NUTRIENT CYCLING AND COVER CROP DECOMPOSITION IN STRIP-TILL AND CONVENTIONAL COTTON TILLAGE SYSTEMS

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Introduction

Cover crops and conservation tillage have important roles in agriculture because of their ability to reduce soil erosion, conserve soil moisture, potentially increase soil organic matter, and suppress numerous pests (Gallaher and Hawf, 1997; Siri-Prieto et al., 2007). However, there has been concern of cover crops tying up too much N and the timing of its release to the next crop (Vyn et al., 1999). A study in Ontario comparing legume and non-legume covers found improved N availability only following a legume (Vyn et al., 2000). However, Weinert et al. (2002) reported accumulation of 55-115 lb N/ac in overwintering rye on an irrigated sandy soil, which could be returned to the soil and a following crop.

In the hot and humid climate of the southeast, along with the sandy soils of the Coastal Plains, cover crops may deteriorate at different rates compared to more temperate environments and the heavy textured soils of the north, from where most decomposition data comes. Therefore, it is important to study the decomposition rates and nutrient cycling capabilities of various cover crops in southeastern crop production. These climates also alter activity of insect populations and feeding patterns. Since there is considerable acreage in both conventional and reduced tillage management in this region, and the incorporation of residues should drastically alter the rate of residue breakdown and thrips behavior, it is important to study decomposition effects and thrips populations in various cover crops common to the region under both tillage management scenarios. Therefore, the objectives of this experiment were to compare decomposition rates of cover crop residues and thrips activity in conventional and triptill cropping systems, including ‘AU Robin’ crimson clover (*Trifolium incarnatum* L.),‘Wrens Abruzzi’ rye (*Secale cereale* L.), and ‘AGS 2026’ wheat (*Triticum aestivum* L.) as winter cover crops.

Materials and Methods

Cover crops were planted 23 December 2009 in randomized complete block design at the University of Georgia Rigdon Farm in Tifton, GA. Treatments were organized as a 2 x 4 two-factor factorial with four replications. Independent variables consist of two tillage systems (conventional and strip-till) and four cover crop treatments (crimson clover (*Trifolium incarnatum* L.), rye (*Secale cereale* L.), wheat (*Triticum aestivum* L.), and bare soil). Individual plots were 0.01 ha (7.3 m x 13.7 m). Recommended seeding rates

(Sustainable Agriculture Network, 2007) were followed for planting crimson clover (17 kg ha^{-1}), rye (101 kg ha^{-1}), and wheat (134 kg ha^{-1}) with a Tye Pasture Pleaser no-till grain drill (AGCO Corp., Duluth, GA). Statistical analyses conducted with parametric statistical tests such as ANOVA and regression.

Due to the late planting of cover crops, which was a result of weather delays to harvesting the preceding cash crop in the assigned research plot location, cover crop establishment was poor. Crimson clover plots had to be abandoned for the strip-till treatment because of this unforeseen hardship. Crimson clover plots were salvaged in conventional tillage plots by bringing in residue from a neighboring field of reseeding crimson clover from another trial and spreading a prescribed amount of material (based on previous year’s data) by hand and then incorporating via tillage.

A comprehensive sampling plan has been devised to monitor changes in soil nutrient mineralization and availability, nutrients in cover crops, and cotton biomass. Comparisons will be made across treatments and over time. Cover crops received a burn-down herbicide application of glyphosate (1.40 kg a.i. ha^{-1}) on 26 April 2010, and tillage treatments were established on 12 May 2010. All plots were planted with ‘DP 161’ (BGII/RF) cotton seed with Avicta Complete Pack seed treatment on 26 May 2010 at a 10 cm in-row seed spacing. Plots were fertilized with 22 kg N ha^{-1} + 4 kg S ha^{-1} in the form of 28-0-0-5 fertilizer on 26 July 2010. Other management practices were consistent with UGA Extension recommendations (Collins et al., 2010).

To evaluate the fate of cover crop residue and the movement of nutrients from cover crops to soil to cotton, biomass and soil samples were removed over the course of the season. The initial cover crop biomass sampling occurred on 13 April 2010 using a 0.5 m^2 quadrant for consistent sampling area among treatments. Another sampling was made on 27 May 2010, just prior to planting. Since cover crop tissue is buried in conventional tillage plots, a mesh litterbag made from fiberglass screen with 2.86 mm^2 holes (35 holes cm^{-2}) (Phifer, Inc., Tuscaloosa, AL) were constructed and filled with a prescribed residue amount (corresponding to 3.48 g dry matter [DM] of rye per bag, 2.7 g DM wheat per bag, 13.9 g DM crimson clover per bag) based on initial aboveground biomass residue. Dimensions of each bag cover 15 cm x 20 cm, or 300 cm^2 (Wang et al., 2004). Bags were buried in the conventional-till plots on 27 May 2010 at a depth of 15 cm so decomposition of incorporated residue could be simulated and retrieved over the course of time. Enough bags were buried so that one would be extruded on each sample date over the season to determine amount of original material remaining in the bag. Cover crop residue samples were then subsequently removed throughout the season on each field sampling date, which consisted of 6 July, 26 July, 17 August, 7 September, 23 September, and 20 October 2010. On each of these sample dates, aboveground biomass of the cotton plants residing within the 0.5 m^2 sample area were also removed. All plant tissue samples were dried and sieved to remove residual soil, rocks, and other contaminants. Dry matter was determined, then samples were ground and sent for plant nutrient analyses at the UGA Soil, Plant, and Water Laboratory. Soil samples at 0-5 cm and 5-20 cm depths were also taken on each sample date throughout the season. Soil samples at both depths were analyzed for soil macro and micro nutrients. Shallow soil samples were also analyzed for available nitrate and particulate organic matter at the beginning and end of the season. Due to the sheer volume of samples, not all plant tissue and soil samples have been processed and analyzed for nutrients at this time. Thus, the nutrient concentration results in cover crop tissue, soils, and cotton vegetation will be incorporated at a later time for submission to an appropriate scientific journal.

Results

Aside from a large discrepancy in initial quantity of cover crop biomass, due to the poor establishment conditions and bringing in residue for crimson clover plots at the previous year's biomass rate, decomposition in conventional tillage treatments followed relatively similar trends after planting (Fig. 1). Since there was very little wheat residue to begin with, the majority of it had decomposed between burndown and planting. Rye and crimson clover decomposed rapidly within the first six weeks after planting, with 70-78% of the residue being lost within the first six weeks, and only 15-20% loss from that point on. However, the total decomposition rate from initiation until late September when plants had reached maximum vegetative biomass, was similar among all three cover crops (crimson clover = 75%, rye = 83%, wheat = 76%). In strip-till management, rye residue did not break down as rapidly, with less than 25% decomposition in the first six weeks after planting (Fig. 2), and 45% decomposition from that point on. The total decomposition in strip-till was only 60% in rye, but was over 85% in wheat – that is primarily due to the fact that there was not a large quantity of wheat to begin with so total surface area being deteriorated by microorganisms caused rapid and near complete decomposition with wheat.

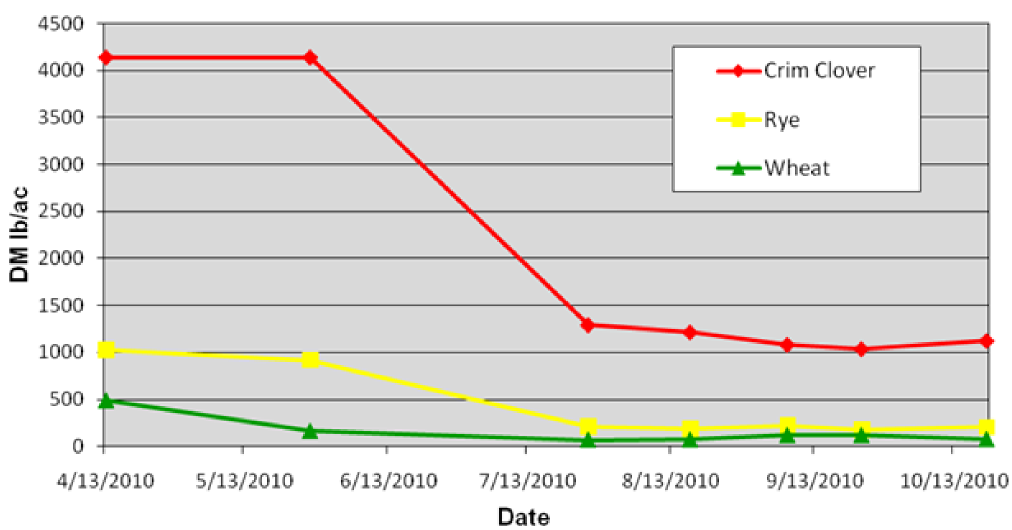

Figure 1.Cover Crop Biomass Breakdown Under Conventional Tillage

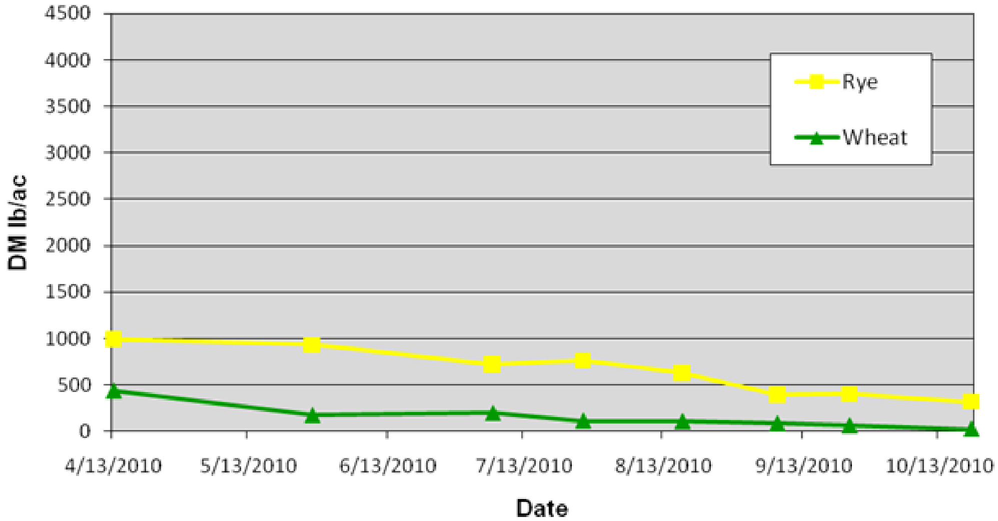

Figure 2. Cover Crop Biomass Breakdown Under Strip Tillage.

There were no major differences in biomass accumulation for the cotton among the various treatments in either conventional or strip-till. This is likely due a combination of the very low residue amounts of the cover crops aside from crimson clover and the masking of cover crop nutrients from the application of sidedress fertilizer in-season. Supplemental research projects are planned to assist in determining the effect of cover crops with various rates of sidedress fertilizer application in order to avoid this masking effect and assist with fertilization recommendations using different cover crops. It is noted that biomass accumulation did continue longer in plots where crimson clover was used than with any other cover crop treatment in conventional tillage (Fig. 3). Strip-tillage plots followed the same pattern regardless of cover crop used or lack of cover crop (Fig. 4), since residue levels were low and broke down slowly, thus neither causing tie up of N early in the season, nor providing nutritional benefits late in the season.

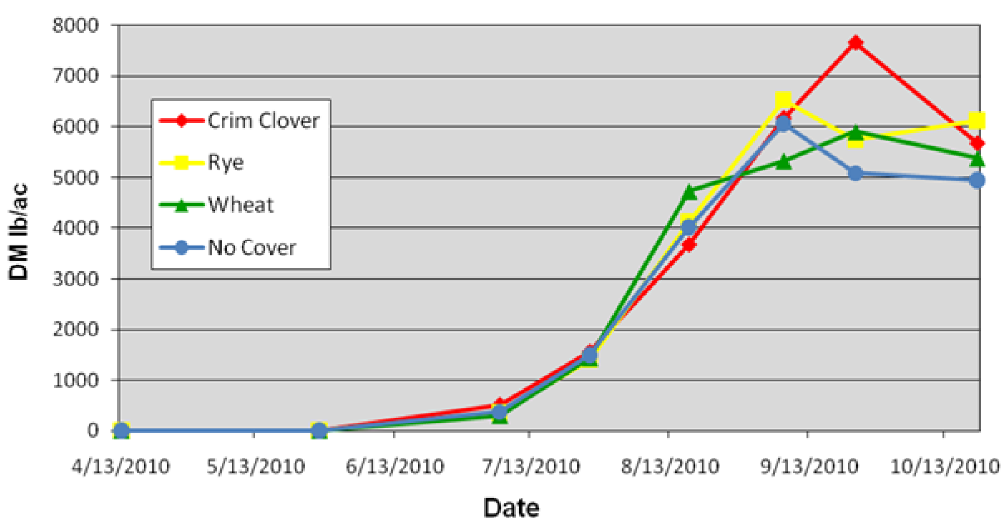

Figure 3. Cotton Vegetative Biomass Accumulation under Conventional Tillage.

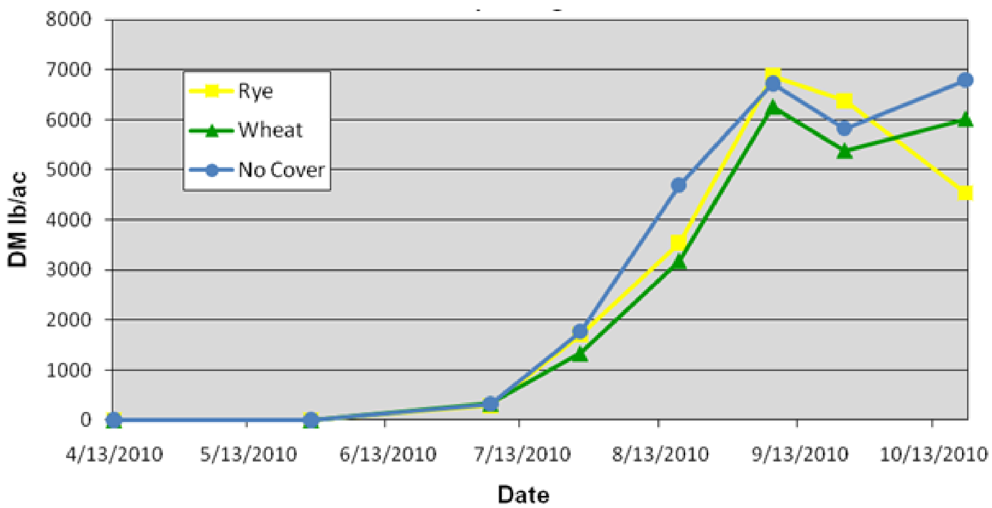

Figure 4. Cotton Vegetative Biomass Accumulation under Strip Tillage.

There were also no statistical differences among treatments in cotton plant height (Fig. 5). These data were from 16 Sept., approximately at maximum vegetative production, so cotton plants would have reached maximum height at this point. There was a trend that the plots supplying more nutrients over the course of the season did have the tallest plants numerically. This was seen in crimson clover plots in conventional tillage and in rye plots in strip-tillage. In these two scenarios, there was a larger total content of residue that decomposed over the course of the season, thus supplying greater total quantities of nutrients to the cotton plants.

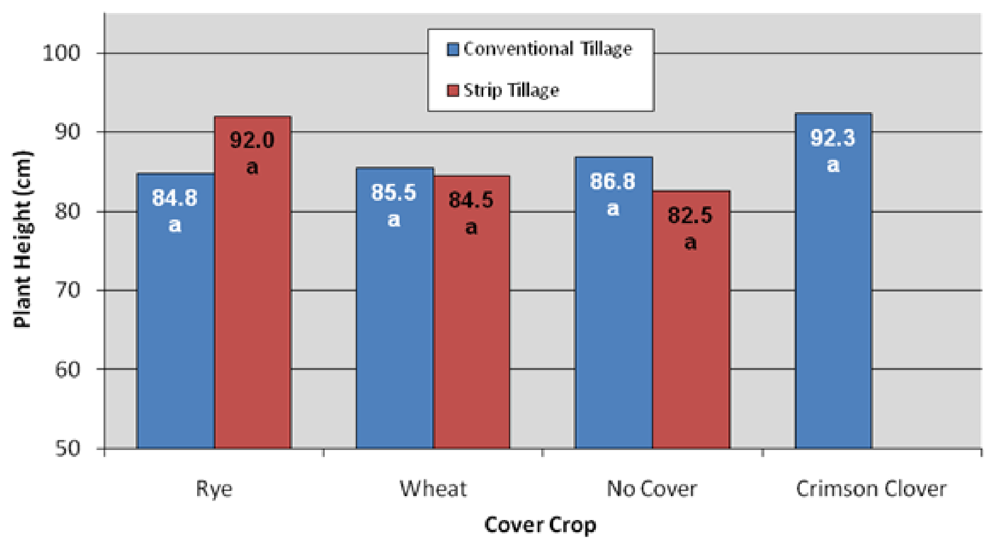

Figure 5. Cotton Plant Height by Tillage and Cover Crop

Similar to most of the other results, there ended up being no differences among treatments in regards to final lint yield (Fig. 6). There was a general trend that strip-till plots yielded greater than conventional tillage plots however, as seen in all three scenarios where both tillage systems occurred (rye, wheat, no cover). It should be noted that no plant growth regulator was applied in this project in order to gain a vegetative growth perspective on the cover crop treatment effects on the cotton plant behavior. Likewise, there were no plant stand differences among treatments (Fig. 7).

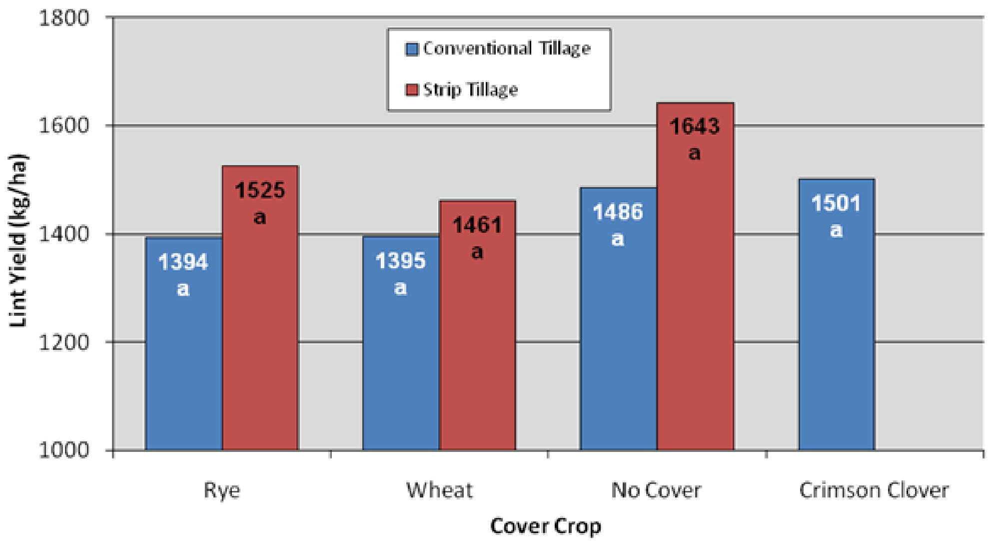

Figure 6. Cotton Yield by Tillage and Cover Crop.

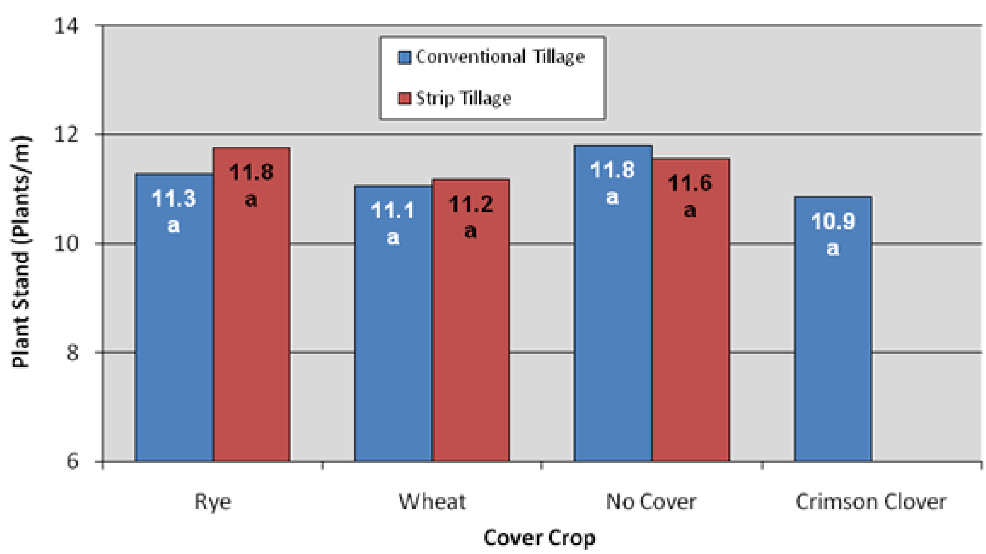

Figure 7. Cotton Plant Stand by Tillage and Cover Crop.

There were some minor fluctuations in economic differences for adjusted revenue (Fig. 8). Adjusted revenue is defined as revenue adjusted for yield, cover crop, tillage, and marketing costs. Gross revenue reflected base cotton prices for the southeast as of Dec. 2010. Total costs were higher for conventional tillage on a per acre basis (convent.

= $239.06 vs. strip-till = $216.01), primarily due to costs associated with tillage operations (additional trips through the field = more fuel and labor costs). When the cost of seed is factored into the equation, total costs are significantly higher for the various cover crops compared to where no cover crop was used. Since there were no major differences in yield, the adjusted revenue favored the treatments with low seed costs, especially the no cover crop treatment.

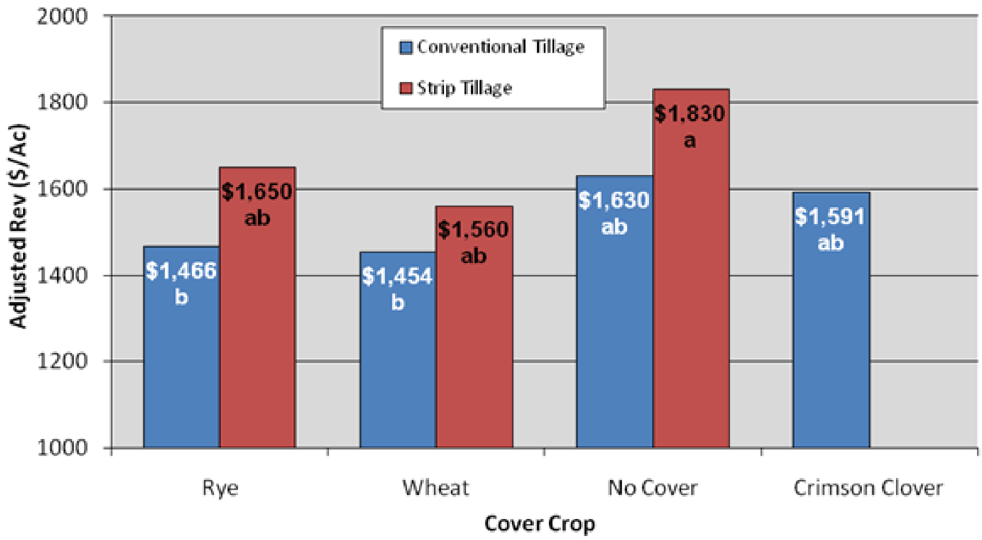

Figure 8. Cotton Adjusted Revenue by Tillage and Cover Crop.

These results as a whole tend to favor the use of no cover crop in a strip-till management scenario. However, there are a number of factors to contemplate that are not able to be incorporated into the final yield and revenue results. First, the inclusion of cover crops has been documented to reduce soil erosion and improve soil quality (improved organic matter and biodiversity) and structure. It is difficult to put a price tag on this, however it is widely recognized that the long-term sustainability of agronomic row cropping systems is dependent on maintaining valuable resources such as soil. In this year's results from this trial, the cover crop biomass residues achieved did not warrant the cost of the seed nor the effort to plant the cover crop. However, it was consistent throughout the southeastern crop production region that all cover crops were planted late in fall/winter 2009 heading into the 2010 growing season, and maximum benefits were not able to be achieved, as reflected in the final results of this experiment. The data did support the use of conservation tillage systems over conventional tillage systems however, and under normal circumstances, strip-tillage into a cover crop should usually offer much greater benefits than strip-tillage into weedy-fallow ground.

It is believed that the addition of supplemental fertilizer may have masked the effects of the cover crops, not allowing for as much separation among the treatments for biomass accumulation, yield, and other variables. The decision to add fertilizer was made in order to represent practices similar to what a grower might do. Since it is not realistic for a grower to forego N application, we opted to apply fertilizer, which in hindsight was likely at the expense of gaining a better grasp of the full comparative benefits of cover crops and their potential to reduce inputs like fertilizer. This information has given rise to a supplemental project to evaluate different fertilization rates for cotton and whether those applications are affected by the type of cover crop being grown prior to cotton using both grass and leguminous cover crops suitable for southeastern production systems.

Discussion and Summary

Cover crops decomposed at a greater rate in conventional tillage than in strip-till. Since the residues are incorporated into the soil using conventional tillage, there is more surface area of the residue being contacted by soil micro-organisms, and therefore it is more rapidly decomposed than when the residues remain on the soil surface and only a fraction of the material is exposed to the soil. The C:N ratio plays a large role in how rapidly plant tissue will breakdown. Legumes and immature plants have lower C:N ratios than mature grasses. In the results of this experiment, the majority (over 70%) of cover crop residue had decomposed within the first six weeks after planting in conventional tillage, but decomposition leveled off after that point with less than 20% decomposition for the remainder of the season after the initial six week period. The deterioration of cover crop residue was slower in strip-till with less than 25% decomposition of rye in the first six weeks, and 45% decomposition after that.

By the end of the trial, decomposition rates were the same regardless of cover crop, however (crimson clover = 75%, rye = 83%, wheat = 76%). But there were few cotton responses to cover crop treatment effects as plant biomass, height, stand, and yield all were statistically equal among treatments. Strip-till management did trend toward better results in yield and adjusted revenue than conventional tillage. In order to keep management similar to grower practices, there was supplemental fertilizer applied in this experiment, which apparently masked any beneficial nutrient effects being provided by decomposition of the cover crops. Yet, residue levels in this year were so low for most treatments, that total nutrient content would not have been at a sufficient level to support or supplement cotton growth at a very high level.

All in all, despite no yield differences, there were several positive results using strip-till management over conventional tillage. Although there were no economic advantages to using cover crops over having no cover crop in place, there are many documented benefits of growing cover crops which often have no inherent monetary value, but can save money in the long run. Reduced soil erosion on the highly erodible soils of the southeast is one of the most important, since a large rainfall can wash volumes of priceless soil out of a field, and leach nutrients out of the soil profile. Cover crops will hold soil and nutrients in place for future crops that follow. The long-term sustainability and productivity of coastal plains soils will depend heavily on ensuring good management practices are used to prevent misuse and eventual loss of the soil, our most valuable resource.

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