Southern Cover Crops
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Nitrogen Release from Cover Crops

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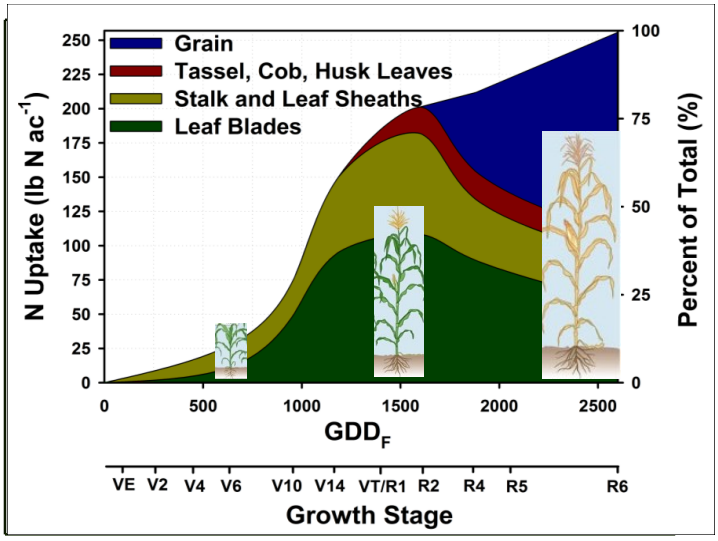

Fig. 1. Visualization of corn nitrogen demand at different growth stages. Adapted from Bender et al. 2013. Better Crops with Plant Food 97 (1):7-10.

Nutrient management is a timely agricultural topic that boils down to determining the right rate, source, timing, and placement of nutrients. Nitrogen is of particular concern because it is highly mobile in the environment. It readily leaches down through the soil, runs off into surface water, and volatilizes into the atmosphere. By minimizing nitrogen loss from their cropping systems, farmers can minimize their environmental impact while lowering the cost of production by increasing nitrogen efficiency.

Cover crops can greatly influence nitrogen management either by providing available nitrogen for cash crops or by immobilizing nitrogen and creating the need for greater nitrogen fertilizer for cash crops. The amount of nitrogen available from cover crops and the timing of its release is complex. Nitrogen availability from decomposing cover crops is affected by plant biomass quantity and quality, species mixture composition, cover crop management (i.e. termination timing), and climate. Ultimately, the goal is to maximize nitrogen efficiency by decreasing nitrogen loss from the system and maximizing synchronization between nitrogen release from cover crop biomass and corn nitrogen demand (Fig. 1).

Factors Affecting Nitrogen Accumulation and Release

In order to estimate the amount of nitrogen that could be released from a cover crop, you first need to know how much nitrogen the cover crop potentially accumulated in its tissues. Grasses (i.e. cereal rye—*Secale cereale*) and broadleaves (i.e. forage radish—*Raphanus sativus*) scavenge residual nitrogen from the soil. The potential for grass and broadleaf cover crops to accumulate nitrogen is thus partly dependent on the soil fertility in a field. In a field with low residual fertility such as after a highly productive corn crop, such cover crops may not accumulate much nitrogen and thus will have less nitrogen to release to a following cash crop. Legumes (i.e. hairy vetch— *Vicia villosa*) fix nitrogen from the atmosphere and thus legume nitrogen accumulation is less dependent on residual soil fertility. With all cover crops, however, nitrogen accumulation is also dependent on biomass production. A cover crop that has produced little biomass will likewise have accumulated less nitrogen than a more robust cover crop.

Nitrogen release is also dependent on cover crop biomass quality. Cover crops with high carbon to nitrogen (C:N) ratios accumulate relatively large amounts of C compared to N while cover crops with low C:N ratios accumulate less C compared to N. Grasses such as cereal rye typically have high C:N ratios (>25:1) and tissue nitrogen concentrations of 1-2%. Legumes such as crimson clover (*Trifolium incarnatum*) typically have low C:N ratios (<20:1) and tissue nitrogen concentrations of 3-4%.

TABLE 1. Low,- mid-, and high-range biomass production estimates, C:N ratio, and total N accumulation of grasses and legumes .

Species	Cover Crop Biomass (lb ac^{-1})			C:N Ratio	Total N
Grasses	*low range*	*mid range*	*high range*		
- Tillering	300-700	700-1100	1100-1500	18:1	~20
- Stem elongation	1000-1600	1600-2400	2400-3000	24:1	~30
- Boot	1500-2500	2500-3500	3500-4500	35:1	~46
- Anthesis	2000-4250	4250-6750	6750-9000	50:1	~54
Legumes					
- Early termination	1000-2000	2000-3000	3000-4000	13:1	~122
- Mid termination	3000-4000	4000-5000	5000-6000	13:1	~153
- Late Termination	4000-5000	5000-6000	6000-7000	13:1	~166

Broadleaf cover crops such as forage radish and phacelia vary, but typically have low to moderate C:N ratios. The ratio of C:N in a given cover crop can vary with growth stage, especially in grasses. Cereal rye at the tiller stage will have a lower C:N ratio than cereal rye at anthesis (flowering). Cover crops with high C:N ratios are slow to decompose and risk depriving a following cash crop of timely needed nitrogen through nitrogen immobilization in the soil. Cover crops with low C:N ratios decompose quickly and thus risk loss of the nitrogen from the system (i.e. through leaching) before a following cash crop could make use of it.

Cover crop mixtures (Fig. 2) are useful because they allow you to "balance" the cover crop C:N ratio, increasing the likelihood that nitrogen will be available at the time of highest cash crop demand, such as V6 in corn (Fig. 1). In cover crop mixtures, potential nitrogen accumulation and subsequent release is dependent on the species composition. A mixture in which grasses such as annual ryegrass (*Lolium multiflorum*) dominate will have a higher C:N ratio than a mixture in which legumes such as winter pea (*Pisum sativum* subsp. *arvense*) dominate. A cover crop mixture with a moderate C:N ratio of roughly 25:1 strikes a balance between preventing nitrogen loss while also avoiding long-term soil nitrogen immobilization. For more information about cover crop mixtures, please see the Cover Crop Mixture Selection and Management fact sheet.

Cover crop management likewise influences potential for nitrogen accumulation and release. Any management activity that influences cover crop biomass accumulation and/or C:N ratio may affect subsequent nitrogen release. The application of fall fertilizer or organic amendments to a grass or broadleaf cover crop may increase nitrogen accumulation and potential release. Cover crop planting can affect nitrogen release, because earlier planting in the fall generally maximizes biomass and thus nitrogen accumulation. Spring cover crop termination timing can likewise affect cover crop nitrogen release. Legumes that are terminated early have less time to fix nitrogen and so have less nitrogen to potentially provide to a following cash crop. Cover crop species with high C:N ratios at maturity

Fig. 2. An oats and crimson clover cover crop ready to be terminated. Photo by Julia Gaskin

may be terminated early (i.e. at tillering rather than anthesis) to decrease the risk of nitrogen immobilization in the soil.

Finally, climate influences nitrogen release because of its effect both on cover crop growth and nitrogen accumulation, and because it affects the microbes that break down cover crop biomass to release nitrogen. Most microbes thrive in warm, damp but not saturated soils. Under such conditions, nitrogen release will occur more quickly than under cold, dry conditions.

The Keys to Maximizing Nitrogen

There are several things farmers can do to make sure that they are getting the most nitrogen out of a cover crop. First, treat your cover crop like a crop. This means using good quality seed, the right seeding rate, and timely planting with good seed soil contact so you obtain a good stand. Deal with weeds and weed seeds before you plant the cover crop. Plant just before a rain or irrigate the cover crop so it gets a good start. If you are planting legumes, use a fresh inoculant and make sure you are using the right inoculant for the legume species planted. This is just good insurance to maximize the amount of nitrogen fixed by the cover crop. All these practices will help you get a good stand that will maximize biomass. Finally, terminate the legume at mid-bloom when the cover crop contains the most nitrogen. If you are concerned about nitrogen immobilization due to a cover crop with a high C:N ratio, consider terminating it prior to anthesis when the C:N ratio is relatively low. Also consider growing a cover crop mixture of at least one species with a high C:N ratio (i.e. cereal rye) and one species with a low C:N ratio (i.e. hairy vetch) to balance the C:N ratio and maximize total biomass accumulation and nitrogen accumulation.

Fig. 3. Mustards are broadleaf cover crops with a low to moderate C:N ratio. Photo by Steven Mirsky

Fig. 4. Like all legumes, winter pea (pictured) will accumulate more nitrogen the longer it is left to grow. Photo credit: Steven Mirsky

Tools to Predict Available N from Cover Crops

Predicting the amount of nitrogen provided by a cover crop can be difficult due to the combination of factors that affect nitrogen release. In the past, rules of thumb such as half the total nitrogen in the cover crop when it is incorporated have been used to get a rough estimate. A new tool is being developed to predict available nitrogen from the cover crop based on the aboveground biomass of the cover crop and cover crop quality (percent nitrogen, carbohydrates, cellulose and lignin) along with soil temperature and moisture from nearby weather stations. The Cover Crop Nitrogen Availability Calculator has been tested in several research and farm settings. Results indicate that the Calculator can be used to modify nitrogen fertilizer management without sacrificing yields. See the Cover Crop N Availability Calculator Field Demo Fact sheet for more information.

The Farmer's Perspective

Cover crops are an essential part of fertility management at JRH Grain Farms. The farm regularly uses cover crop

mixtures to build soil, suppress weeds, and keep nutrient available to cash crops. For example, a mixture of grains is used before a soybean crop (Fig. 5 and 6). Nutrient cycling can be one of the toughest things for a farmer to predict, but with patience and practice, you develop an eye for watching cover crops breakdown and estimating the release to the cash crop. AT JRH Grain Farms, we start with taking biomass samples before termination and sending these off for nutrient analysis. We plan on 50% of the nitrogen and 75% of the phosphorus and potassium being released during to growing season to the cash crop. If we are taking a nutrient credit, we follow up with a plant tissue test during the growing season and in corn, we use a Stalk Nitrate tissue test after black layer to confirm our changes in fertility management.

Summary

Cover crops play an important role in fertility management on the farm by scavenging nitrogen that would otherwise be lost to the system and in the case of legumes fixing additional nitrogen. Maximizing biomass is key in obtaining the most nitrogen from the cover crop. Timely planting, termination as late as practical as well as treating the cover crop similar to a cash crop will help maximize biomass. There are a number of factors that affect nitrogen release to the cash crop. Soil sampling, measuring cover crop biomass and quality, as well as tissue sampling in cash crops can help farmers better manage this important fertility resource.

Fig. 5. Russell Hedrick of JRH Grain Farms in North Carolina standing in a mixed grain cover crop that will be planted into soybeans. Photo by Russell Hedrick

Fig. 6. Soybeans at the JHR Grain Farms in North Carolina coming up through the mixed grain cover crop. Photo by Russell Hedrick

References

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