Cover Crops Impacts on Louisiana Corn Production and Soil Properties

Ina Sanchez, Lisa M. Fultz,* Josh Lofton, and Beatrix Haggard

ABSTRACT

Conventionally managed, continuous monoculture row-crop production has depleted the soil of nutrients, organic matter, and overall productivity. This has increased the need for external inputs, specifically N, to meet crop demand. Despite the growing interest in conservation practices, including minimal tillage and cover crops, little work has been reported in the Mid-South region. Cereal rye (Secale cereale L.), forage radish (Raphanus sativus var. longipinnatus L.), berseem clover (Trifolium alexandrinum L.), crimson clover (Trifolium incarnatum L.), winter pea (Pisum sativum L.), hairy vetch (Vicia villosa Roth), and a cereal rye–forage radish mix were seeded in discrete blocks in October 2014, 2015, and 2016 along with a non-cover fallow. Each block was divided into 16 sub-plots to which one of four N fertilizer rates (0, 235, 268, and 302 kg N ha⁻¹) were applied. Corn (Zea mays L.) grain yields increased with additions of N fertilizer; however, no difference was observed between the three fertilizer rates in 2 of 3 yr. Cover crops aided in the uptake and recycling of inorganic N, potentially reducing losses and providing N for subsequent cash crops. Following legume cover crops, corn grain yields were maximized with the addition of 235 kg N ha⁻¹. Inclusion of grass and brassicas with no additional N input reduced corn grain yield, which remained lower than yield measured following legumes up to the 302 kg N ha⁻¹ rate. Secondary benefits of cover crops included increased soil C (36%) and N (22%), and N cycling over a 2-yr period.

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due to decreased soil stability and erosion have the potential to make corn production systems less favorable. This necessitates alternative management practices that will maintain or increase productivity while conserving the system's resources. To address this problem, conservation practices must be adopted and included as a vital part of system management.

Combining conservation practices, such as conservation tillage and cover crops, in agronomic systems is one of the many alternatives available to producers. Conservation tillage reduces disturbance of the soil ecosystem, increasing soil organic matter, soil stability, water infiltration, and nutrient cycling (Beare et al., 1994; Six et al., 1999). Cover crops are planted during the fallow period between cash crops and, though initially used to reduce soil loss by erosion (Weil and Kremen, 2007), they provide a suite of secondary changes. These changes include improved pest suppression and buildup of natural predators (Tillman et al., 2004; Lundgren and Fergen, 2010; Hooks et al., 2013), and increasing soil nematode communities, not only harmful, but also beneficial taxa (Ito et al., 2015). Cover crops also increase and affect both physical (Nascente et al., 2013) and chemical (Ding et al., 2006) properties of soil organic matter, increasing total C and N, thereby influencing nutrient cycling in the soil system (Mazzoncini et al., 2011; Blanco-Canqui et al., 2013; Hubbard et al., 2013). However, it is possible that the benefits associated with cover crops may become localized in conservation tillage systems, with the majority of biomass buildup at the soil surface. For this reason, investigations of the impacts of conservation tillage and cover crops usage in surface soils is necessary.

In systems with high fertilizer demand, such as corn, efficient management of N is a priority, with the goal of reducing N losses and a reduced dependency on inorganic fertilizer applications. Depending on the species, cover crops can contribute to N cycling through the uptake of residual N or by adding N to the system through N fixation, potentially reducing dependency on inorganic fertilizer applications. Grass cover crop species are efficient in capturing and using residual N (Brinsfield and Staver, 1991; Shipley et al., 1992; Kramberger et al., 2009). Legumes also scavenge residual N in addition to supporting N fixing bacteria in the soil, potentially adding N to the soil ecosystem and significantly impacting N management of successive cash crops (Kuo and Jellum, 2002; Rosolem et al., 2004; Parr et al., 2011). For example, the use of monocultures of grasses, brassicas, and legumes as cover crops reduced soil NO$_3^-$ -N by 10 to 20 kg ha$^{-1}$ during the fallow period, which was recycled following cover crop termination (Baggs et al., 2000). If not managed correctly within the agroecosystem, however, the buildup of soil N following cover crop termination may lead to increased N losses following ammonification and nitrification to the more mobile NO$_3^-$ form (Kuo et al., 1997; Poffenbarger et al., 2015).

Cover crop selection based on geographic location and climate is essential to facilitate efficient N uptake capacity of the cover crops and their potential benefits to row-crops. In the semiarid Texas High Plains, combining conservation tillage with cereal rye (Secale cereale L.) cover crops reduced cotton yields when compared with conventional tillage (Lewis et al., 2018). However, in sandy coastal plain soils, the integration of black oat (Avena strigose Schreb.) resulted in increased cotton yields (Schomberg et al., 2006). In Arkansas, although the use of cereal cover crops aided in weed management by reducing populations of Palmer amaranth (Amaranthus palmeri L.), pitted morningglory (Ipomoea lacunosa L.), and goosegrass (Galium aparine L.), there was no difference measured in cotton yields compared with fallow treatments (Norsworthy et al., 2011). In an oxisol in Parana Brazil, yield response to cover crops differed depending on the cash crop. When compared with winter fallow treatments, soybean (Glycine max (L.) Merr.) yields were highest following a black oat cover crop (2.0 vs. 2.7 Mg ha$^{-1}$, respectively), corn responded better to a white lupine (Lupinus albus L.) cover crop (5.1 vs. 6.4 Mg ha$^{-1}$, respectively), and kidney bean (Phaseolus vulgaris L.) yield increased under black oat and oilseed radish (Raphanus sativus L. var. oleifera) (0.4 vs. 0.7 Mg ha$^{-1}$, respectively) (Derpsch et al., 1986). This variation in response to cover crops by cash crops necessitates extensive examination of cover crops across a variety of environmental conditions.

Although research on the effects of cover crops on different production systems and geographic regions is ongoing and increasing, the integration of cover crops in Mid-South humid subtropical production systems is still recent, and more information is needed to enable effective decision making by producers. It was expected that alternative production practices would lead to more efficient use of resources while maintaining and increasing the long-term fertility and productivity of the soil. The objective of this trial was to evaluate the effects of cover crops and N fertilizer rates on corn grain yield, yield characteristics, and soil chemical properties in a conservation tillage corn production system.

**MATERIALS AND METHODS**

**Site Description and Treatments**

The field study was conducted in 2014 through 2016 at the Louisiana State University AgCenter’s Macon Ridge Research Station near Winnboro, LA (32°09'48" N 91°43'24" W). The soil at the research station is classified as a Gigg–Gilbert silt loam (finely-silty, mixed, thermic Typic Fragiudalfs) (Soil Survey Staff, 2010). The area received an average rainfall of 185 cm and average high and low temperature of 25 and 13°C, respectively (Fig. 1).

Treatments included six monoculture cover crops, one cover crop mix, and a fallow control combined with four N fertilizer application rates (0, 235, 268, and 302 kg N ha$^{-1}$) applied as urea (46-0-0) for a total of 32 treatments. Cover crop species consisted of cereal rye planted at 78.5 kg ha$^{-1}$, forage radish (Raphanus sativus var. longipinnatus L.) planted at 10.1 kg ha$^{-1}$, crimson clover (Trifolium incarnatum L.) planted at 22.4 kg ha$^{-1}$, and winter pea (Pisum sativum L.) planted at 44.8 kg ha$^{-1}$, hairy vetch (Vicia villosa Roth) planted at 22.4 kg ha$^{-1}$, and a cereal rye–forage radish mix planted at 72.9 and 4.5 kg ha$^{-1}$, respectively. A fallow plot served as a control treatment with native winter vegetation composed mostly of henbit (Lamium amplexicaule L.) and reygrass (Lolium spp.), which was left uncontrolled through the fallow period. The field, measuring 0.72 ha, was divided into eight equal blocks within which one type of cover crop was planted. Cover crops were seeded in mid-October in 2013, 2014, and 2015 by broadcast seeding using a Gandy 10T-series drop spreader (Gandy Company, Owatonna, MN) and shallowly incorporated using a custom-fabricated row shaper. No further application of fertilizer, herbicide, or pesticide until the first of February. Winter temperatures in the Mid-South were not...
sufficient to cause a natural termination of the cover crops; therefore, 6 wk prior to intended corn planting, approximately 1 February of each year, cover crops were terminated with an application of 2,4-D amine (2,4-dichlorophenoxyacetic acid) and glyphosate (Roundup PowerMAX; N-phosphonomethylglycine) at a rate of 0.5 and 1.5 kg a.i. ha\(^{-1}\), respectively. Following termination, each of the eight cover crop blocks were further divided into 16 sub-plots (4 reps × 4 N fertilizer rates). Each sub-plot measured 13.7 m in length and 4 m in width with 1-m row spacing. Plots were sown with Pioneer 1319HR corn at the rate of 79,040 plants ha\(^{-1}\) using a John Deere MaxEmerge 2 (John Deere Manufacturing Co., Moline, IL) planter. The N fertilizer rates were hand-applied to the corn crop at first true leaf (V1; Hicks and Thomison, 2004) to ensure adequate stands were achieved and incorporated within 48 h of application with at least 1.25 cm of rainfall or irrigation. Phosphorus and K were applied in mid-February at a rate of 67.3 kg ha\(^{-1}\) as triple superphosphate (0–46–0) and potassium chloride (0–0–60), respectively. A Kincaid 8-XP (Kincaid Equipment, Haven, KS) plot combine was used to harvest the two middle rows of each sub-plot. Grain yields were collected at harvest in August 2014, 2015, and 2016. Within each sub-plot, a small subsample was collected and used to evaluate grain moisture. A Dickey–John Grain Moisture Meter (Dickey–John Corp., Auburn, IL) was used to determine grain moisture immediately following harvest. Seed moisture was used to adjust grain yields to 15.5 g kg\(^{-1}\). Seed density was assessed by determining the 100-seed weight and from random grain samples collected from each sub-plot.

**Litter Bag Study**

In February 2015, 40 nylon rumen bags of mesh size 50-μm (model R510; Ankom Technologies, Macedon, NY) were filled with a known weight of cover crop biomass collected from each cover crop block prior to termination. The technique was based on the buried-bag technique by Golden et al. (2009). To determine the amount of residue to place in the bag, five residue samples from a 5 × 10 cm area for each cover crop treatment were collected. The average weight was used to fill the rumen bags with a representative biomass for each respective cover crop during that specific growing season. The weight of the rumen bags containing the plant material was recorded. The top of the bag was then folded, heat sealed, and labeled with an aluminum tag attached to fishing line with a 7 cm piece of 2-cm diameter PVC pipe. The PVC pipe was color coded to denote sampling times that occurred during the summer growing season. The final weight of the bag + biomass + tag + fishing line + PVC pipe was recorded. Bags were buried along the center two rows of the four-row plot at a depth of 2.5 cm in the subplots receiving 0 and 268 kg N ha\(^{-1}\) in their respective cover crop sections. One bag from each subplot was extracted every month for 5 mo (March–July 2015). Retrieved bags were washed to remove soil, dried at 65°C, and the contents were weighed and submitted, for C and N analysis, via high-temperature induction furnace dry combustion analysis using a Leco TruSpec CN analyzer (St. Joseph, MI). Carbon and N results for March (1 mo post burial) were not included in the final analysis due to collection errors.

**Soil Sampling and Analysis**

Soil samples were collected from 0 to 10 cm using a 5-cm diameter soil probe following corn harvest but before cover crop planting (October 2014, 2015, and 2016). This depth was selected to capture the direct impact of cover crop residue in a conservation tillage corn production system on soil surface conditions. Plots were also sampled after cover crop termination but before corn planting (late-February 2015 and 2016). Six soil samples were collected from each sub-plot, three from between planting rows and three from the harvested rows and composited. Samples were air-dried at room temperature for 5 d, sieved to <2 mm, and submitted for further analysis.

Soil samples were analyzed for soil pH (1:1 in deionized water) and total C and N via high-temperature induction furnace dry combustion analysis using a Leco TruSpec CN analyzer (Nelson and Sommers, 1996). Inorganic N (NO\(_3^–\)–N and NH\(_4^+\)–N) was extracted from 1 g of soil using 10 mL of 1 M KCl and analyzed using a flow injection analyzer (Lachat Quickchem 8500; Loveland, CO). Soil moisture was determined gravimetrically using convective oven drying. The modified hydrometer method as described in Grossman and Reinsch (2002) was used to determine particle-size distribution of the soil samples. Soil texture was determined using the USDA soil textural triangle as a silt loam with 9% sand, 16% clay, and 75% silt.

![Fig. 1. Average monthly high and low temperatures and total monthly precipitation from October 2014 through October 2016.](image_url)
Data Analysis

Statistical analyses were performed on soil, biomass, and corn variables using PROC MIXED in SAS 9.4 (SAS Institute, 2012). Mean separation was done using Tukey’s Honestly Significant Difference (HSD) method at a 5% confidence level. A formal test could not be done to evaluate the main effect of individual cover crops. For this reason, cover crop treatments were grouped by type, i.e., legumes (berseem clover, crimson clover, hairy vetch, and winter pea) and grass and brassicas (cereal rye, radish, and cereal rye–radish mix). As the fallow treatment was not replicated it was not included in the statistical analysis; however, values were provided for qualitative comparison. The means model used for the soil and corn output response variables included cover crop type, N application rate, and sampling time.

RESULTS

Treatment and Sampling Dates Effects on Corn Production

Corn grain yield, averaged across cover crops and N fertilizer rate, decreased from 11.7 Mg ha⁻¹ in 2014 to 8.6 Mg ha⁻¹ in 2016 (P < 0.0001). Average seed weight also decreased from 29.6 to 22.5 g 100 seeds⁻¹ in 2014 and 2016, respectively (P < 0.0001). Significant decreases in grain yield (P < 0.0001) and 100-seed weights (P < 0.0001) were found comparing 2014 and 2015, with the exception of 100-seed weights at the 302 kg N ha⁻¹ N application rate. In 2014 and 2016, corn grain yields significantly increased from the non-applied check plots to the 235 kg N ha⁻¹ but did not significantly increase with additional fertilizer application (Table 1). In 2015, significantly increased yields were noted up to 268 kg N ha⁻¹ with no further increase at the 302 kg N ha⁻¹ application rate. Where no N applications were made, corn grain yield was 52% greater following legumes compared with the grass and brassica cover crops treatment (Table 1). Following legume cover crops, significant yield increases were measured with applications of 235, 268, and 302 kg N ha⁻¹ compared with the 0 kg N ha⁻¹ treatment; however, no yield increases were measured between the three N fertilizer application rates. Conversely, when following grass and brassica cover crops, significant yield increases were noted at 235 and 268 kg N ha⁻¹ and again at the 302 kg N ha⁻¹ application rate. No significant yield effect (P = 0.0723) was found between sampling year when evaluated within cover crops.

Litter Bag Study

As expected, cover crop residue C/N ratio increased from 10.8 at 8 wk post-termination to 13.7 by 20 wk post-termination (P < 0.0001). What was unexpected was the narrower C/N ratio of the grass and brassica residue (11.4) when compared with the legume residue (13.2) (P < 0.0001). Without initial N concentration measurements, it was not possible to calculate N release curves from the time of termination; however, N content for cover crop residue continued to decreased significantly over time (Fig. 2) for both the legume (P < 0.0001) and grass and brassica (P < 0.0001) residues. Decreases in N concentration were greatest in grass and brassica treatments, decreasing from 34.5 to 15.5 g kg⁻¹, whereas N concentrations in legume residue decreased from 31.7 to 20.6 g kg⁻¹ (Fig. 2).

Treatment Effects on Soil Chemical Properties

Soil pH levels ranged from 5.7 to 6.5 and were lowest under legumes (6.0) compared with grass and brassica (6.2) cover crops (P < 0.0001). As expected, soil pH decreased with addition of urea-based N fertilizer over time (P = 0.0267). This decrease was first observed in samples collected in October 2015 across all N fertilizer treatments, after which little to no recovery was measured (Fig. 3). A decrease in soil pH from 6.2 where no fertilizer was applied, to 6.0 at the

Table 1. Effect of N rate, cover crop type, and sampling year on corn grain yield. Standard error in parentheses. Fallow values are provided for qualitative comparison only and were not used in statistical analysis.

<table>
<thead>
<tr>
<th>Sampling year</th>
<th>N rate, kg ha⁻¹</th>
<th>Mg ha⁻¹</th>
<th>0</th>
<th>235</th>
<th>268</th>
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<td>2014</td>
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† Different uppercase letters indicate significant difference (α = 0.05) between N fertilizer rates within sampling year or cover crop type.  
* Different lowercase letters indicate significant difference (α = 0.05) between sampling year or cover crop type with N fertilizer rates.
highest fertilizer application rate of 302 kg N ha\(^{-1}\) was measured \((P < 0.0001)\). Soil organic matter \((P < 0.0001)\), total C \((P < 0.0001)\), and total N \((P < 0.0001)\) were only impacted by sampling date. Soil organic matter increased by 15% \((21.9–25.2 \text{ g kg}^{-1})\) over the course of 2 yr under cover crops and conservation tillage management. In that time total C also increased by 35% \((9.1–12.3 \text{ g kg}^{-1})\) and total N increased by 22% \((1.1–1.3 \text{ g kg}^{-1})\).

Nitrogen fertilizer applications did not impact extractable NO\(_3^–\)-N or NH\(_4^+\)-N concentrations in the soil \((P = 0.1768\) and \(P = 0.8174\), respectively). Nitrate-N, however, was influenced by sampling date \((P < 0.0001)\) and NH\(_4^+\)-N was impacted by cover crop type \((P = 0.0005)\) and sampling date \((P < 0.0001)\). Soil NO\(_3^–\)-N levels were always greatest in the fall following the corn harvest and decreased in the spring of 2015 and 2016 across all treatments (Fig. 4). Ammonium-N levels were significantly reduced in samples collected following the corn harvest but increased following cover crop termination (Fig. 4). Legume cover crops averaged 9% more NH\(_4^+\)-N compared with grass and brassica treatments \((26.4\) and \(24.2 \text{ mg N kg}^{-1}\), respectively).

**DISCUSSION**

The use of inorganic N fertilizers can decrease soil pH, particularly when the fertilizer is ammonium based (Brady and Weil, 2004). Nitrogen was applied in the form of urea and, although its incorporation in the soil initially results in an increase in pH due to the reactions involved in urea hydrolysis (Juo et al., 1995; Chien et al., 2008), its long-term use results in an overall decrease in soil pH. Decreased soil pH in the presence of plant material has also been observed previously in incubation studies (Murungu et al., 2011). This decrease may be linked to residue quality and quantity, as well as the initial pH of the soil (Xu and Coventry, 2003). Nitrification of ammonium released from cover crop residue, specifically that which may contain high N concentrations like legumes, may also contribute to decreases in soil pH (Xu et al., 2006). Soil pH is a major driver of many chemical and biological processes in the soil including nutrient cycling and availability. As soil pH decreases, availability of nutrients such as P, K, S, Ca, and Mg can also decrease. This decrease in pH likely resulted in the decreased soil-available P, Ca, and Mg measured in this trial (Sanchez et al., 2019) and may have contributed to decreased yields measured over time.

Analysis of grass and legume cover crop residue collected 1 month after termination yielded C/N ratios of 16:1 and 14:1, respectively, suggesting the two different types of biomass in this scenario may undergo a similar degradation pattern. The narrow C/N ratio \((<24:1)\) of both legume and grass and brassica cover crops in this study was likely indicative of the current termination recommendations for Louisiana that suggest cover crop termination should occur 4 to 6 wk prior to planting of cash crops. For corn production in Louisiana, this translates to termination occurring around 1 February, which for grasses such as cereal rye, was prior to the joint stage. At this early termination date, the cereal rye biomass resulted in a narrow C/N ratio, similar to that of legume cover crops, and may have a significant impact on nutrient cycling in these systems (Wägger, 1989; Nicolardot et al., 2001; Poffenbarger et al., 2015; Mirsky et al., 2017).

We hypothesize that the early termination of cover crops produced more easily degradable residue and supported the greater rate of loss from the grass and brassica residue, which differs from previous research demonstrating that, compared to hairy vetch, cereal
rye typically results in lower N release, 24 kg N ha$^{-1}$ compared with 60 to 132 kg N ha$^{-1}$ from legumes, with longer degradation intervals (Ranells and Wagger, 1996). Although this increased degradation may be beneficial for subsequent cash crops, termination 4 to 6 wk prior to corn planting may have also resulted in increased available soil NO$_3^-$-N concentrations well before the corn had reached the V6 growth stage when N needs increase (Hanway, 1962; Welch et al., 1971). Additionally, early termination of the legume cover crops, prior to reaching the flowering stage, may have resulted in decreased N concentration in the vegetative biomass and delayed degradation and N release. Due to our sampling schedule it was not possible to determine if this was the case. However, N release curves for cover crops such as crimson clover have shown that as much as 60% of N has been released within 5 wk of degradation (Ranells and Wagger, 1996), with this amount increasing to 80% of N released from hairy vetch (Wagger, 1989; Radietti et al., 2016). Mineralization of N from radishes may produce a more long-term nutrient source with between 50 and 60% of residue N remaining up to 7 mo post termination (Thomsen et al., 2016; Hu et al., 2018). We hypothesize that although continued decreases in cover crop residue N were measured—even after 8 wk of degradation, indicating that active mineralization was ongoing—a majority of the biomass N had already been lost between the time of soil sample collection and corn planting.

Previous research has attributed lower yields following grass and brassica treatments to higher C content of the biomass immobilizing N throughout the growing season and reducing availability to the corn crop (Clark et al., 1997; Ku et al. and Jellum, 2002; Pantozza et al., 2015). In particular, Rukart et al. (2018) demonstrated that although radish cover crops may contribute to N scavenging (70% decrease of NO$_3^-$-N) and increased NH$_4^+$-N by 74% prior to corn planting, they did not consistently benefit corn yields, suggesting that additional interactions may be present. Other research found that higher soil N was found following legume cover crops due to their ability to biologically fix N, adding as much as 90 to 100 kg N ha$^{-1}$ from cover crops like hairy vetch (Ebelhar et al., 1984). In their review of winter cover crops for corn silage production, Ketterings et al. (2015) found that the N fertilizer replacement values for cover crops were not able to offset inherent factors in the addition of cover crops to a production system. However, in systems where high mineralization is possible, rates of conversion may reduce the benefits associated with the inclusion of cover crops like clovers, where N may be easily lost. It is therefore essential that time of termination of cover crop management, corn grain yields decreased from 2014 to 2015, to improve the timing of N release relative to cash crop uptake would result in this measured reduction in NH$_4^+$-N measured following corn harvest. Ammonium-based fertilizers and decomposing organic matter, such as that from cover crops, are potential sources of the NH$_4^+$ fraction of soil inorganic N (Bronson, 2008). The increase in soil NH$_4^+$-N observed in February samples (i.e., after cover crop termination) likely stems from cover crop and corn residue decomposition, as samples were collected before N fertilizer applications. As soil conditions were conducive to nitrification, high spring rainfall and subsequent losses due to leaching of the more mobile NO$_3^-$-N and/or runoff of surface NH$_4^+$-N (Shipley et al., 1992; Faber, 1995) may have contributed to the overall decreased yields measured in 2015 and 2016. Similarly, lower overall N concentrations from the grass and brassica treatments likely contributed to lower yields following their termination.

Despite decreased corn yield over time, grain yield was greater following legume cover crops, particularly at the 0 kg N ha$^{-1}$ rate. Of particular interest was the lack of significant difference in corn grain yield under legume cover crops following increased application of N fertilizer while yields did increase with N fertilizer application following grass and brassica cover crops. This increase with no supplemental N fertilizer and lack of difference with N fertilizer applications suggests that legumes were compensating for lower chemical fertilizer applications, reducing the cost to producers. It was also interesting to note that, despite the narrow range in N fertilizer rates (increases of 33 kg N ha$^{-1}$), it was possible to detect differences in corn grain yield, indicating the sensitivity of these systems to small changes in N availability. Optimal N cycling and management is one of the principal secondary benefits of integrating cover crops to a production system. However, in systems where high mineralization is possible, rates of conversion may reduce the benefits associated with the inclusion of cover crops like clovers, where N may be easily lost. It is therefore essential that time of termination of cover crop and N release/mineralization coincides with crop N demands. Further research is needed, particularly in the sub-tropical climate in the Mid-South, to improve the timing of N release relative to cash crop demands.

CONCLUSIONS

In response to factors such as climate and overall systems management, corn grain yields decreased from 2014 to 2015, regardless of N fertilizer rates or cover crops. This yield decrease continued in 2016 in plots with higher N fertilizer rates (268 and 302 Mg ha$^{-1}$), suggesting that increased additions of N fertilizer and the addition of cover crops were not able to offset inherent factors over the winter months. In particular, grasses can reduce N leaching by scavenging for residual N in the soil (Staver and Brinsfield, 1998; Kaspar et al., 2007), sequestering N in biomass for subsequent release. Various research on the effect of cover crops on soil N have found similar results of cover crops of decreasing NO$_3^-$-N loss (Zhu et al., 1989; Baggs et al., 2000; Gabriel et al., 2012; Gabriel et al., 2013). Shipley et al. (1992) reported uptake rates of 48 kg ha$^{-1}$ for cereal rye and 29 kg ha$^{-1}$ for annual ryegrass compared with 9 and 8 kg ha$^{-1}$ for hairy vetch and crimson clover, respectively. Brinsfield and Staver (1991) observed higher N assimilation by cereal rye when compared with other grass species such as wheat (Triticum aestivum L.), oat (Avena sativa L.), and barley (Hordeum vulgare L.). Unlike NO$_3^-$-N, NH$_4^+$-N is not readily leached into the subsoil due to its adsorptive capacity to organic matter and negatively charged surfaces of clay (Brady and Weil, 2004). Nitrification and subsequent corn crop uptake would result in this measured reduction in NH$_4^+$-N following horn harvest. Ammonium-based fertilizers and decomposing organic matter, such as that from cover crops, are potential sources of the NH$_4^+$ fraction of soil inorganic N (Bronson, 2008). The increase in soil NH$_4^+$-N observed in February samples (i.e., after cover crop termination) likely stems from cover crop and corn residue decomposition, as samples were collected before N fertilizer applications. As soil conditions were conducive to nitrification, high spring rainfall and subsequent losses due to leaching of the more mobile NO$_3^-$-N and/or runoff of surface NH$_4^+$-N (Shipley et al., 1992; Faber, 1995) may have contributed to the overall decreased yields measured in 2015 and 2016. Similarly, lower overall N concentrations from the grass and brassica treatments likely contributed to lower yields following their termination.
within these humid subtropical systems. Both legume and grass and brassica cover crop treatments were able to scavenge residual N in their biomass, evidenced by decreased NO⁻₃-N and increased NH₄⁺-N in spring soil samples, which was eventually released into the soil system, and subsequently available for the corn crop. The inclusion of legume cover crops did increase corn grain yields by 52% relative to grass and brassica treatments, without supplemental N fertilizer applications, supporting their use as an alternative source of plant-available N for row crop production. No difference in corn grain yields when combining legume cover crops with increasing N fertilizer rates suggests that legumes are compensating for decreased commercial fertilizer application rates; however, corn grain yield following grass and brassicas did increase by 6% between rates of 235 and 268 kg N ha⁻¹. Termination of cover crops 6 wk prior to corn planting may have resulted in N loss from the system as mineralization occurs during this fallow period. This highlights the need for a better understanding of cover crop degradation in conservation tillage systems as the performance of a cover crop is not only determined by the species but also the interaction of many environmental and management factors.

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DISCLAIMER

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