Enhancing Cover Crop Nitrogen Uptake with Improved Establishment

By Reagan Noland, M. Scott Wells, and Heidi Peterson

Although cover crops have been promoted for their ecological benefits and ability to improve the resiliency of annual cropping systems, producers across the Midwest region of the U.S. have been hesitant to implement them due to challenges in establishment within the short growing season of a humid continental climate and a lack of reliable management practices. In the Midwest, summer-annual crops, specifically corn and soybean, are actively growing in the field for only a few months out of the year. This leaves fallow soils and a window of vulnerability extending between the time of harvest in the fall until planting in the spring. During this time the soils are susceptible to erosion and since crop nutrient uptake is minimal, any residual fertilizer in the soil is at risk of off-site movement, leaving the potential for surface runoff, leaching, and tile-drain discharge.

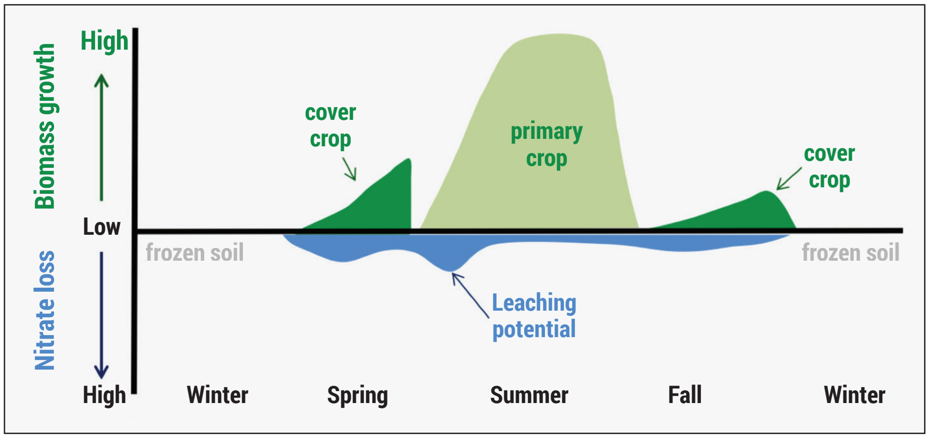

Figure 1. Proper implementation of a cover crop can reduce the opportunity for nutrient runoff and leaching by increasing plant biomass to cover the soil and utilize the available soil nutrients. Adapted from Heggenstaller et al., 2008.

If an adequate cover crop is established across the soil surface, the increased plant biomass will scavenge for residual fertilizer N, reducing the opportunity for nutrient runoff and leaching (**Figure 1**). This also helps to keep the N in the root zone so that it can be used by a future cash crop, improving overall nutrient use efficiency.

The main limitation to properly implementing cover crops following corn harvest in northern climates is the lack of adequate time and favorable soil and weather conditions for their establishment prior to freezing winter temperatures. To get the seed planted before harvest is completed, the cover crop could be interseeded into standing corn. One practice that has been researched and applied across the Midwest uses an aerial broadcast method from an airplane or helicopter. With an aerial application, however, cover crop establishment can be inconsistent due to seed getting caught in the corn canopy, poor seed-soil contact, and seed predation by rodents and insects. Good seed-soil contact and precipitation within a week of aerial seeding are determining factors of successful establishment (Wilson et al., 2013).

Innovative producers are now beginning to interseed cover crops using high-clearance drills to deliver cover crop seed directly between the rows of a standing crop without the need of an aerial application. A study was initiated by the University of Minnesota in 2014 to evaluate establishment success of a range of cover crop species and planting methods, and to determine whether successfully interseeding cover crops into corn will utilize excess N without reducing corn and subsequent soybean yields (Noland et al., 2018).

Study Description

Field experiments were conducted in 2014 through 2016 at the University of Minnesota's Southern Research and Outreach Center at Waseca, MN and at the Southwest Research and Outreach Center at Lamberton, MN. Both field sites were in primary corn production areas of Minnesota and situated in watersheds that drain into the Minnesota River, a tributary to the Mississippi River Basin. Fertilizers were applied in spring prior to seedbed preparation according to preplant soil analysis and University of Minnesota recommendations for corn production (Kaiser et al., 2016).

The experimental design was a randomized complete

In the north central part of the US Midwest, the growing season often offers only a small opportunity for cover crop growth in the corn-soybean cropping system. In Minnesota fields, we show that with planting techniques that produce good seed to soil contact, along with choice of a species that will grow to produce at least 390 kg DM/ha, cover crops can effectively take up residual N to reduce risk of nitrate loss.

KEYWORDS:
cover crop; nutrient loss; interseeding; residual nutrients.

ABBREVIATIONS AND NOTES:
N = Nitrogen; DM = dry matter.

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Table 1. Cover crop species.

Common name	Functional group
Cereal rye	Grass / small grain
Field pennycress	Oilseed brassica
Medium red clover	Legume
Hairy vetch	Legume
Mixture (48% oat , 48% field pea, 4% tillage radish)	Grass, legume, brassica

block with six replicates. The treatments were a factorial arrangement of five cover crop options (**Table 1**) planted using three interseeding methods, resulting in a total of 15 treatments and an experimental control without a cover crop. Cover crops were interseeded into corn at the seven-leaf collar stage (V7) in late June. All legumes were inoculated with appropriate rhizobia species at planting.

Three cover crop planting methods were evaluated. Direct broadcast of seed into the inter-row (DBC) was simulated by hand broadcasting the seed into the three inter-rows of each plot with no soil disturbance. Directed broadcast into the inter-row with light soil incorporation (DBC+INC) was achieved by modifying a high-clearance no-till drill. The drill units were raised so that the seed fell onto the soil surface and were incorporated using a light closing chain followed by a harrow-tine rake to achieve a light soil disturbance. The third method used the same high-clearance no-till drill (DRILL; 3-in-1 InterSeeder™, InterSeeder Technologies). The DRILL treatment had three drill units spaced 7.5 inch apart and centered within three inter-rows per plot, leaving a 15-inch-wide gap for each corn row (**Figure 2**). Seeding rates for each treatment were selected to ensure ample opportunity for comparable establishment with all three planting methods.

Cover crop biomass and N content were measured at corn maturity and in the spring prior to termination. Corn grain, stover, and cob biomass were also sampled and analyzed for N content at maturity. Soil was sampled to a depth of 1.2 meters (about 50 inches) and analyzed for nitrate-N content following corn harvest in the fall, and immediately prior to cover crop termination in the spring.

Cover Crop Biomass and Seeding Method

All cover crops established and survived through the fall except for the mixture, which was not winter-hardy and senesced under the corn canopy at both locations. Cover crop biomass in the fall, averaged by species, ranged from 9 to 84 kg DM/ha (average = 41 kg DM/ha) and was generally greater with planting methods that increase seed-soil contact compared to broadcast seeding without incorporation. The DRILL resulted in greater fall biomass than the other two planting methods for hairy vetch, the mixture, and rye. Red clover fall biomass was greater with DRILL and DBC+INC than DBC, and planting method did not affect fall biomass in pennycress.

Spring cover crop biomass was greater overall with the DRILL and DBC+INC planting methods (average = 641 kg DM/ha) compared to DBC (514 kg DM/ha). Within species, the DBC method resulted in less red clover and hairy vetch biomass compared to other planting methods, but rye and pennycress spring biomass were not affected by planting method.

Figure 2. Main photo shows planting cover crops into V7 corn using a high-clearance InterSeeder™ (inset photo represents DBC+INC) at Lamberton, MN.

Rainfall was above-average during the growing season in all site-years of this study, which likely influenced the success of the broadcast planting methods. Under drier conditions, similar establishment would not be expected of broadcast planting with no incorporation (Wilson et al., 2013). Corn grain and silage yields were not affected by cover crop species or planting method, indicating that the interseeded cover crops did not interfere with corn production when planted at the V7 growth stage. With the exception of hairy vetch that was poorly terminated at Lamberton, subsequent soybean yield was also not affected by the previous cover crop species or planting method.

Cover Crop Nitrogen Uptake

A cover crop that readily winterkills, similar to what was observed in the mixture, will not likely assimilate and retain as much N as winter-hardy species, but it could be a valuable option if an early-spring herbicide application is undesirable, or in no-till organic systems.

The low cover crop biomass accumulation in the fall corresponded to low N uptake (average 1.3 kg N/ha) in the fall. However, spring soil nitrate-N was reduced by rye cover crops at Lamberton compared to other treatments, and by rye, hairy vetch, red clover, and pennycress at Waseca compared to the mixture and check treatments (**Table 2**). An important finding is that differences in spring soil nitrate-N coincided with spring cover crop biomass production (**Table 3**). In all cases where spring soil nitrate-N was reduced, spring cover crop biomass was greater than 390 kg DM/ha. As the spring cover crop biomass increased, the soil nitrate-N decreased (R = -0.70; p = 0.003) compared to the no cover check. This supports that cover crop biomass can serve as an indicator for ecological services in the reduction of excess soil nitrate-N. In this study, the greatest effect was from the interseeded rye cover crops, which reduced spring soil nitrate-N compared to the no cover crop check by 53 kg NO_3-N/ha at Waseca and by 39 kg NO_3-N/ha at Lamberton. Nitrogen content in the aboveground rye biomass did not account for the entire difference in soil nitrate-N, which suggests that there was assimilation by the roots.

Summary

Cover crops can be successfully established into corn at the V7 stage using interseeding practices without affecting corn yield; however, effective termination of cover crops is important to avoid risk of reducing soybean yield. Although it is common for producers in the Midwest to judge the quality of their cover crop on the observed fall biomass, this study indicated that winter-hardy cover crop varieties interseeded to produce 390 kg DM/ha in the spring reduced soil NO_3-N compared to the no-cover crop check. To achieve the conservation benefit and minimize the yield reduction risk, USDA conservation programs (2014) require that zones extending across the Midwest should terminate the cover crop either at planting or before cash crop emergence. The cover crops in this study were terminated with glyphosate within 3 to 16 days of planting.

Planting methods with increased seed-soil contact produced more reliable cover crop establishment, which will be amplified during periods of drought or low precipitation. All cover crop species were successfully established, although over the three-year study, winter rye was consistently amongst the highest in spring cover crop biomass and N uptake, consequently resulting in lower spring soil NO_3-N.

Implementing cover crops as a way to scavenge residual nutrients may not be feasible on every hectare across the Midwest. Producers looking to target cover crop establishment to their most vulnerable land should consider interseeding techniques that increase seed-soil contact to produce the most reliable results for effective nutrient management. **BC**

TAKE IT TO THE FIELD

When looking to use cover crops to effectively scavenge residual nitrate-N, interseeding techniques that increase seed-soil contact compared to direct broadcast should be considered.

Table 2. Effects of interseeded cover crops on two-year (2015, 2016) mean spring soil NO_3-N content to a depth of 1.2 m.

	Soil NO_3-N	
	Lamberton	Waseca
Cover crop species	--------- kg NO_3-N/ha ---------	
No cover crop	75 a[1]	109 a
Winter rye	37 b	56 b
Pennycress	70 a	74 b
Red clover	79 a	69 b
Hairy vetch	75 a	64 b
Mixture	67 a	102 a

[1] Within columns, means with the same letter are not significantly different at $p \leq 0.05$.

Table 3. Cover crop species effect on two-year (2015, 2016) mean spring tissue N content.

	Aboveground tissue N content			
	Hairy vetch	Pennycress	Red clover	Winter rye
Planting Method	---------------- kg N/ha ----------------			
DBC	6.7 b[1]	11.7 a	11.7 b	21.7 a
DBC+INC	14.9 a	11.6 a	19.4 a	25.8 a
DRILL	18.9 a	10.8 a	21.1 a	26.0 a

[1] Within a column, means with the same letter are not significantly different at $p \leq 0.05$.

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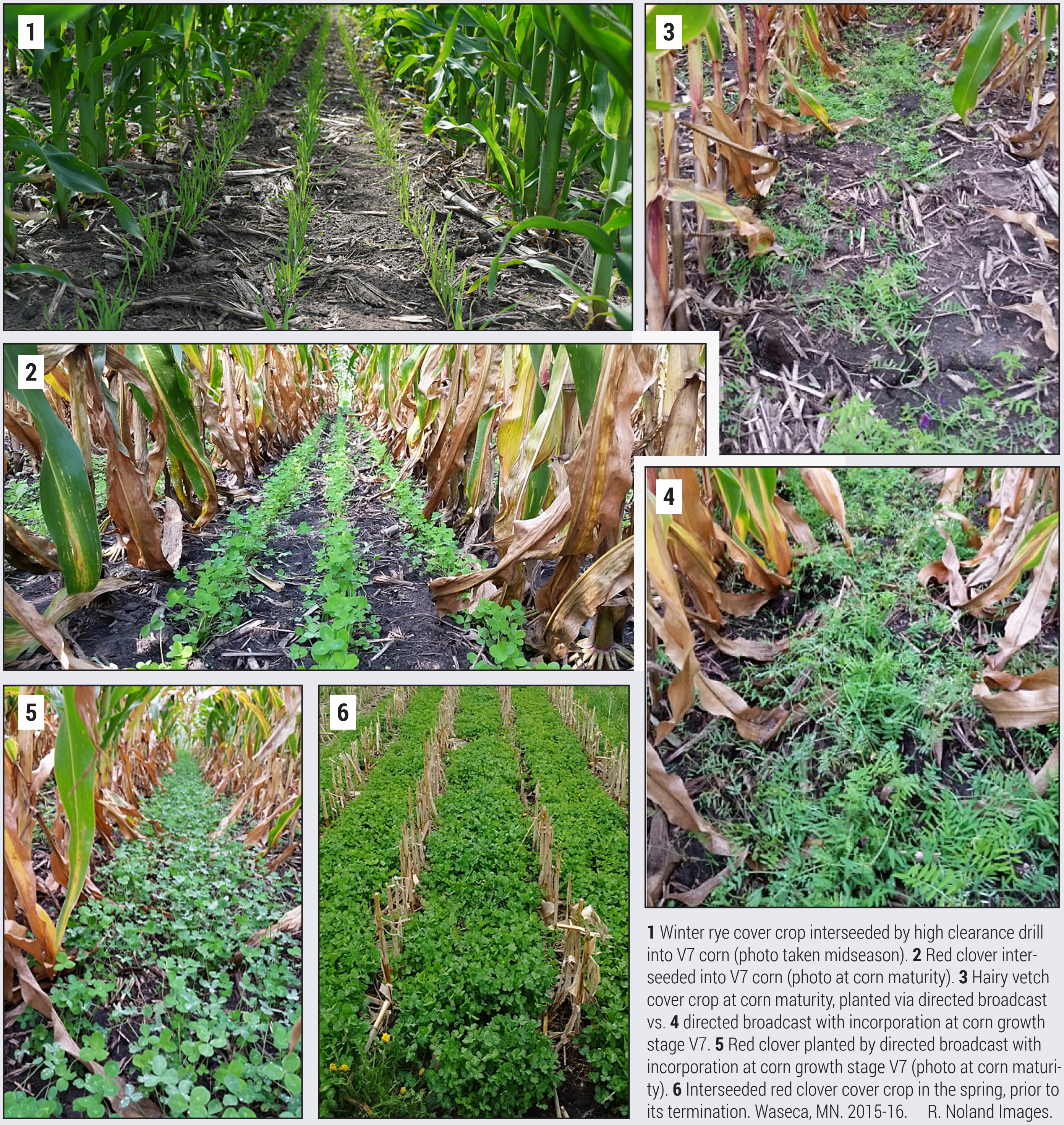

1 Winter rye cover crop interseeded by high clearance drill into V7 corn (photo taken midseason). **2** Red clover interseeded into V7 corn (photo at corn maturity). **3** Hairy vetch cover crop at corn maturity, planted via directed broadcast vs. **4** directed broadcast with incorporation at corn growth stage V7. **5** Red clover planted by directed broadcast with incorporation at corn growth stage V7 (photo at corn maturity). **6** Interseeded red clover cover crop in the spring, prior to its termination. Waseca, MN. 2015-16. R. Noland Images.