ON-FARM RESEARCH AND DEMONSTRATION USING CONSERVATION-TILLAGE IN GEORGIA

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INTRODUCTION

Conservation-tillage in the Southeastern U.S. has the potential to save soil from erosion, increase much-needed soil organic matter levels, and most importantly, save growers money in terms of fuel, labor and trips across the field. Despite these potential benefits, it is estimated that only 15% of the row crops grown in South Georgia (a total of approximately 2.5 million acres of cotton, peanut, corn, and soybean) are grown using conservation-tillage practices. The most common form of conservation-tillage used for row crops in South Georgia is strip-till, where a subsoil shank is used and a narrow seed bed (anywhere from 6 to 18 inches wide) is prepared. Strict no-till (with or without some subsoil tillage such as a paraplow) is being investigated but is currently rarely used. Most experienced strip-till growers plant into a killed winter cover crop such as rye or wheat. Some cotton and soybeans are strip-tilled after wheat for grain. Legumes such as crimson clover are also used, but currently to a much lesser extent. In addition, new strip-till growers often plant summer crops into stubble of the previous summer crop (usually cotton or corn) or winter weeds. The main barriers to adoption of conservation tillage include the cost of purchasing new equipment and concerns about 1) weed control, 2) controlling the winter cover crop in spring (especially rye), and 3) trying something new and different.

Coffee County, Georgia, located approximately 45 miles east of Tifton, is a large agricultural county and is currently viewed as a leader in the area of conservation-tillage. Attempts to begin a conservation-tillage program in the early 1980's in Coffee County actually failed due to lack of suitable equipment and management knowledge. In 1990, the concept of conservation-tillage was revisited, especially with vegetables, with the main goals of decreasing soil erosion and increasing alternative habitats for beneficial insects. As a result, conservation-tillage increased in Coffee county from 15 acres in 1991 to over 25,000 acres in 1996.

As conservation-tillage acres have increased in Coffee County (as well as other counties), additional questions by growers needed to be addressed. Which cover crops are best and how much residue can they produce? When is the best time in the fall to plant winter cover crops? How much nitrogen should be used on cotton following legume or small grain cover crops? In fall 1995, on-farm demonstrations and research studies were started in Coffee County to address these questions. A local grower, Tommie Dorminey, designated a 6-acre block of land (under solid-set irrigation) for conservation-tillage demonstrations and research. Since then, studies have expanded onto other fields on the Dorminey farm and also into other counties. The demonstrations and research reported here were conducted by a team consisting of UGA extension specialists and county agents, as well as personnel from USDA-NRCS.

OBJECTIVES

The overall objective of the on-farm demonstration and research studies reported here was to gain a better understanding of conservation-tillage systems in general. Specific objectives, largely governed by grower interest, included 1) conducting a preliminary screening of cover crops, measuring biomass and nitrogen production, and then observing the growth of different summer crops to follow, 2) investigating the effect of timing of planting winter cover crops in the fall on biomass and nitrogen production, and 3) determining the proper nitrogen rate for cotton planted strip-till after different small grain and legume winter cover crops.

MATERIALS AND METHODS

Cover Crop Screening

Ten different small grain and legume cover crops were planted on December 5, 1995, on a Tifton loamy sand on the farm of Tommie Dorminey in Coffee County. Cover crops included in the screening were 'AU Robin' crimson clover, 'Tibbee' crimson clover, big berseem clover, ball clover, 'Cherokee' red clover, 'AU Early Cover' vetch, 'Cahaba' white vetch, rye, and blue lupine. Plot size was 6 feet wide by approximately 800 feet long. Plots were seeded using a modified broadcast turfgrass seeder with rolling baskets. Legumes were inoculated with proper species and at the recommended rate. Seeding rates as recommended by the UGA Extension Service were used. All treatments were replicated four times. Irrigation was used to establish the new seedings and sparingly over the winter.

On April 8, 1996, all cover crops were sampled to estimate biomass and nitrogen production (above- and below-ground). Two areas in each plot measuring 14 inches by 14 inches were sampled. Top growth was clipped at ground level and removed by hand, then dried, weighed, and analyzed for nitrogen using a standard Kjeldahl procedure. Crowns and roots to a depth of approximately 6 inches were then removed from the same sampling areas. The roots/crowns were removed using a flat-faced garden shovel and initially shaken by hand to remove excess soil. The roots/crowns were then further cleaned by washing with a garden hose under pressure. Roots/crowns were then dried, weighed and analyzed for nitrogen content like the shoots.

Immediately after sampling for biomass, the cover crops were killed or burned down with a herbicide mixture of Gramaxone and Karmex. Two weeks later, cotton, corn, pearl millet, and grain sorghum were planted using strip-tillage, each on one of the four replications. Each summer crop was managed according to the grower and included using sidedress nitrogen on all four summer crops.

Timing of Planting Winter Cover Crops

In fall 1996, a study to examine the effect of planting date on winter cover crop biomass and nitrogen production was conducted using the same 6-acre block used for the cover crop screening study described above. The number of winter cover crops used was narrowed from ten to five based on observations in the screening study. ‘AU Robin’ crimson clover and ‘AU Early Cover’ vetch were chosen for their demonstrated earliness, ease of planting summer crops, and reseeding potential. ‘Cherokee’ red clover and ‘Cahaba’ white vetch were chosen based on their potential to maintain or suppress existing cotton nematode populations. Rye was also included for a small grain comparison and its demonstrated high biomass production. Planting dates for the five cover crops were October 2, October 23 and November 18, 1996. Plot size was increased in width to 12 feet, but reduced in length to 150 feet with 40 foot alleys. Irrigation was used again to assure establishment of the legumes but sparingly over the winter. Each planting date followed a different summer crop with October 2 following mostly pearl millet, October 23 following mostly corn and November 18 following mostly grain sorghum. Plots were established using a 10 foot wide no-till drill, recommended seeding rates, and inoculants. All planted on the October 2 date except the rye failed to get a stand. Therefore, all but the rye were reseeded on October 23, the same time as the second planting date.

On April 15, 1997, cover crops in all plots were sampled for biomass and nitrogen production (above- and below-ground) using the same methods described for the cover crop screening study. On May 1, 1997, cotton was planted using strip-tillage on all plots. Irrigation was only used when very dry.

Nitrogen Rates For Strip-Till Cotton

Three separate studies (one in 1997 and two in 1998) were conducted to determine the proper nitrogen rate for cotton following certain cover crops.

__**1997:** In 1997, three different nitrogen rates (0, 30, and 60 lb N/a) were applied to cotton following cover crops in the October 23, 1996, planting date in the aforementioned study (on the same 6-acre block at Tommie Dorminey’s). Again, the five cover crops used were ‘AU Robin’ crimson clover, ‘AU Early Cover’ vetch, ‘Cherokee’ red clover, ‘AU Early Cover’ vetch, and rye. Plot size was 12 feet wide (4 rows) by 50 feet long. No preplant nitrogen fertilizer was applied. Nitrogen was applied by hand at sidedressing time (between first square and first bloom) using ammonium nitrate. Four replications were used. Cotton was harvested on November 4, 1997, using a 2-row picker. Cotton was gathered off the floor of the picker and placed in bags that were later weighed and sampled for turnout. All yields were then calculated and converted to a lb lint/a basis.

1998-1: In 1998, a study similar to the one described above was conducted on a different irrigated field, using larger plots and using the same cover crops except ‘Cherokee’ red clover, which was replaced by reseeded ‘AU Robin’ crimson clover. Soil type was predominately Tifton sandy loam with some Dothan loamy sand. ‘AU Robin’ crimson clover, ‘AU Early Cover’ vetch, ‘Cahaba’ white vetch, and rye were planted in fall 1997. Reseeded ‘AU Robin’ crimson clover was used as a fifth treatment and was already establishing itself when the other covers were planted. Cover crop plots size was 36 feet (12 rows) by approximately 700 feet long. All treatments were replicated four times. In spring 1998, all cover crops were sampled for above- and below-ground biomass and nitrogen production using methods described previously.

Cotton was established on all plots in May 1998. No preplant nitrogen fertilizer was applied. On June 29, 1998, sidedress N rates of 0, 30, and 60 lb N/a were applied as split plots on each cover crop using liquid nitrogen solution (UAN, 32% N). Each split plot measured 12 feet (4 rows) by the length of the field (approximately 700 feet long). On October 15, 1998, cotton was harvested from each plot using a 4-row picker and a boll buggy equipped with load cells and a scale. Cotton lint yields on a lb/a basis were then calculated using a common turnout factor of 38%.

__**1998-2**: Another study of nitrogen rate for cotton following a cover crop was conducted in 1998 in Cook

County on the farm of Simmie King. 'AU Robin' crimson clover was established in a 10 acre dryland field on a Fuquay loamy sand in fall 1997. Biomass and nitrogen production by the cover crop was not measured but was estimated to be comparable to what had been observed in Coffee County – approximately 5 ton/a and 200 lb N/a between above- and below-ground biomass. Roundup Ready cotton was strip-tilled into the clover cover crop in spring 1998 and no herbicide used until spraying Roundup at the 4th leaf stage of the cotton. Sidedress N rates of 0, 30, and 60 were then applied at first square using liquid nitrogen solution (UAN 32%). Each plot measured 12 feet (4 rows) wide by approximately 600 feet long. The treatments were replicated 6 times. On October 14, 1998, cotton was harvested using a 4-row picker and weighed in a boll buggy equipped with scales. Cotton seed samples were taken from each plot and ginned for turnout. Yield was calculated on a lb lint/a basis.

RESULTS AND DISCUSSION

Cover Crop Screening

Adequate stands of all cover crops were initially established. Rye produced the most biomass with over 2 ton/a of above-ground dry matter and 1 ton/a of roots/crowns (Figure 1). 'AU Robin' crimson clover, big berseem clover, and 'Tibbee' crimson clover all produced around 2 ton/a of total biomass (above- and below-ground dry matter). Of these three, 'AU Robin' crimson clover had the most above-ground biomass and Big Berseem below-ground biomass. Arrowleaf clover, 'Cherokee' red clover, ball clover, and 'AU Early Cover' vetch all produced just under 2½ ton/a total biomass. Below-ground biomass for arrowleaf clover, 'Cherokee' red clover, and ball Clover accounted for about half of the total. In other words, there was as much biomass produced below-ground by these clovers as there was above-ground. 'AU Early Cover' vetch, on the other hand, produced very little below-ground biomass. This is characteristic of vetches, where root systems are small compared to above-ground growth. Vetch roots are also much finer than the other crops and thus harder to recover with the sampling method used, which may also have led to the lower below-ground biomass estimate. Both the 'Cahaba' white vetch and lupine cover crops appeared to have suffered sever cold damage and, in the case of lupine, winterkill. Again, initial stands were established, therefore cold weather in February and March seemed to limit total biomass production to less than a half ton/a for 'Cahaba' white vetch and essentially zero for lupine. An earlier planting date may have helped avoid this problem and using a different variety of lupine (maybe white instead of blue) may also have helped.

'AU Robin' crimson clover produced the most nitrogen in the total biomass with just under 160 lb N/a (Figure 2). Big berseem clover was a close second, producing around 150 lb/a total N. The distribution of nitrogen between above- and below-ground biomass was different between these two clover species, with 'AU Robin' crimson clover having most of the N in above-ground biomass, whereas almost half of the total N produced by big berseem was in below-ground biomass. 'Tibbee' crimson clover and 'AU Early Cover' vetch both produced around 120 lb total N/a with most in the above-ground biomass. Ball clover and 'Cherokee' red clover both produced just over 100 lb total N/a with 25% in below-ground biomass for ball and almost 50% for 'Cherokee' red. Arrowleaf clover and rye both produced around 90 lb total N/a. Almost half the N in arrowleaf was below-ground whereas a very small percentage of N was below-ground for rye. The high N production by rye was surprising and may be related to an application of 3 ton/a of poultry litter which all plots received before the cover crops were established. The plots thus were essentially fertilized with approximately 90 lb/a of available N which the legume cover crops did not take as much advantage of since they can fix their own nitrogen.

All cover crops were adequately burned down with the herbicide mixture with the exception of 'Cherokee' red clover. Lack of control on this legume cover crop was thought to be due to its growth habit (a late spring start continuing into the summer crop growing season).

All summer crops seemed to produce well regardless of which cover crop they followed. No establishment problems, problems during the growing season, or harvest problems were encountered.

Timing of Planting Winter Cover Crops

Failure to get a stand of the legume cover crops on the first planting date (October 2) may have been due to seeding depth being too deep or possibly allelopathic effects of the preceding summer crop (pearl millet). A combination of these two problems is also a possibility. Since all but the rye were replanted at the second planting date, there was very little visual difference in stands and biomass produced at the time of sampling the cover crops in the spring. There was also very little visual difference in cover crop biomass production between the first two planting dates and the last planting date (November 18). Therefore, biomass production is reported for the October 23 planting date only (Figure 3). Rye produced the most total (above plus below-ground) biomass at just over 8 ton/a. Again, about twice as much biomass was produced above-ground vs. below-ground for rye. Total biomass production by rye was significantly more than when planted late (December) in the cover crop screening the year before, when only about 3 ton/a total biomass were produced. For the legumes, both clovers and vetches produced about the same amount of total biomass, at about 8 ton/a. This was also more than when planted late in the screening study, when only about 1½ ton/a were produced. Distribution of biomass between above- and below-ground for the legumes was also similar to the screening study with 'AU Robin' crimson clover and 'AU Early Cover' vetch putting less growth below-ground compared to 'Cherokee' red clover and 'Cahaba' white vetch.

The cover crop biomass samples were not analyzed for nitrogen, therefore accurate estimates for nitrogen production can not be made. In fact, if nitrogen production is predicted by using the N content as analyzed the year before in the cover crop screening study, the estimates would range from 225 lb N/a for rye to 524 lb N/a for 'Cahaba' white vetch. These would obviously be an overestimation, especially for the legumes. It is likely that the N content of legumes in this study are lower due to the greater amount of biomass. Also, the greater amount of biomass in this study was likely due to being planted earlier.

Nitrogen Rates For Strip-Till Cotton

1997: There was no statistically significant cotton yield response to either cover crop or nitrogen rate measured in this study (Figure 4). Numerically, cotton yields following rye and 'AU Robin' crimson clover were greater than the other cover crops by at least 100 lb lint/a. Numerically, cotton yields also increased slightly with increasing N rates. Lack of statistical response could be attributed in part to variation in the study as indicated by a coefficient of variation of 21%. Some of this variation may have been due to nematode pressure that ranged from low to severe and was spatially random throughout the plots. Another possible explanation for the lack of response to cover crops or N rates was that the soil fertility level in the plots was very good, having a long history of fertilizing for high-yield vegetable production in addition to the poultry litter application made in 1995.

1998-1: There was no statistically significant cotton yield response to cover crops in this study; however, there was a statistically significant cotton yield increase with increasing rates of nitrogen (Figure 5). Reasons for the more positive response to N in this study compared to the 1997 study reported above include 1) different climatic conditions between years, and 2) lower overall soil fertility (again, no preplant N was used either year), and 3) fairly severe nematode damage throughout most of the plot area.

There was also no significant interaction between cover crop and N rate. This was unexpected and hard to explain. It was expected that the legume plots alone would have produced cotton yields similar to the small grain cover crop (rye) with some additional N. Also, yield increases with increasing N rates applied to the legume cover crops were not expected.

1998-2: In this study, there was a statistically significant cotton yield increase when going from the 0 to 30 lb/a sidedress N rate and following a good stand of 'AU Robin' crimson clover (Figure 6). However, there was no additional yield increase when going from the 30 to 60 lb N/a sidedress rate. Yield levels were also respectable for dryland cotton grown on a fairly sandy Coastal Plain soil. This indicates that the optimum N rate for cotton following a legume cover crop may be 30 lb N/a. Applying no sidedress N in this situation will sacrifice yield, and applying more than this rate may not be justified economically.

CONCLUSIONS

The overall objective of gaining a better understanding of cover crops and conservation-tillage was met in these studies and therefore the project can be considered successful as a whole. Results from the cover crop screening emphasized the strong and weak points of each cover crop for use in a conservation-tillage system. Rye produced the most biomass, or residue, but legumes produced more nitrogen. However, in both studies where different N rates were applied to both rye and legume cover crops, the effect of cover crop was not significant. In other words, cotton yields increased with increasing N rate regardless of which cover crop was used. It appears that the addition of 30 to 60 lb/a of sidedress N, depending on the fertility history of the field and nematode pressure, may optimize cotton yields. Although nematodes were not reported in this study, samples were taken and there are some indications that 'Cherokee' red clover and 'Cahaba' white vetch do not suppress nematodes as expected, and that rye may be the best cover crop to help keep nematode levels in check. The earliness of maturity of 'AU Robin' crimson clover and 'AU Early Cover' vetch make them good choices as legume cover crops for conservation-tillage system using cotton. The optimum planting window for cover crops seems to be from around the first of October to the end of Thanksgiving. Planting cover crops in December or later should be avoided if possible to maximize biomass and N production and avoid possible winterkill.

Future studies already implemented on-farm using cover crops in conservation-tillage include documented effects on nematode populations and the need for fertilization, especially N on small grain cover crops. Studies involving grazing of cover crops and then the effect on subsequent summer crop yields are also needed, as well as documentation of the long term effect of cover crops and conservation-tillage on soil organic matter levels and nutrient stratification.

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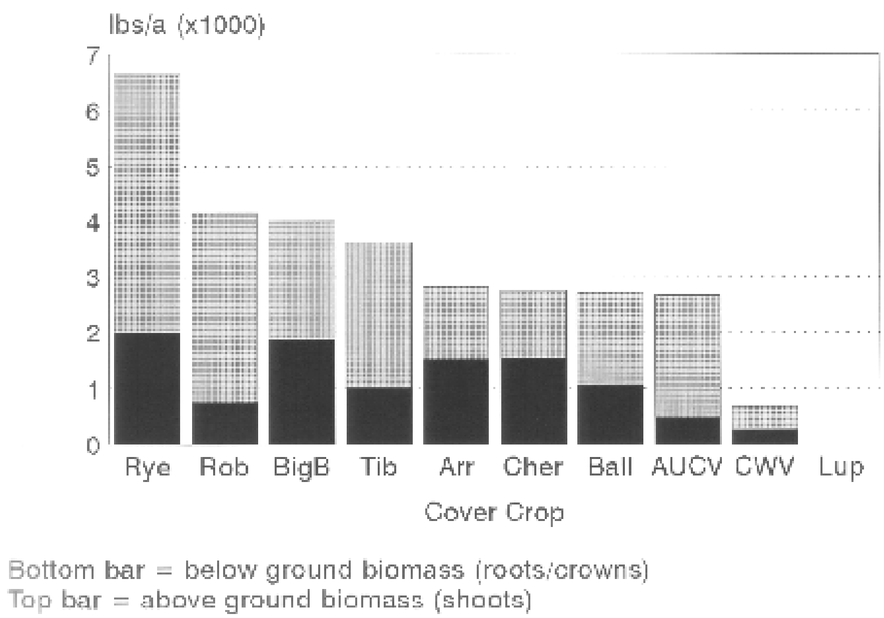

Fig 1. Above and below ground biomass production in cover crop screening study, Coffee County, GA, 1996.

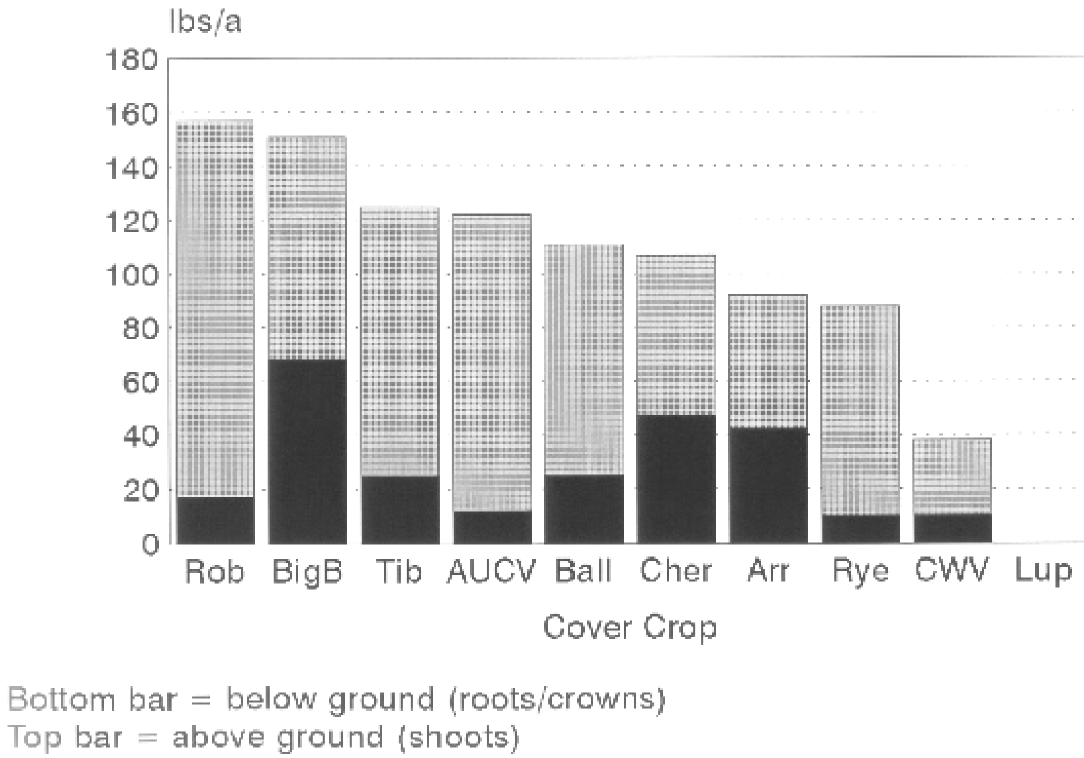

Fig. 2. Nitrogen production by above and below ground biomass in cover crops screen study, Coffee County, GA, 1996.

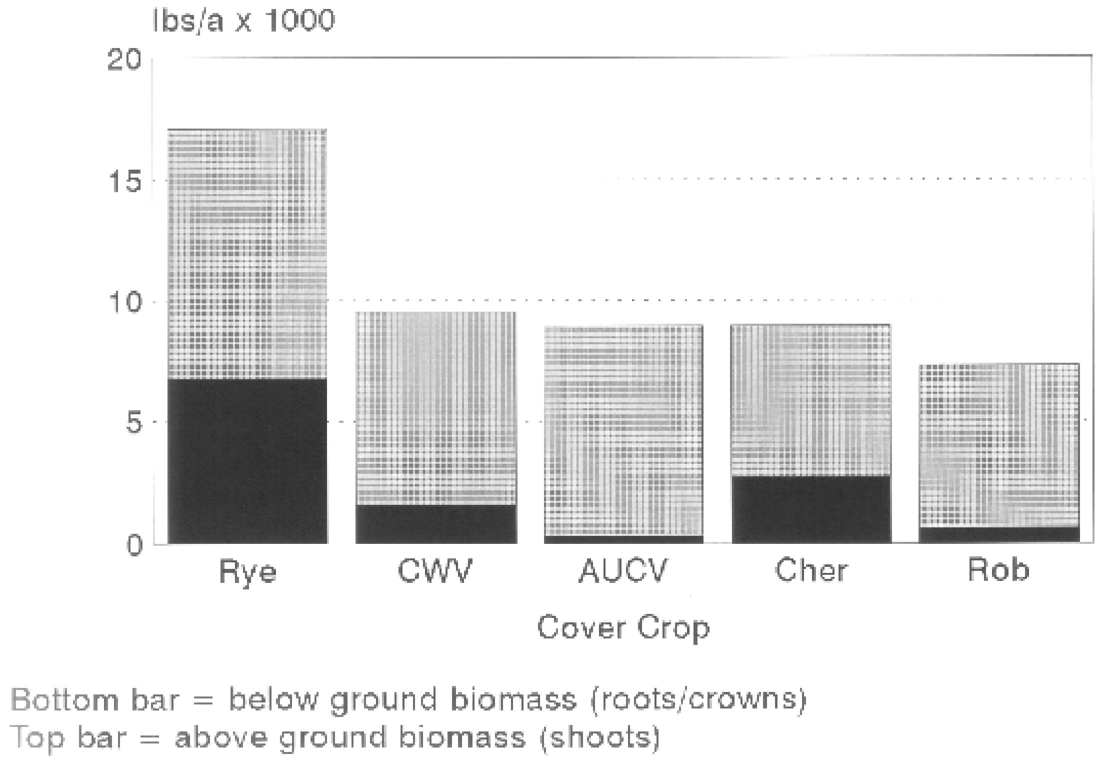

Fig. 3. Above and below ground biomass in timing of planting winter cover crop study, Coffee County, GA, 1997

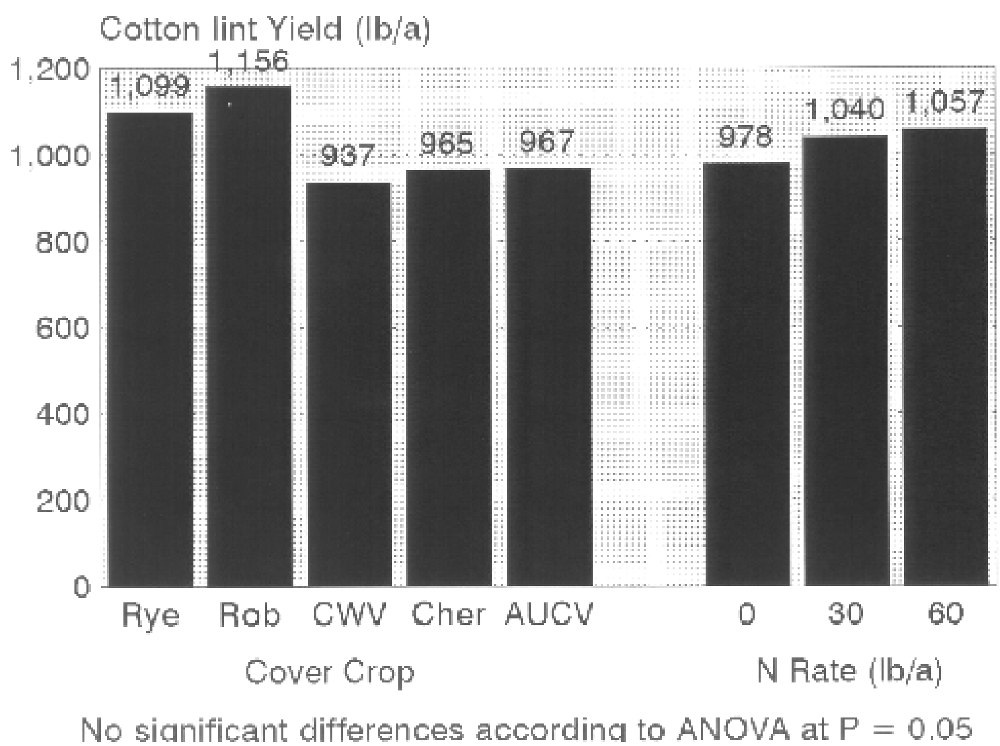

Fig. 4. Cotton yield response to cover crop and sidedress N rates, Coffee County, 1997.

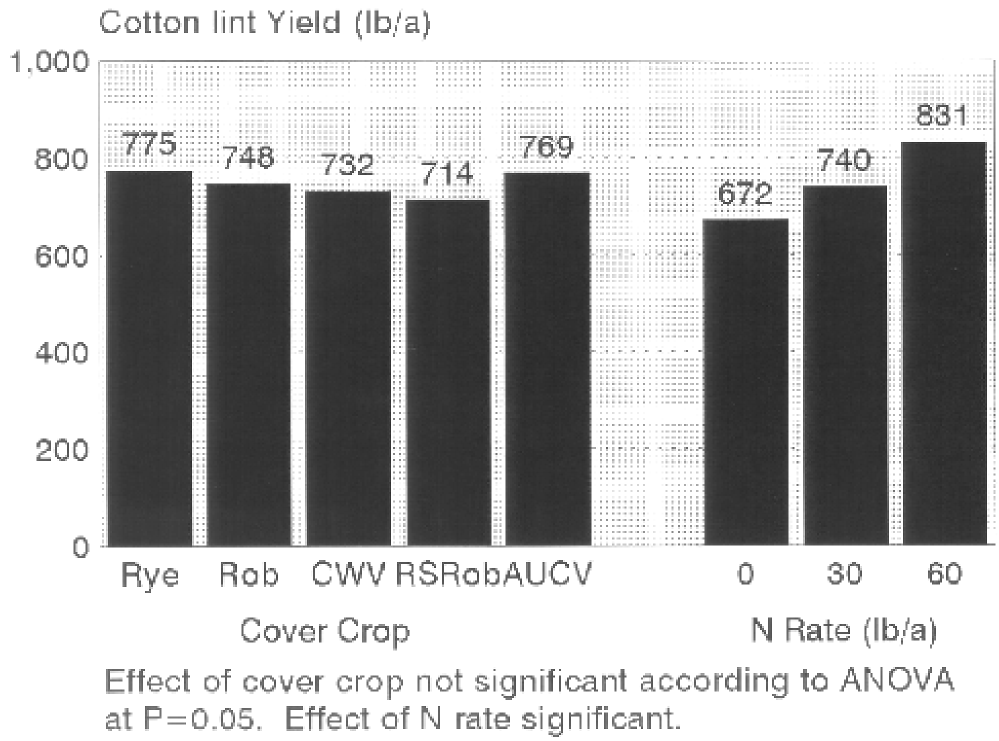

Fig. 5. Cotton yield response to cover crop and N sidedress rate, Coffee County, Effect of N rate is significant.

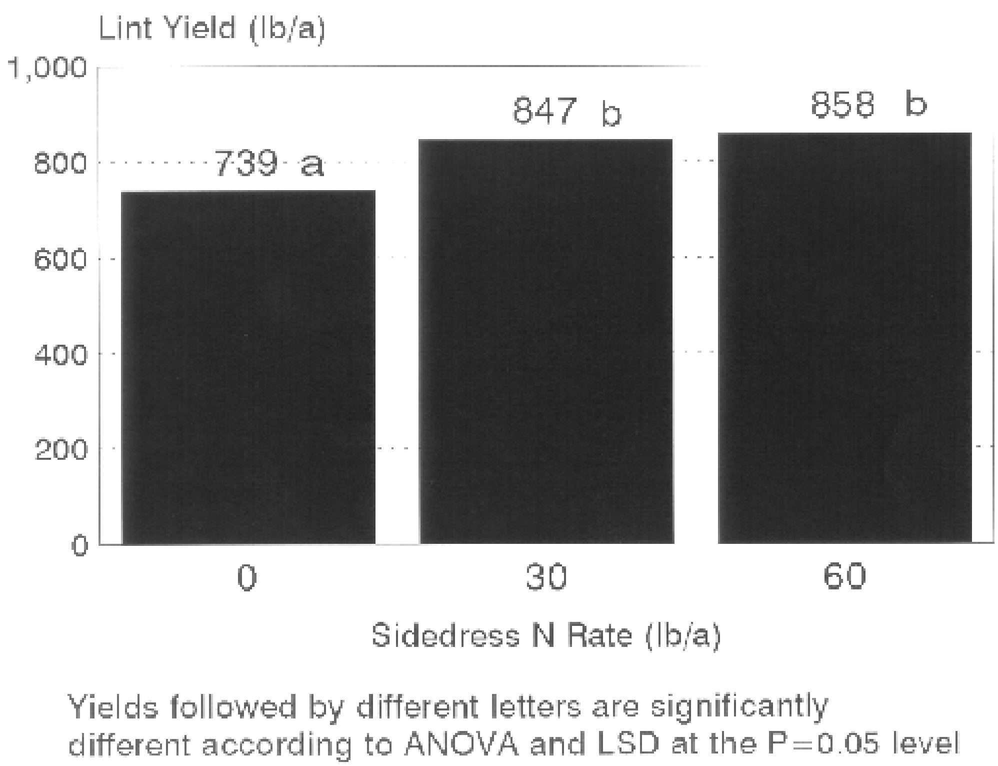

Fig. 6. Cotton yield response to sidedress N rates when following a crimson clover cover crop, Cook County, GA. 1998