FERTILIZATION AND COVER CROP INTERACTIONS FOR STRIP-TILL COTTON

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Introduction

Cover crop selection plays an important role in conservation tillage cropping systems, including strip-till cotton (*Gossypium hirsutum* L.) production in Georgia. Some benefits of growing a cover crop in row crop systems include reduced soil erosion in the winter. Reduced fertilizer input is also possible since the cover crop will scavenge nutrients that will then become available to the subsequent crop as the cover crop residue deteriorates during the growing season. Cover crops alone cannot supply the nutrient needs of a cotton crop; however, the balance between the recycling of nutrients from cover crops along with supplemental applications of fertilizer will be useful information to help inform growers about the potential for reducing fertilizer inputs while simultaneously conserving non-renewable resources such as soil and energy inputs required to make fertilizers.

There has been concern of cover crops tying up too much nitrogen and the timing of its release to the next crop (Vyn, Janovicek, Miller, and Beauchamp, 1999). However, cotton yields have been increased with the use of a cover crop compared to not using one (Raper, Reeves, Burmester, and Schwab, 2000). In addition, the type of cover crop selected can supply vastly different amounts of certain nutrients. For example, leguminous cover crops, which can biologically fix atmospheric nitrogen, can add nitrogen the system, while grass cover crops cannot offer this benefit. Yet, even different legumes have different biomass potential, which alters the amount of total nitrogen content that may be available for a following cotton crop. One study has shown higher dry matter and higher nitrogen availability from hairy vetch (*Vicia villosa* Roth) than from other leguminous cover crops as well as higher corn (*Zea mays* L.) yield after vetch than following rye (*Secale cereale* L.) (with no supplemental fertilizer) (Ebelhar, Frye, and Blevins, 1984).

Experiments on the potential yield and quality impact of cotton following certain cover crops have been conducted recently in Georgia. However, the full impacts and nutrient availability of cover crops can be masked by the addition of supplemental fertilizers. The information generated from this project is designed to gain a greater understanding of cover crop and fertilization management, along with their interactive effects, for producing the most economical cotton crop possible under strip-till management.

Materials and Methods

A split-plot experiment with four replications was established on the University of Georgia's Lang Farm on the Tifton Campus in a 1-acre field. Main plot treatment areas measuring 48 feet wide and 45 feet long were planted to one of five treatment effects as cover crop establishment. These included 1) no cover crop, 2) crimson clover (*Trifolium incarnatum* L.), 3) hairy vetch, 4) rye, and 5) winter wheat (*Triticum aestivum* L.). Sub-treatment effects of side-dress fertilization were randomly designated within each main plot treatment as 12 feet x 45 feet sub-plots, including zero, 30, 60, and 90 lbs/acre of nitrogen.

Cover crops were planted on 11/4/2011 as follows:
Crimson clover, 18 lb/acre; hairy vetch, 20 lb/acre; rye, 90 lb/acre; wheat, 90 lb/acre.

Rye and wheat cover crops were terminated on 3/12/2012 and crimson clover and vetch were terminated on 4/3/2012 with Roundup at 2 quarts/acre. Plots were strip-tilled on 5/9/2012. Cotton (DPL 1252) was planted at 3 seed/foot of row at approximately 0.75 inches deep on 5/11/2012. Pre-emergence herbicides were applied on 5/11/2012 including Prowl at 10 ounces/acre, Reflex at 10 ounces/acre, and Cotoran at 1 pint/acre. On 6/11/2012, an application of Roundup Powermax (1 quart/acre) + Staple LX (3 ounces/acre) + surfactant was applied for supplemental weed control. In addition, a directed spray of MSMA (2.5 pints/acre) + Direx (1 quart/acre) + crop oil (1 quart/acre) was applied on 7/13/2012.

Cover crop biomass measurements and soil sampling occurred around the time of cover crop termination on 4/2/2012, prior to the side-dress nitrogen application (7/3/2012) and at maximized vegetative growth (9/25/2012). The mid-season and final sample dates also included cotton whole-plant biomass sampling. Treatment-specific side-dress nitrogen rates were applied on 7/10/2012. Lint harvest occurred on 11/2/2012.

Results

By the time of cover crop termination, crimson clover had produced the most biomass, with three to five times the amount of biomass as the rye and wheat cover crops (Table 1). However, crimson clover decomposed fairly rapidly and was statistically equal to the residue levels of rye and wheat by early July. This is consistent with results from a previous iteration of this research in 2009. There was little remaining residue by late season. The growth of cotton was influenced by the cover crop being grown, as total plant biomass was greatest where the leguminous cover crops were decomposing. This was true prior to the application of side-dress nitrogen in early July, and still the case at the end of the season at peak vegetative biomass production in late September (Table 1). Likewise, nitrogen application affected vegetative biomass growth of cotton linearly, with around a 20 grams per plant difference in dry matter for every additional 30 lbs/acre of nitrogen that was applied (Table 2).

Table 1. Cover Crop Residue Decomposition and cotton vegetative Growth for Cover Crop Effects, Averaged Over N Rates, University of Georgia, Tifton, 2012

Cover Crop	4/2/12 CC[x] Residue Biomass (kg DM[y]/ha)		7/3/12 CC Residue Biomass (kg DM/ha)		9/25/12 CC Residue Biomass (kg DM/ha)		7/3/12 Cotton Biomass (g DM/plant)		9/25/12 Cotton Biomass (g DM/plant)	
Crimson Clover	6447	A	1876	AB	504	A	16.0	A	165.8	A
Vetch	2774	B	859	C	202	B	15.1	AB	154.1	AB
Rye	1404	B	1225	BC	112	B	11.9	CD	116.0	C
Wheat	1919	B	2502	A	410	A	9.7	D	129.4	BC
No Cover	-		-		-		12.8	BC	121.7	C
level p	0.0012		.0005		.0002		0.0001		0.004	
SE[z]	890		383		90		1.4		14.6	

[x] CC = Cover Crop
[y] DM = Dry Matter
[z] SE = Standard Error

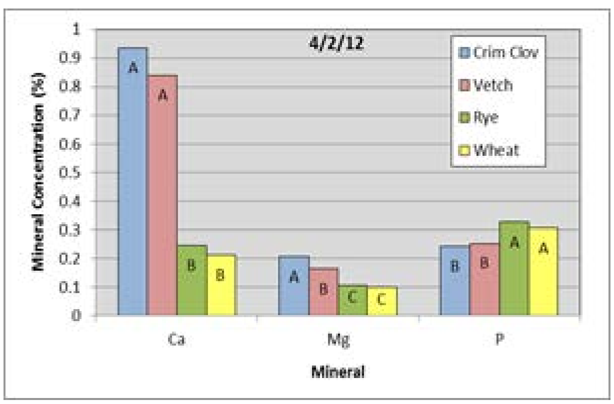
Table 2. Cotton Vegetative Growth for Four N Rates, Averaged Over Cover Crops, University of Georgia, Tifton, 2012

N Rate (lb N/acre)	7/3/12 Cotton Biomass (g DM[y]/plant)		9/25/12 Cotton Biomass (g DM/plant)	
0	14.1	A	108.1	C
30	11.7	A	126.7	BC
60	13.6	A	145.8	AB
90	13.0	A	169.0	A
level p	0.231		.0002	
SE[z]	1.2		13.1	

[y] DM = Dry Matter

[z] SE = Standard Error

The mineral concentration in the cover crops varied at time of termination, and it was common for the two leguminous cover crops (crimson clover and vetch) to have similar values to each other and the two grass cover crops (rye and wheat) to have similar values to each other. But, the legume vs. grass comparisons were often different. The legume cover crops had greater mineral concentrations for calcium, magnesium, nitrogen, potassium, copper, zinc, and boron, while the grass cover crops had more phosphorus, and there was no difference among any of the species for manganese (Figures 1-3).



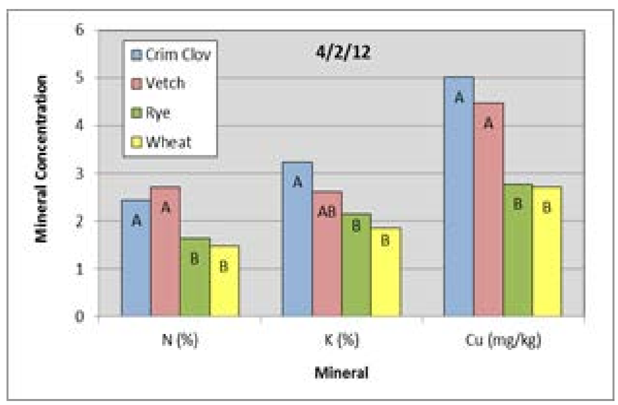


Figure 1 (left). Mineral Concentration of Ca, Mg, and P in Cover Crop Residue at Cover Termination, University of Georgia, Tifton, 2012

Figure 2 (right). Mineral Concentration of N, K, and Cu in Cover Crop Residue at Cover Termination, University of Georgia, Tifton, 2012

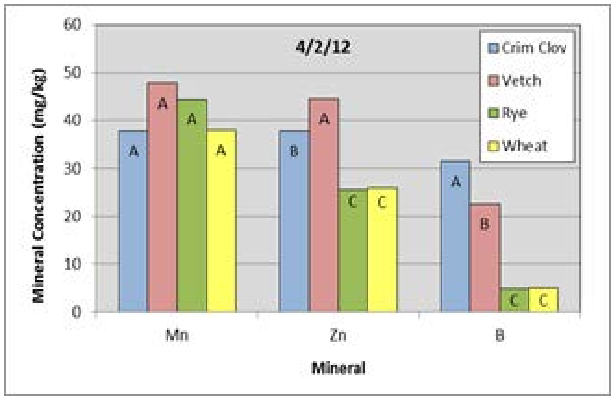
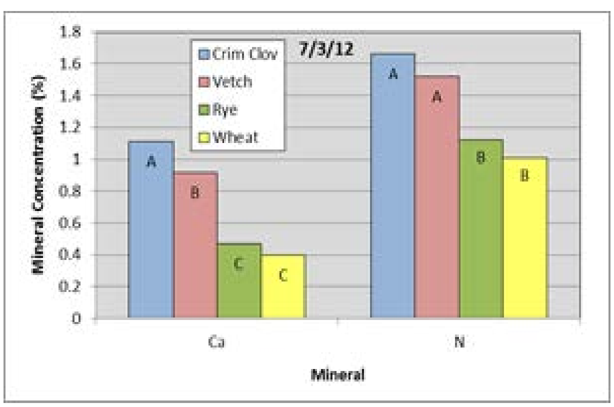


Figure 3. Mineral Concentration of Mn, Zn, and B in Cover Crop Residue at Cover Termination, University of Georgia, Tifton, 2012

By the time of side-dress nitrogen application in early July, after a period of decomposition had occurred (especially for the leguminous covers), the mineral concentration in the remaining cover crop residue still had some similar trends to the sampling in April for certain minerals. However, the separation was less pronounced, and crimson clover had a tendency to retain more nutrients than vetch (such as phosphorus, potassium, magnesium, and boron). There was still a much larger quantity of those nutrients released in crimson clover plots, since the total amount of biomass that decomposed was much greater, but it shows that the concentration of nutrients in vetch tissue was much more rapidly released (Figures 4-6). Concentration levels for the grasses were consistent in their level of release.



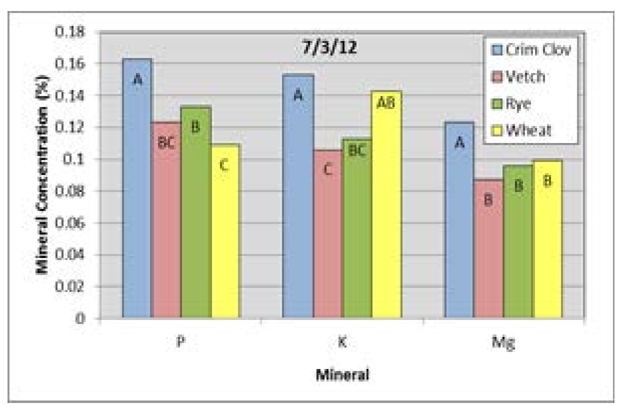
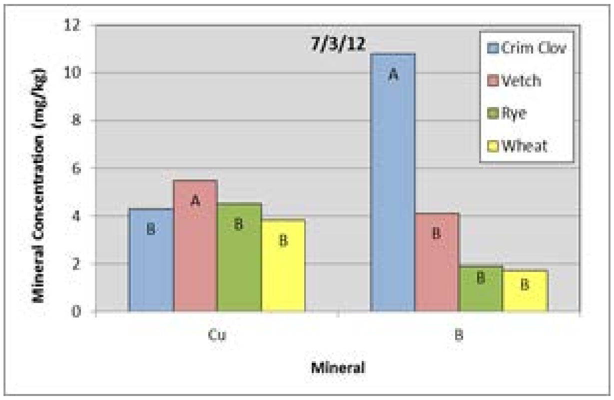


Figure 4 (left). Mineral Concentration of Ca and N in Cover Crop Residue Prior to Side-Dress N Application, University of Georgia, Tifton, 2012

Figure 5 (right). Mineral Concentration of P, K, and Mg in Cover Crop Residue Prior to Side-Dress N Application, University of Georgia, Tifton, 2012



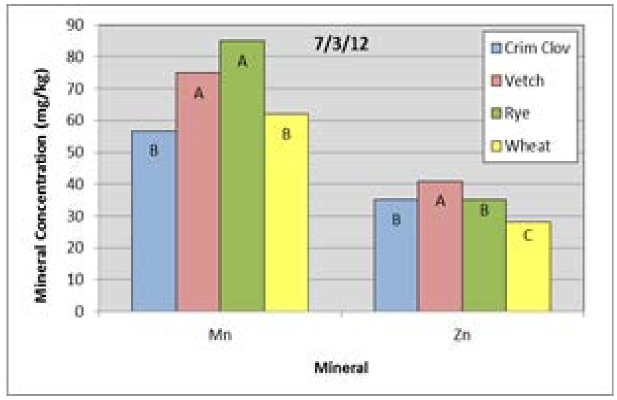
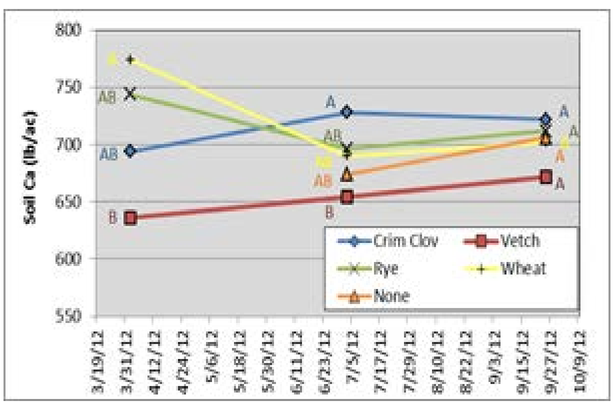


Figure 6 (left). Mineral Concentration of Cu and B in Cover Crop Residue Prior to Side-Dress N Application, University of Georgia, Tifton, 2012

Figure 7 (right). Mineral Concentration of Mn and Zn in Cover Crop Residue Prior to Side-Dress N Application, University of Georgia, Tifton, 2012

Soil test levels for calcium responded as expected. Calcium increased in plots where the leguminous cover crops were planted, as they had rapid decomposition and much higher calcium concentration than the grass covers (Figure 8). Soil calcium decreased during the first three months after cover crop termination where grass covers were grown, since there was very little decomposition of residues during this timeframe and the cotton plants were removing calcium from the soil at a more rapid rate than replenishment by the covers. By the end of the season, additional deterioration of cover residues and less need by the cotton plant (seen in the reduction in concentration within the cotton plant by late September, Figure 9) caused soil test calcium levels to remain the same or slightly increase.



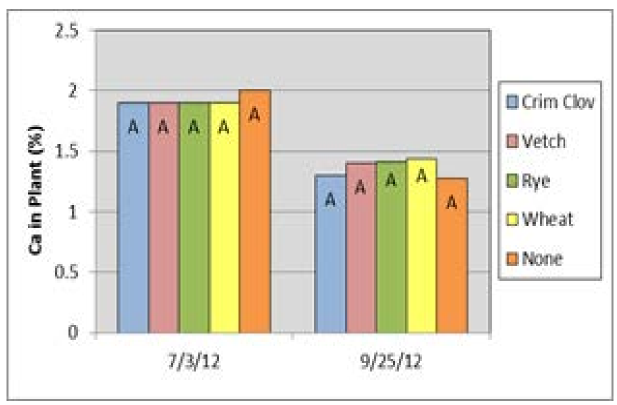
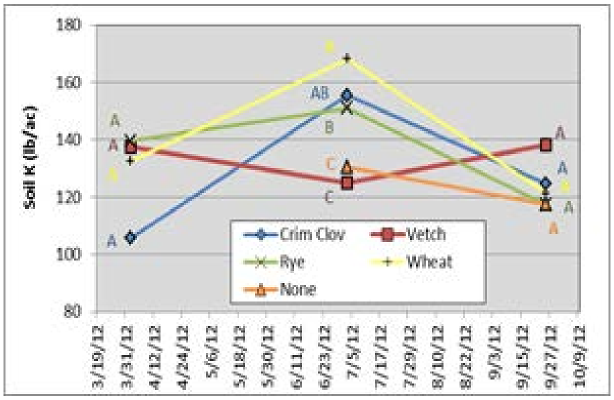


Figure 8 (left). Soil Ca During Growing Season, University of Georgia, Tifton, 2012

Figure 9 (right). Mineral Concentration of Ca in Cotton Plants Averaged Over Side-Dress N Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

Potassium concentration in residue decreased dramatically from April until July (Figures 2 and 5), meaning the majority of potassium left the residue since it is a mobile element. This may explain why soil potassium levels increased from April until July for most plots (Figure 10).

Since cotton biomass increased ten-fold from July until September, while potassium concentration remained nearly the same during this timeframe (Figure 11), soil potassium levels decreased. In addition, there were relatively consistent rains during the latter half of the season, and with the relative mobility of potassium in the soil, it is possible that some leaching of the element occurred, pushing it below our sample depth.



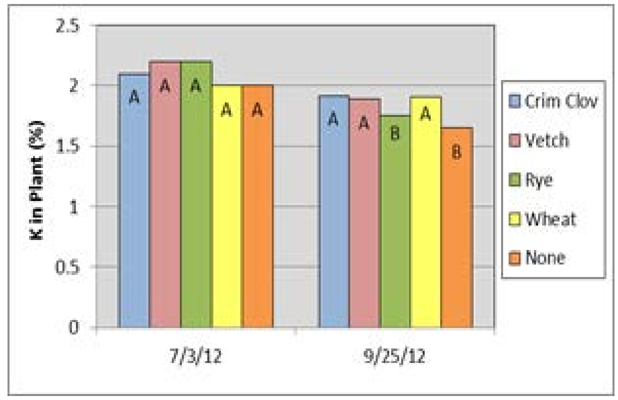
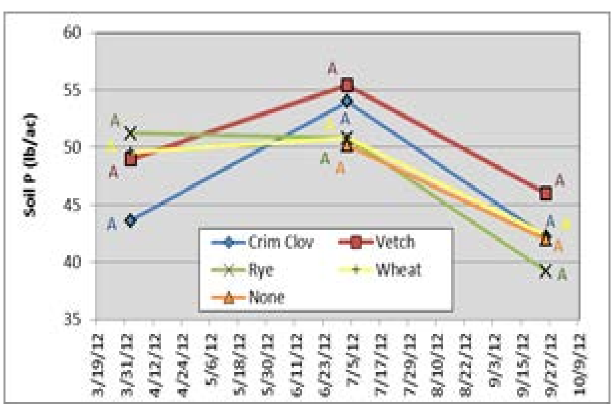


Figure 10 (left). Soil K During Growing Season, University of Georgia, Tifton, 2012

Figure 11 (right). Mineral Concentration of K in Cotton Plants Averaged Over Side-Dress N Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

There was a greater initial concentration of phosphorus in the grass cover crops (Figure 1), but the larger quantities of biomass decomposition by the legumes caused an increase in turnover of phosphorus to the soil for those crops before side-dress nitrogen, while the lack of decomposition of the grasses caused soil phosphorus to remain the same during the same timeframe (Figure 12). There was a decrease in late season soil phosphorus as the cotton plant grew. By end of the season, there was a higher concentration of phosphorus in cotton plants where the grass cover crops were grown (Figure 13).



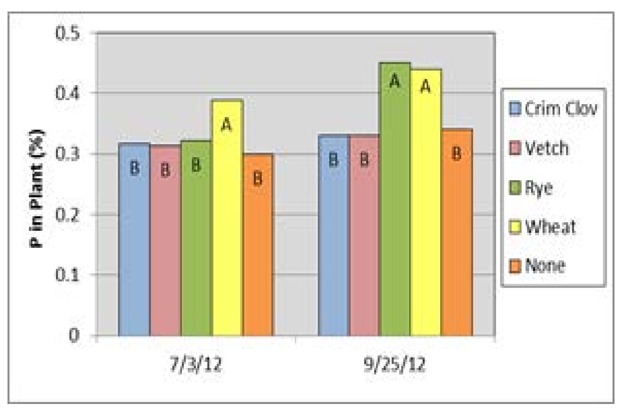
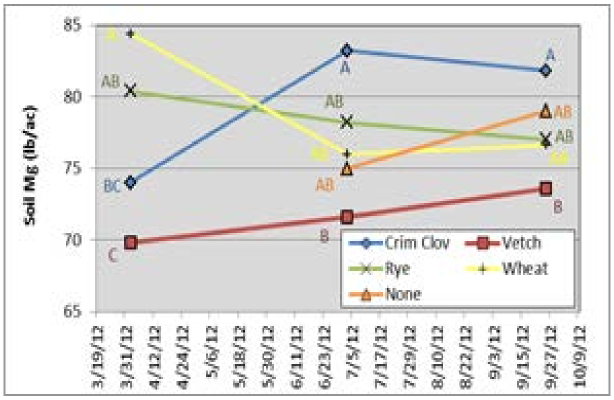


Figure 12 (left). Soil P During Growing Season, University of Georgia, Tifton, 2012

Figure 13 (right). Mineral Concentration of P in Cotton Plants Averaged Over Side-Dress N Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

Magnesium was in higher concentration in the leguminous cover crops than any other cover crop at the time of termination (Figure 1). Because of the decomposition of the leguminous cover crops over time, the soil concentration of magnesium increased (Figure 14), and provided more magnesium for cotton plants to uptake by mid-season (Figure 15). However, there was no difference in magnesium in cotton plant tissue by the end of the season, and only crimson clover plots had statistically more soil magnesium than vetch at the final sampling, partially because of the larger amount of residue that decomposed over the course of the season.



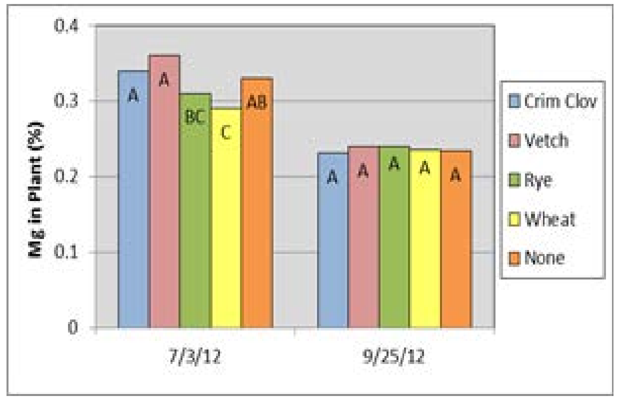
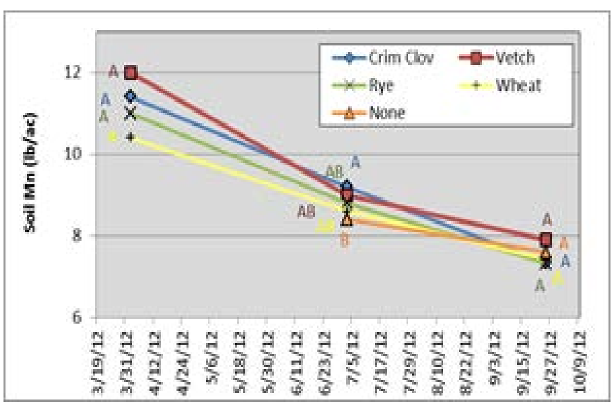


Figure 14 (left). Soil Mg During Growing Season, University of Georgia, Tifton, 2012

Figure 15 (right). Mineral Concentration of Mg in Cotton Plants Averaged Over Side-Dress N Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

There were few statistical differences in cover crop (Figures 3 and 7), soil (Figure 16), or cotton tissue (Figure 17) concentrations for manganese during the season. Consistent with a sister trial from 2007, concentrations of manganese in the cover crop tissue increased from termination until mid-season. Since manganese is considered an immobile element, it is not likely to rapidly decompose or leach from cover crop residue, and thus uptake by the cotton plant causes depletion of soil manganese.



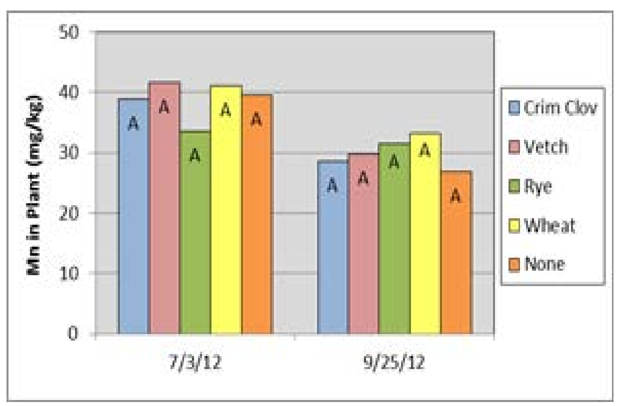
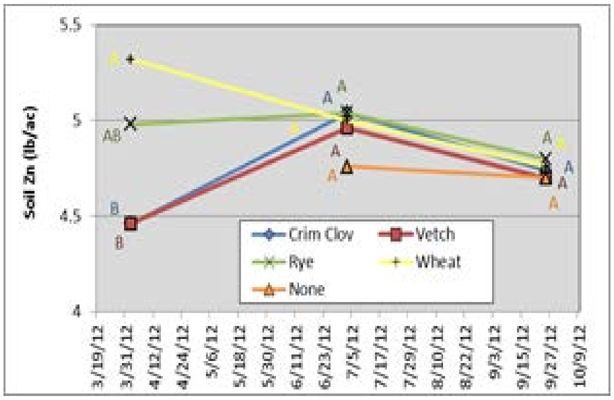


Figure 16 (left). Soil Mn During Growing Season, University of Georgia, Tifton, 2012

Figure 17 (right). Mineral Concentration of Mn in Cotton Plants Averaged Over Side-Dress N Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

Concentration of zinc in cover crop tissue was initially highest in leguminous cover crops (Figure 3), and remained higher than in wheat by mid-season (Figure 7). The greater quantities of legume decomposition in the first half of the season caused an increase in soil zinc levels initially (Figure 18). However, all plots resulted in depletion of soil zinc during the latter half of the season. At the end of the season, there were higher concentrations of zinc in plots where rye and wheat were grown. There were no direct indications why this occurred.



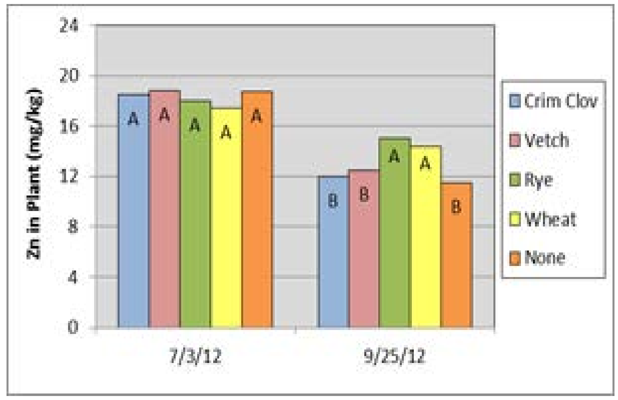


Figure 18 (left). Soil Zn During Growing Season, University of Georgia, Tifton, 2012

Figure 19 (right). Mineral Concentration of Zn in Cotton Plants Averaged over Side-Dress N Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

Concentration of nitrogen was highest in leguminous cover crops at burndown and mid-season, as expected (Figures 2 and 4). This translated to higher levels of nitrogen in cotton plants following the leguminous covers in most pairwise comparisons to other cover crop treatments (Figure 20). Soil nitrogen was not collected because of the extreme mobility in sandy soils and expense for conducting soil nitrogen tests for relatively inaccurate information. Results for copper in both cover crop (Figures 2 and 6) and cotton plant tissues (Figure 21) were similar to zinc over the course of the season. Boron had much higher concentrations in leguminous crops, especially in crimson clover (Figures 3 and 6), although this did not result in higher boron concentrations in the cotton plants (Figure 22).

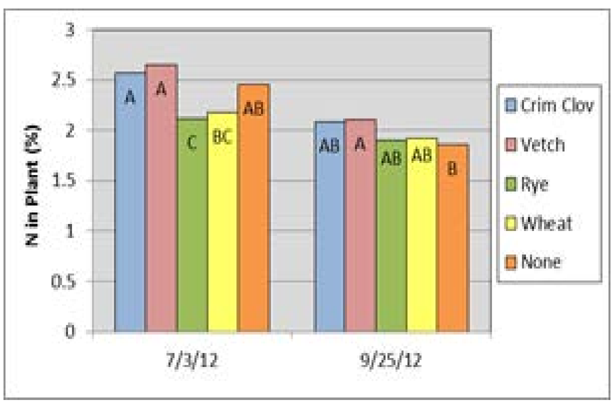
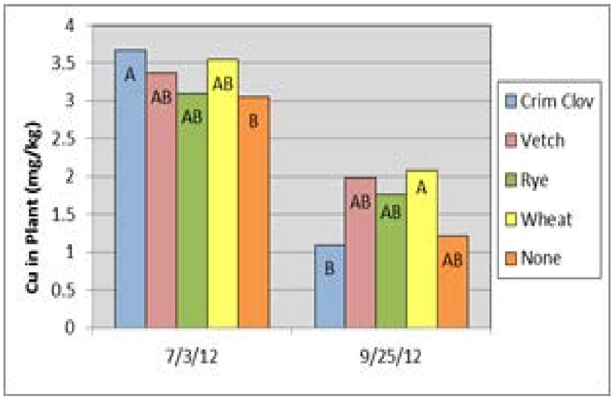


Figure 20. Mineral Concentration of N in Cotton Plants Averaged Over Side-Dress N Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012



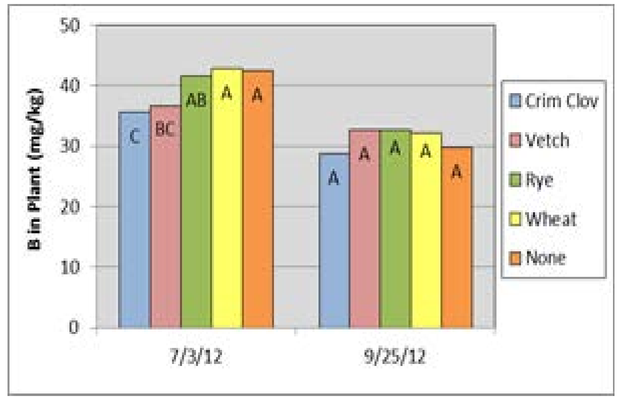
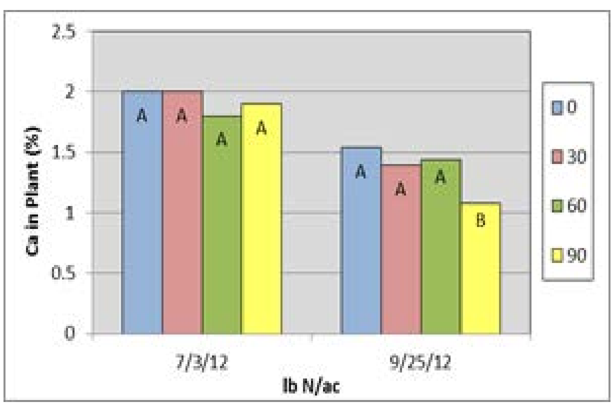


Figure 21 (left). Mineral Concentration of Cu in Cotton Plants Averaged Over Side-Dress N Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

Figure 22 (right). Mineral Concentration of B in Cotton Plants Averaged Over Side-Dress N Treatments, Pre-Sidedress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

General trends for application of side-dress nitrogen were similar for most minerals (Figures 23-31). In most cases, there was a decreasing trend in concentration of the various nutrients tested with increasing rate of nitrogen application. This was noted for calcium, phosphorus, magnesium, manganese, and zinc, especially at the end of the season. There was no evidence of nutrient differences for potassium, nitrogen, or boron at any of the side-dress nitrogen rates, especially at the end of the season. The only nutrient with a highly abnormal response at the various nitrogen rates was copper, where the zero, 30, and 90 lbs/acre of nitrogen rates followed a decreasing trend with increasing nitrogen rate, but the 60 lbs/acre of nitrogen rate resulted in the highest concentration of copper (Figure 28).



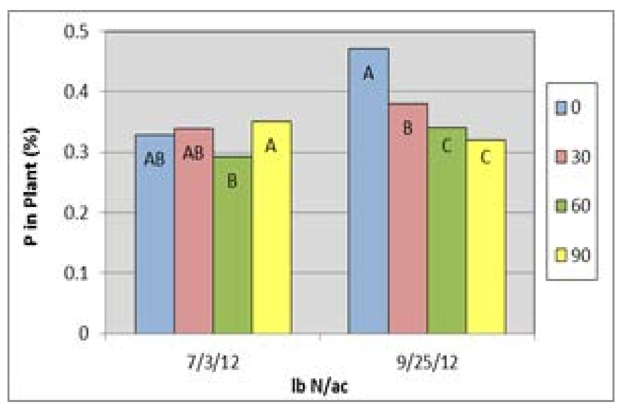
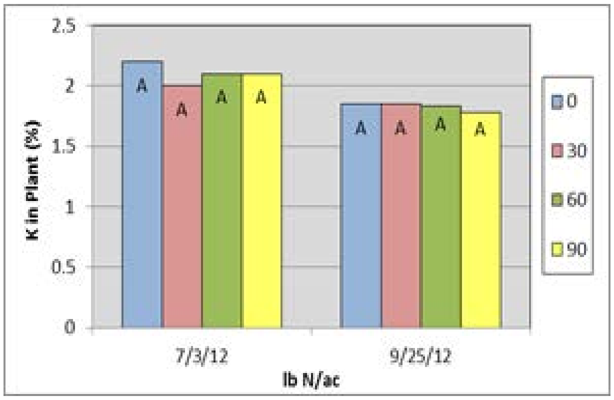


Figure 23 (left). Mineral Concentration of Ca in Cotton Plants Averaged Over Cover Crop Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

Figure 24 (right). Mineral Concentration of P in Cotton Plants Averaged Over Cover Crop Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012



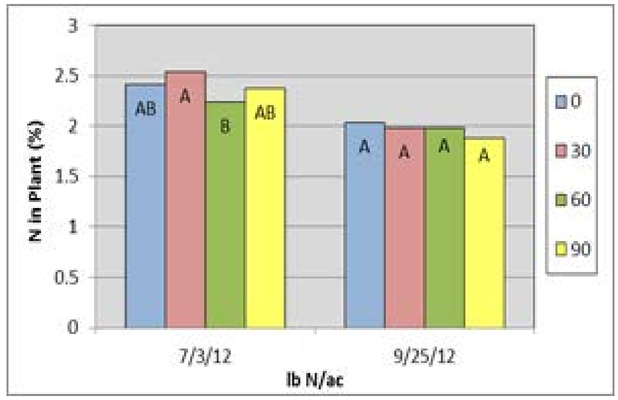
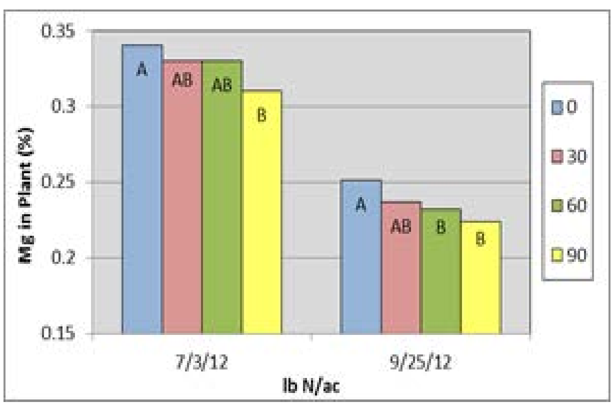


Figure 25 (left). Mineral Concentration of K in Cotton Plants Averaged Over Cover Crop Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

Figure 26 (right). Mineral Concentration of N in Cotton Plants Averaged Over Cover Crop Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012



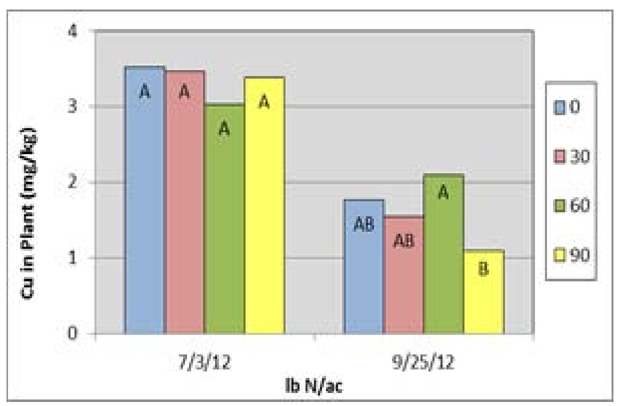
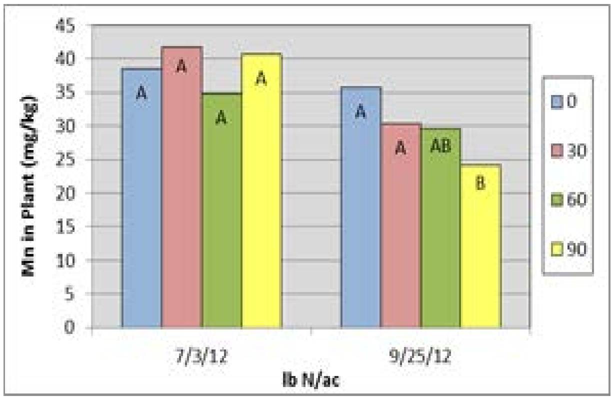


Figure 27 (left). Mineral Concentration of Mg in Cotton Plants Averaged Over Cover Crop Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

Figure 28 (right). Mineral Concentration of Cu in Cotton Plants Averaged Over Cover Crop Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012



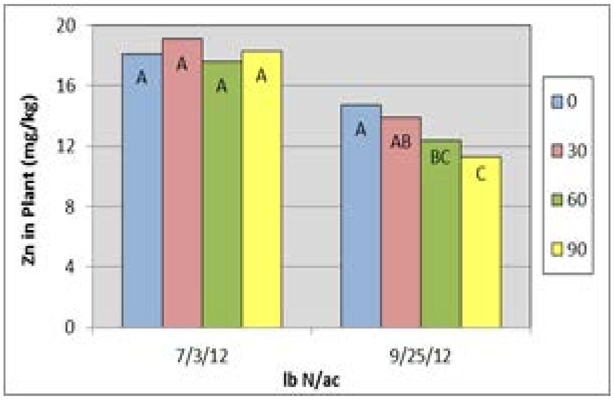


Figure 29 (left). Mineral Concentration of Mn in Cotton Plants Averaged Over Cover Crop Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

Figure 30 (right). Mineral Concentration of Zn in Cotton Plants Averaged Over Cover Crop Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

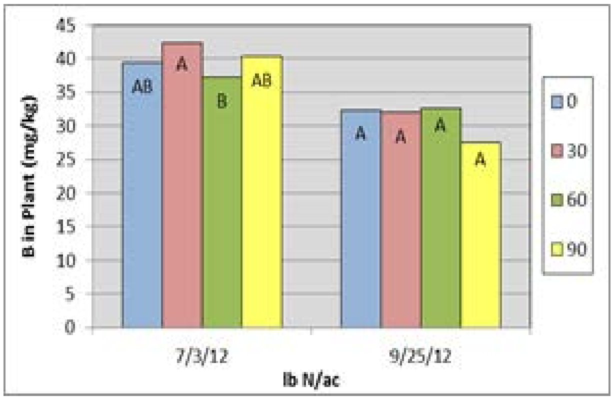


Figure 31. Mineral Concentration of B in Cotton Plants Averaged Over Cover Crop Treatments, Pre-Side-Dress (7/3/2012) and Pre-Defoliation (9/25/2012), University of Georgia, Tifton, 2012

Aside from all nutrient data, the most important take-home message to a grower is yield. There were significant differences in yield response to cover crop (Table 3) and to side-dress nitrogen rate (Table 4). There was an interaction of cover crop x side-dress nitrogen rate at the $0.10 > p > 0.05$ level of significance, although data for the interaction will not be shown in this report. When analyzed at the $\alpha=0.10$ level, the primary trend in the interaction effects were that there was no statistical difference in nitrogen rate at any level for crimson clover and vetch, while there was a difference for low input rates (zero and sometimes 30 lbs/acre of nitrogen) when compared to high input rates (60 and 90 lbs/acre of nitrogen) for the rye, wheat, and no cover crop treatments. This would indicate that the supplemental nutrients supplied by leguminous cover crops (crimson clover and vetch) may make it possible for reduced side-dress nitrogen applications for cotton, or less detrimental effect of untimely or lost fertilizer nitrogen due to volatilization or leaching, when following these cover crops.

When viewing the individual treatment factors alone and not in interaction, expected trends were observed. Lint yield was highest when cotton followed the leguminous cover crops (Table 3). There was no major advantage of having a grass cover crop over having no cover crop in terms of yield, and this would be an even narrower margin when the economics of additional seed and planting costs for the cover crop are incorporated. However, the benefits of grass cover crops are not typically observed in the short-term, but in the soil quality parameters built over time (such as soil organic matter). With respect to side-dress nitrogen application, yields increased with increasing nitrogen rate, although there was no statistical advantage from applying 90 lbs/acre of nitrogen over 60 lbs/acre of nitrogen (Table 4). This data would suggest that planting a leguminous cover crop provides the greatest opportunity for maximized yield, and a side-dress nitrogen application rate of approximately 60 lbs/acre of nitrogen is needed for optimized production. However, a closer look at the interaction values varies between cover crop and nitrogen rate applications.

Table 3. Lint Yield (lb/acre) for Cover Crop Effects, Averaged Over N Rates, University of Georgia, Tifton, 2012

Cover Crop	Lint Yield (lb/ac)	
Crimson Clover	1450	AB
Vetch	1566	A
Rye	1396	BC
Wheat	1414	BC
No Cover	1294	C
level p	0.0011	
SE[z]	60.4	

[z] SE = Standard Error

Table 4. Lint Yield (lb/acre) for Side-Dress N Rate Effects, Averaged Over Cover Crops, University of Georgia, Tifton, 2012

N Rate (lb N/ac)	Lint Yield (lb/ac)	
0	1285	C
30	1406	B
60	1469	AB
90	1536	A
level p	0.0002	
SE[z]	54.0	

[z] SE = Standard Error

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