatments of variable N rates were applied (0, 50, 100, 150, 200, 250 lb N/ac). Nitrogen was broadcast applied as urea with Agrotain®.

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Results and Discussion

- Dry matter cover crop yield of winter rye was at least 0.5 ton/ac at all locations, with all locations in 2016 having greater than 1 ton/ac of DM biomass (Table 3)
- Winter rye always reduced soil nitrate in the upper 1' in the fall compared to no cover at Arlington and Lancaster; effects were less pronounced at Marshfield (Tables 4 and 5)
- Averaged across six site-years, winter rye led to a 16 bu/ac yield drag, while spring barley led to 7 bu/ac (Table 6).
- On average corn following winter rye required 35 lb-N/ac more nitrogen compared to without a cover crop (based on linear-plateau regression models); spring barley had a minimal effect on optimum N rate (Table 6).
- Preliminary results regarding who wins: the soil (less erosion) and groundwater (less potential leaching of nitrate)
- Preliminary results regarding who loses: the corn (lower yields) and the manure (less N credit with winter rye?)

Table 1. Study dates for 2014-2015 cropping season.

| Event | Arlington | Lancaster | Marshfield |
|---|---|---|---|
| Harvest silage | 9/8/2014 | 9/18/2014 | 9/24/2014 |
| Apply manure | 9/17/2014 | 9/23/2014 | 9/25/2014 |
| Drill CC seed | 9/18/2014 | 9/29/2014 | 9/26/2014 |
| Winterkill AGB & soil | 11/14/2014 | 11/13/2014 | 11/11/2014 |
| | | | |
| PPNT | 4/28/2015 | 4/29/2015 | 5/5/2015 |
| Burn down | 4/30/2015 | 5/1/2015 | 5/5/2015 |
| Planting | 5/8/2015 | 5/13/2015 | 5/13/2015 |
| Sidedress | 5/13/2015 | 5/14/2015 | 5/21/2015 |
| Grain harvest | 10/26/2015 | 10/22/2015 | 11/11/2015 |

Table 2. Study dates for 2015-2016 cropping season.

| Event | Arlington | Lancaster | Marshfield |
|---|---|---|---|
| Harvest silage | 9/11/2015 | 9/9/2015 | 9/15/2015 |
| Apply manure | 9/15/2015 | 9/16/2015 | 9/17/2015 |
| Drill CC seed | 9/23/2015 | 9/23/2015 | 9/21/2015 |
| Winterkill AGB & soil | 11/10/2015 | 12/11/2015 | 11/4/2015 |
| | | | |
| PPNT | 4/15/2016 | 4/13/2016 | 4/19/2016 |
| Burn down | 4/18/2016 | 4/15/2016 | 4/29/2016 |
| Planting | 5/6/2016 | 4/25/2016 | 5/6/2016 |
| Sidedress | 6/9/2016 | 6/10/2016 | 6/21/2016 |
| Grain harvest | 10/25/2016 | 11/1/2016 | 11/11/2016 |

Table 3. Aboveground dry matter (DM) biomass and N uptake in aboveground biomass collected at winterkill or spring before termination.

| Location | Cover | Winter 2014 | | Winter 2015 | | Spring 2015 | | Spring 2016 | |
|---|---|---|---|---|---|---|---|---|---|
| | | DM | N uptake | DM | N uptake | DM | N uptake | DM | N uptake |
| | | lb/ac | lb-N/ac | lb/ac | lb-N/ac | lb/ac | lb-N/ac | lb/ac | lb-N/ac |
| ARL | Sp. Barley | 783 | 42 | 737 | 40 | * | * | * | * |
| | Winter Rye | 583 | 25 | 798 | 42 | 2464 | 83 | 3249 | 100 |
| LAN | Sp. Barley | 265 | 14 | 1958 | 82 | * | * | * | * |
| | Winter Rye | 303 | 14 | 1249 | 50 | 1582 | 36 | 2565 | 63 |
| MAR | Sp. Barley | *na* | *na* | 492 | 25 | * | * | * | * |
| | Winter Rye | *na* | *na* | 743 | 37 | 1025 | 23 | 2259 | 49 |

* = Cover crop did not survive winter or biomass was minimal.

Table 4. Soil nitrate measurements in cover crop treatments at winterkill 2014 and preplant 2015.

| Location | Cover | Winter | | Spring | |
|---|---|---|---|---|---|
| | | 0-1’ | 1-2’ | 0-1’ | 1-2’ |
| | | mg $NO_3$-N / kg | | | |
| ARL | None | 27.3 | 6.6 | 20.7 | 23.0 |
| | Rye | 10.9 | 4.4 | 2.2 | 7.7 |
| | Sp. Barley | 6.8 | 3.8 | 13.9 | 17.2 |
| LAN | None | 12.1 | 6.2 | 11.4 | 4.6 |
| | Rye | 8.1 | 4.6 | 1.1 | 2.4 |
| | Sp. Barley | 6.6 | 3.9 | 8.4 | 3.4 |
| MAR | None | 4.3 | *NA* | 5.4 | 2.9 |
| | Rye | 4.7 | *NA* | 5.3 | 2.1 |
| | Sp. Barley | 5.7 | *NA* | 8.1 | 3.6 |

Table 5. Soil nitrate measurements in cover crop treatments at winterkill 2015 and preplant 2016.

| | | Winter | | Spring | |
|---|---|---|---|---|---|
| Location | Cover | 0-1’ | 1-2’ | 0-1’ | 1-2’ |
| | | mg $NO_3$-N / kg | | | |
| ARL | None | 19.3 | 14.1 | 6.3 | 7.2 |
| | Rye | 4.7 | 4.5 | 1.0 | 0.8 |
| | Sp. Barley | 7.3 | 8.2 | 8.0 | 6.8 |
| LAN | None | 8.7 | 19.1 | 6.4 | 6.6 |
| | Rye | 1.7 | 0.9 | 1.7 | 1.1 |
| | Sp. Barley | 9.1 | 5.6 | 13.4 | 7.3 |
| MAR | None | 10.4 | 1.2 | 6.7 | 3.5 |
| | Rye | 9.3 | 1.0 | 2.2 | 0.9 |
| | Sp. Barley | 8.6 | 1.0 | 2.7 | 1.3 |

Table 6. Corn yield plateaus based on linear-plateau regression models following no cover crop, winter rye, or spring barley. The yield difference and optimum N rate difference is relative to the no cover crop treatment. A negative yield difference value implies a yield decline with cover crops and a positive optimum N rate difference implies more N was required to achieve the yield plateau.

| Site | Year | Cover | Yield plateau | Yield diff. | Optimum N rate diff. |
|---|---|---|---|---|---|
| | | | bu/ac | bu/ac | lb-N/ac |
| ARL | 2015 | None | 191 | | |
| | | Winter Rye | 174 | -17 | 38 |
| | | Sp. Barley | 192 | 1 | 28 |
| ARL | 2016 | None | 252 | | |
| | | Winter Rye | 231 | -21 | -12 |
| | | Sp. Barley | 241 | -11 | -33 |
| LAN | 2015 | None | 196 | | |
| | | Winter Rye | 196 | 0 | 21 |
| | | Sp. Barley | 185 | -11 | 5 |
| LAN | 2016 | None | 260 | | |
| | | Winter Rye | 230 | -30 | 102 |
| | | Sp. Barley | 252 | -8 | 0 |
| MAR | 2015 | None | 195 | | |
| | | Winter Rye | 181 | -14 | 21 |
| | | Sp. Barley | 194 | -1 | 16 |
| MAR | 2016 | None | 241 | | |
| | | Winter Rye | 227 | -14 | 42 |
| | | Sp. Barley | 232 | -9 | 11 |
| | Average | Winter Rye | | -16 | 35 |
| | | Sp. Barley | | -7 | 5 |