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Cover crops, manure, and nitrogen management

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Cover crops are a proven way to conserve soil and plant nutrients as well as potentially improve soil health. Growers in Wisconsin are experimenting with different cover crops to conserve soil and retain plant nutrients, specifically nutrients applied as manure. However, there are important agronomic and environmental trade-offs to consider when using cover crops following a manure application. This publication discusses these trade-offs and provides guidelines for adjusting nutrient management plans when using cover crops with manure.

Managing fall manure

The abundance of late summer-harvested corn silage in Wisconsin means that there are many acres where manure can be applied between late summer and late fall. Current nutrient management guidelines estimate manure nitrogen (N) availability based on animal source, solids content, and application method (Laboski and Peters 2012) but no adjustments are made regarding application timing. Warm conditions during the August through November application period may promote both the mineralization of the organic N in manure and the nitrification of ammonium to nitrate, which can lead to N losses in the winter and spring. Nitrate is easily mobile in soils; the occurrence and intensity of rainfall events between manure application and spring planting dictate how much N from the manure remains available to the next corn crop. Cover crops are a recommended management practice in this cropping system to provide ground cover and to trap excess N from leaching into groundwater or tile drains.

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Table 1. Grass cover crop options for Wisconsin, summarized from the Midwest Cover Crop Selector Tool (http://mccc.msu.edu/covercroptool/covercroptool.php) and *Cover Crops 101* (Smith et al. 2019).

Cover crop	Seeding rate (lb/ac)*	Survives the winter?	Suitable for poorly drained soils?	Latest planting dates†
Annual ryegrass	12–20	Variable	Yes	Aug. 25–Sept. 5
Oats	30–60	No	Yes	Aug. 25–Sept. 5
Spring barley	50–75	No	No	Sept. 20–Oct. 1
Winter barley	40–60	Variable	No	Oct. 5–Oct. 15
Winter rye	40–60	Yes	Yes	Oct. 18–Nov. 1
Winter triticale	40–60	Yes	Yes	Oct. 5–Oct. 15
Winter wheat	40–60	Yes	Yes	Oct. 5–Oct.15

* This seeding rate is for drill seeding; increase rate by 5–20% if broadcast seeding and by 10–30% if aerially seeding.
† In general, the latest planting date range is from northern to southern Wisconsin. For county specific recommendations, use the MCCC Selector Tool.

Table 2. Average aboveground biomass and N uptake for each cover crop and change in plant available nitrogen (PAN) in the spring relative to no cover crop use.

Cover crop	Total aboveground biomass (lb/ac)*	N uptake (lb-N/ac)†	Change in PAN (lb-N/ac)‡
Annual ryegrass	970	26	-5
Spring barley	1,210	46	-10
Winter rye	2,150	54	-40

* Cover crop biomass for winter rye was measured in the spring prior to chemical termination; biomass for annual ryegrass and spring barley was measured prior to winterkill in the fall.
† N uptake in aboveground biomass.
‡ PAN includes both nitrate-N and ammonium-N and was determined in the upper 2′ of soil 10 days before corn was planted; the change in PAN is the difference between the PAN in cover cropped plots minus the PAN in plots without cover crops. See study inset on page 3 for details.

Cover crop options following corn silage

Corn silage harvest removes a lot of biomass from the production system, exposing the soil to erosion losses and depleting the soil organic matter. Planting cover crops following corn silage harvest can control erosion and return some carbon to the soil. The late summer corn silage harvest date limits cover crop options to grass varieties because of their cold tolerance. Grass cover crop options and management information for Wisconsin are shown in table 1.

A Wisconsin Fertilizer Research Program-funded research project (page 3 inset) has evaluated growth and N uptake of three popular cover crops: winter rye (which survives Wisconsin winters), annual ryegrass (which sometimes survives Wisconsin winters), and spring barley (which rarely survives Wisconsin winters).

The results showed that winter rye averaged over 2,000 lb/ac of dry matter biomass with aboveground biomass uptake of over 50 lb-N/ac, averaging twice the growth and over twice the N uptake compared to annual ryegrass (table 2). Spring barley produced 40% less biomass than winter rye but nearly the same N uptake (46 lb-N/ac) (table 2).

From a water quality perspective, the research found that there was 40 lb/ac less plant available N (PAN; comprised of both ammonium and nitrate) in the soil when a winter rye cover crop was used compared to no cover crop (table 2). Less N in the soil following winter rye means that the N is "trapped" in the rye biomass, unable to be washed out of the field. Winterkilled cover crops (spring barley and annual ryegrass) did not have as big of an effect, likely due to the fact that growth was limited to the fall only and no additional N uptake in the spring occurred.

Cover crops and nutrient management

While using cover crops to trap N in the field is beneficial from a water quality perspective, there are potential trade-offs with fertilizer need and management for the next corn crop. For example, in the Wisconsin study, since N in the rye biomass is not expected to become plant available for the next corn crop and there are large reductions in PAN at the time of planting, additional inorganic N fertilizer may be required to optimize corn yield. Table 3 gives N credit recommendations based on system cover crop biomass.

Table 3. Adjustments to manure N availability estimates based on the amount of cover crop biomass.

Cover crop biomass (lb/ac)	Estimated N uptake (lb/ac)	Amount to adjust manure N credit (lb/ac)
<1,000	<25	No adjustments needed
1,000–2,000	25–45	Subtract 35 lb/ac from manure N credit if winter rye was used*
>2,000	>50	Do not take any manure N credit†

* There was no clear effect when winterkilled cover crops were used based on Wisconsin research (inset).
† This recommendation applies to manure N applications up to 100 lb/ac of available N.

Recent Wisconsin research (page 3 inset) has determined that when cover crop biomass is less than 1,000 lb/ac of dry matter, there will be little influence on nitrogen management. This appears to be an ideal amount of biomass as it provides a fair amount of soil protection (figure 1 and figure 2A) while not taking up too much N (typically less than 25 lb-N/ac) (table 3). The recommended practice for keeping biomass below 1,000 lb/ac is to terminate the cover crop as early as possible in the spring.

When cover crop biomass exceeds 1,000 lb/ac of dry matter at the time of termination (via chemical termination or winterkill), adjustments to nitrogen fertilizer application are needed. When winter rye cover crop biomass is between 1,000 and 2,000 lb/ac of dry matter, subtract up to 35 lb-N/ac from the manure N credit. This means an additional 35 lb-N/ac of N from another source may be required to optimize corn yield. This recommendation is only for winter rye, as the requirement for more N tends to be negligible when spring barley is used. The photos in figure 1 and figure 2 can be used to visually estimate the biomass of your cover crop. Also, it may also be worthwhile to use presidedress nitrate tests (Laboski and Peters 2012) when using winter rye with manure applications to verify the N credit of the manure.

When cover crop biomass exceeds 2,000 lb/ac of dry matter, the N from the manure that is typically available to the corn crop is reduced to zero. In this case, the cover crop functions similar to any other crop by taking up all the N that was supplied. While the rye provides a huge benefit to water quality, the cover crop steals too much N from the next crop and perhaps creates conditions where N immobilization is occurring. Immobilization occurs when soil bacteria consume PAN in order to break down grass biomass, reducing the amount of N in the soil that is available for the plant. Under these conditions, no manure N credit should be taken when building nutrient management plans.

Recommendations for managing cover crops

Farmers should always terminate their cover crops as early in the spring as possible, ideally between 6 and 12" tall. It is important to monitor cover crop growth in the fall to anticipate if an early spring termination will be necessary. If cover crop biomass in excess of 2,000 lb/ac of dry matter cannot be avoided, then consider harvesting the winter rye as a winter silage crop (Stute et al. 2007), although herbicide use will need to be considered (Smith et al. 2019). From a nutrient management perspective, the nutrients in the manure would count toward this winter silage crop and not the subsequent corn crop (Laboski and Peters 2012). If unable to terminate early or harvest as a winter silage crop, although available N is reduced or eliminated, the cover crop biomass returned to the soil will replenish soil organic matter and help to maintain soil biological activity.

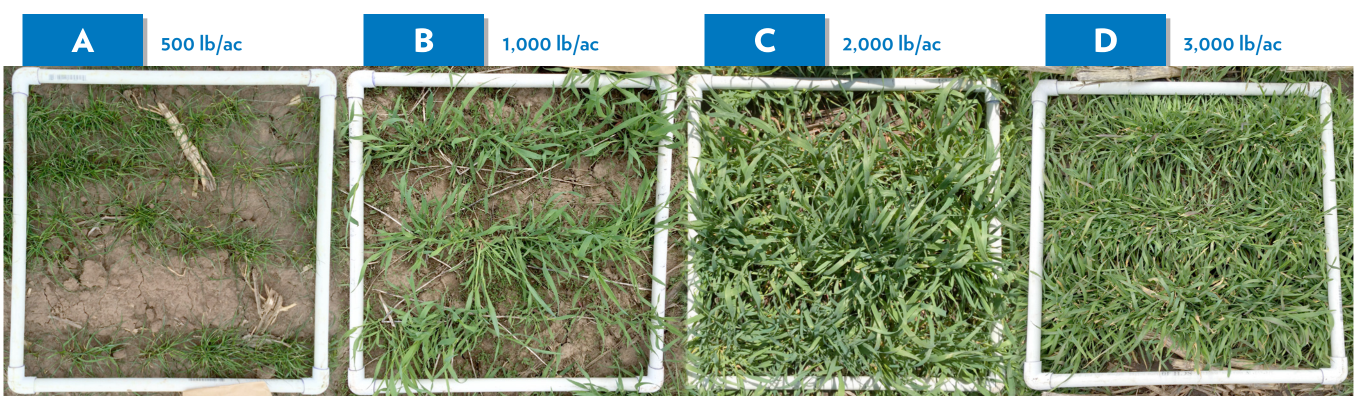

Figure 1. Overhead view of grass cover crop biomass representing (A) 500 lb/ac; (B) 1,000 lb/ac; (C) 2,000 lb/ac; and (D) 3,000 lb/ac of dry matter biomass. A 2'×2' PVC square is provided for reference.

Cover crops and corn yield

Research in Wisconsin (inset) and Iowa (Pantoja et al. 2015; Practical Farmers of Iowa 2019) has shown that although there is potential yield loss when corn is planted following a grass cover crop, this risk appears to be dependent on the amount of cover crop biomass at the time of termination. Plot-level research in Wisconsin (inset) and Iowa (Pantoja et al. 2015) indicates yield loss can occur when cover crop biomass exceeds 1,000 lb/ac, with most yield losses being between 2 and 10 bu/ac. In contrast, field-scale strip trials conducted by the Practical Farmers of Iowa with experienced cover croppers have shown the risk to corn yield can be low, with yield reductions occurring in only 5 of 39 studies. In Wisconsin, large yield losses (>15 bu/ac) were associated with very large biomass amounts (over 2,000 lb/ac) and when the corn planter had difficulty planting into high residue, non-tilled conditions.

FIELD RESEARCH *in* WISCONSIN

The field research used to inform this publication was conducted in Wisconsin between 2014 and 2017 to investigate how grass cover crops planted after liquid dairy manure application influenced subsequent corn yields and response to N fertilizer. At Arlington, Lancaster, and Marshfield Agricultural Research Station test plots, the cropping system included a corn silage harvest followed by liquid dairy manure application (at a targeted rate of 10,000 gal/ac applying ~72–100 lb-N/ac; a low solid liquid manure was used at Marshfield applying 25 lb-N/ac), and then planting (drill seeding) three cover crop species. The cover crops studied were winter rye (at 90 lb/ac of pure live seed (PLS)), annual ryegrass (at 13 lb/ac of PLS), and spring barley (at 80 lb/ac of PLS). Winter rye was chemically terminated in the spring, annual ryegrass in one instance survived winter and was chemically terminated in spring (but in all other times winterkilled), and spring barley always winterkilled. Cover cropped plots were compared to plots without cover crops. Winter rye biomass was collected in the spring and annual ryegrass and spring barley was collected in the fall. Soil was collected at 0–12" and 12–24" 10 days prior to corn planting and analyzed for nitrate (NO_3^-) and ammonium (NH_4^+). Corn was no-till planted with starter N fertilizer in all plots on the same day, approximately 10 days after termination of the winter rye. The plots received various fertilizer rates over the season (six rates up to 240 lb-N/ac) and then harvested for grain. New plots were established each year; cover crop cumulative effects were not measured. The research was funded by the Wisconsin Fertilizer Research Program.

A

B

Figure 2. Field view of winter rye cover crop with (A) 1,000 lb/ac and (B) 2,000 lb/ac of dry matter biomass.

Recommendations to decrease chance of yield loss

- When planting corn, consider using row cleaner attachments to increase soil warming around the seed. Check planting depth and seed furrow closure shortly after beginning to plant in order to make necessary adjustments.
- Terminate as early in the spring as possible and wait 10 or more days before planting corn.
- Use starter fertilizer, ideally as with a 2″×2″ placement that includes N at a rate of 30–40 lb-N/ac.
- Where wet conditions delay ideal termination timing of the cover crop, it may be better to plant corn into standing rye biomass shortly after spraying to avoid planting into a wet soggy mat of biomass.

Conclusions

Using cover crops following corn silage harvest and manure application provides an excellent way to reduce erosion, build soil health, and trap nitrate that may otherwise leach into groundwater. However, in Wisconsin there are trade-offs between cover crop growth and agronomic and nutrient management. Since cover crops require extra field work in the fall and spring, farmers must be aware of these trade-offs and utilize best management practices to prevent economic loss. The biggest agronomic risk arises from overabundant cover crop biomass, so it is important to monitor cover crop growth and have plans to terminate or harvest the biomass as well as alter N management practices as necessary.

References

Laboski, C.A.M. and J.B. Peters. 2012. *Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin*. University of Wisconsin–Madison Division of Extension Publication A2809. **https://learningstore.extension.wisc.edu/products/nutrient-application-guidelines-for-field-vegetable-and-fruit-crops-in-wisconsin-p185**.

Midwest Cover Crops Selector Tool. 2019. **http://mccc.msu.edu/covercroptool/covercroptool.php**.

Pantoja, J.L., K.P. Woli, J.E. Sawyer, and D.W. Baker. 2015. *Corn nitrogen fertilization requirement and corn-soybean producitivity with a rye cover crop*. Soil Sci. Soc. Am. J. 79:1482–1495. Available open access: **https://dl.sciencesocieties.org/publications/sssaj/articles/79/5/1482**.

Practical Farmers of Iowa (PFI). 2019. *Winter cereal rye cover crop effect on cash crop yield*. **https://practicalfarmers.org/wp-content/uploads/2019/01/18.FC_.CC.Winter_Rye_Effect_on_Yield_Year_10.pdf**.

Smith, D.H., M. Broeske, J. Patton, K. Shelley, F. Arriaga, B. Jensen, M.C. Oliveria, B. Briski, B. Bubolz, R. Rushmann, H. Johnson, G. Schriefer, and M. Sorge. 2019. *Cover Crops 101*. University of Wisconsin–Madison Division of Extension Publication A4176. **https://learningstore.extension.wisc.edu/products/cover-crops-101**.

Smith, D.H., R. Proost, M.C. Oliveira, R. Dewerff, and R. Werle. 2019. *Herbicide rotation restrictions for cover crop and forage cropping systems*. UW Nutrient and Pest Management Program. **https://ipcm.wisc.edu/download/pubsPM/2019_RotationalRestrictions_final.pdf**.

Stute, J., K. Shelley, D. Mueller, and T. Wood. 2007. *Planting winter rye after corn silage: Managing for forage*. UW Nutrient and Pest Management Program, Publication I-0907-5C. **https://fyi.extension.wisc.edu/forage/planting-winter-rye-after-corn-silage-managing-for-forage**.

Thapa, R., S.B. Mirsky, and K.L. Tully. 2018. *Cover crops reduce nitrate leaching in agroecosystems: A global meta-analysis*. J. Environ. Qual. 47:1400–1411.

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