# THE EFFECT OF A COVER CROP AND CROP ROTATION ON COTTON: PLANT GROWTH AND YIELD

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## Abstract

Previous research conducted at the Texas A&M University Agricultural Research & Extension Center, Corpus Christi, TX demonstrated that reduced tillage practices increase water infiltration rates and enhance soil water storage capacity. In dryland cotton production, these practices can result in enhanced vegetative growth and increased lint yield potential. Increased rates of infiltration however, promotes the leaching or redistribution of residual nitrates in the soil profile during periods of high precipitation. In the Lower Coastal Bend Region of Texas (LCBR), high precipitation periods coincide with the time in which the soils are bare and exposed to water erosion. A long term, reduced tillage experiment was designed to (1) evaluate the feasibility of establishing a cover crop in LCBR and (2) to study the effect of cover crops on cotton growth and yield. The oats cover crop produced 842 lbs acre$^{-1}$ of dry matter during the follow period of 93/94 and 1540 lbs acre$^{-1}$ in 94/95. Tissue analysis showed that the cover crop assimilated 22.3, and 35.4 lbs acre-1 during 1994 and 1995, respectively. In 1994, the use of cover crop increased cotton lint yield by 8%; however, in 1995 no differences in lint yield were detected. The difference in yield response during the two years are attributed to a delayed termination of the cover crop and to the lack of rainfall prior to planting in 1995. This caused water stress during the early stages of crop development which lead to reduced rates of vegetative development and yield potential.

## Introduction

Approximately 425,000 acres of non-irrigated upland cotton are produced in the Coastal Bend Region of Texas (Texas Agricultural Statistical Service, 1993). Production practices that maximize the utilization of rainfall are essential to ensure maximum yields for this region. Lawlor et al., (1992) found reduced tillage practices to be one means of enhancing cotton lint yield by increasing water infiltration and soil water storage capacity.

Data collected in reduced tillage plots at the Texas A&M University Agricultural Research & Extension Center in the fall of 1989, 1990, and 1991 from a tillage study shows that increased water infiltration rates during fallow periods promotes the movement or leaching of nitrates (Figure 1). Nitrates are soluble in water and move through the soil profile with wetting fronts. Therefore, reduced tillage increases the probability of residual nitrates being redistributed in the soil profile below depth of normal root penetration. Methods of increasing infiltration and managing residual nitrates would benefit cotton production by providing a greater amount of soil moisture and nutrients for utilization in plant growth and development.

Cover crops utilize (in the production of organic matter) residual nitrates and nitrogen that is being released from organic matter decomposition in what would traditionally be a fallow period (Doran and Smith, 1991; Evanylo, 1991). The additional biomass produced by the cover crop provides protection against water and wind erosion. The rate of runoff is also reduced by the additional organic matter reducing the velocity of the water and increasing water infiltration (Louw and Bennie, 1991). This study was conducted to 1) determine the feasibility of consistently establishing a fall cover crop in South Texas, 2) evaluate the effects of the fall cover crop on soil water balance (Azevedo et al., 1996), 3) evaluate the effects of the cover crop on plant growth and lint yield.

## Materials and Methods

A long term cropping system study being conducted at the Texas A&M Agricultural Research & Extension Center at Corpus Christi was modified to evaluate the effects of cover crops in the Coastal Bend Region of Texas. The experimental design is a split plot design with four replications. The main plots are crop rotation sequences comprised of cotton, sorghum, and soybeans (continuous cotton, cotton-sorghum, cotton-soybean, continuous sorghum, sorghum-cotton, sorghum-soybean, soybean-cotton, soybean-sorghum). The sub-plots are two cover crop treatments (no cover crop, and oats cover crop). The predominate soil type is a Victoria clay series (fine montmorillonitic, hyperthermic, Typic Pellustert).

For the 1993-1994 growing season, all previous crops were shredded, disked, and plowed out using 20" ultra wing flat sweeps. The cover crop plots were disked a second time for seed bed preparation. Feed grade oats were planted on October 6, 1994 at the rate of 150 lbs acre$^{-1}$ with a John Deer double disk opener grain drill on 10" centers. All plots were sprayed on December 2, 1993 with glyphosate [N-(phoshonomethyl) glycine] and 2,4-D [2,4-Dichlorophenoxyacetic acid] to terminate cover crop growth and control winter weeds. The desiccated cover crop was allowed to remain standing until preparation for spring planting. The study was fertilized with 200 lbs. acre$^{-1}$ of 15-25-0 in a band application on February 19, 1994. Plots were field cultivated on February 20 and March 25, 1994. A Delta Pine 50 cotton cultivar was planted on

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March 26. A pre-emergence herbicide application of metolachlor [2-chloro-N-(2-methoxy-1-methylethyl) acetamide] and flometuron [N,N-dimethyl-N' - (3-trifluoromethyl - phenyl] urea was performed at recommended rates on March 27. A side-dress application of 188 lbs. acre$^{-1}$ of 32-0-0 was made with the third cultivation on May 17.

In the 1994-1995 growing season, all previous crops were shredded, disked, and plowed out using 20" ultra wing flat sweeps. All plots were disked a second time to level the soil surface. Feed grade oats were planted on September 24 at a rate of 150 lbs acre$^{-1}$ with a John Deer double disk opener grain drill on 10" centers. The cover crop plots were sprayed on January 13 with glyphosate [N-(phoshonomethyl) glycine] and 2,4-D [2,4-Dichlorophenoxyacetic acid] to terminate cover crop growth. All non-cover crop plots were field cultivated for winter weed control. All plots received a pre-plant, broad cast application of 30 lbs. acre$^{-1}$ of N which was incorporated with a field cultivator on March 23. A Delta Pine 50 cotton cultivar was planted on March 24 with starter fertilizer (3 gallons acre$^{-1}$ of 8-24-2). A pre-emergence herbicide application of metolachlor [2-chloro-N-(2-methoxy-1-methylethyl) acetamide] and flometuron [N,N-dimethyl-N' - (3-trifluoromethyl - phenyl] urea was made at recommended rates on March 25. Two cultivations on April 24 and May 17 were performed to control volunteer weeds. A side-dress application of 188 lbs. acre$^{-1}$ of 32-0-0 was made with the second cultivation.

Plant tissue samples were collected from the cover crop prior to termination for dry matter yield and for tissue analysis in both years of the study. Soil samples were collected after cessation of plant growth for moisture determination and elemental analysis. Plant mapping was performed once during the 1993-1994 growing season on July 20 to monitor crop development. In the 1994-1995 growing season, plant mapping was accomplished three times during the season on June 1, June 27, and July 18. Data was analyzed by ANOVA analysis of variance with LSD values being reported at the $P \leq 0.05$ level.

## Results and Discussion

### Rainfall Summary

Cotton lint yield is dependant upon available soil moisture during the bloom and boll filling periods of crop development. A summary of rainfall for the two year period in which this research was conducted is presented in Table 1. Pre-season rainfall (PSR) for the 1993-1994 growing season was 3.41 inches below normal which is reflected in the low biomass production of the cover crop for this year. In-season rainfall (ISR) was also found to be lower than normal by 2.10 inches.

In the 1994-1995 growing season, rainfall patterns were strikingly different. In this year of the study, PSR was found to be 6.83 inches higher than levels normally observed during this period. A deficit of 2.16 inches in ISR was also observed for this year with all of the March rainfall occurring prior to planting. Therefore, substantial soil moisture accumulated in March was lost due to final land preparation and planting. Although rainfall levels for the year were higher than normal, severe soil moisture deficit was observed at the critical stage of plant development (1-63 days after planting) for both the cover and non cover crop plots (Azevedo et al., 1996).

### Cover Crop Dry Matter Yield and Nutrient Content

Dry matter yield and nutrient content were calculated for the oats cover crop in both years of the study. Mean values for oat dry matter (DM) are presented in Table 2. The cover crop produced an average of 874.3 lbs. acre$^{-1}$ in the fall of 1993 under below normal rainfall conditions. In the second year of the study, the cover crop yielded an average of 1632.9 lbs. acre$^{-1}$. Yields were higher for the 1994 cover crop due to greater than normal precipitation. Visually, the cover crops provided significant protection during storm events in which surface runoff caused severe erosion damage to neighboring crop land.

Laboratory analysis of tissue samples showed the cover crop utilized a substantial amount of nutrients in the production of the additional organic matter. Nutrient uptake of the cover crop for 1993 was 22.3 lbs. of N, 2.2 lbs. of P, and 35.5 lbs. of K per acre (Table 3). In 1994, the nutrient uptake levels were 35.4 lbs., 5.7 lbs., and 55.3 lbs per acre, respectively.

### Plant Growth and Lint Yield

Plant height is one element of plant growth which is directly related to the availability of soil water. Plant height was found to be significantly reduced at the first mapping date in 1995 (Figure 1) by 6.0 cm (LSD=1.0 cm) due to utilization of soil water by the cover crop. At the second mapping date, plant height suggested that the cover crop better utilized the 3.18 inches of rainfall received in May. At the final mapping date in 1995, no significant differences in plant height were observed. In 1994, final plant height (Figure 2) was found to be significantly enhanced by the cover crop by 4.7 cm (LSD=4.6 cm).

In both years of the study, the cover crop had a tendency to delay maturity. Green boll numbers at the final mapping date in both years of the study were observed to be higher in the cover crop plots (Figure 3). The cover crop plots were found to have a significantly greater number (LSD =18.0) of green bolls per meter of row in 1994. The opposite trend was observed in open boll numbers in both years of the study (Figure 4). In 1994, the non-cover crop plots were observed to have a significantly greater number of open bolls per meter of row (LSD=9.0).

The cover crop showed a tendency to increase the total number of bolls produced in a meter of row in both years of this study at a non significant level (Figure 5). The increases in total boll numbers is also reflected in a non significant increase in lint yield in 1994 (Figure 6). In 1995, mean lint yield in the cover crop plots was 6 lbs. acre$^{-1}$ less than that observed in the non-cover plots. The dissimilarity in lint yield verses total boll number 1995 is due to a shortage of rainfall and stored soil moisture during June and July (critical boll filling period).

The lack of beneficial effects of the cover crop on plant growth and lint yield is believed to be a result of delayed termination of the cover crop (12/21/93 for the 1994 study and 01/13/19 for the 1995 study). The cover crop continued to utilize stored soil moisture and rainfall providing less time for reserves to be replenished prior to planting.

**Rainfall Pattern and Lint Yield**

Rainfall patterns verses lint yields was also considered as a possibility to explain the contrasting differences in the two years of the study. A correlation of in-season rainfall to lint yield is presented in Figure 7. Under non-cover crop practices, base line yield at the Texas A&M Agricultural Research & Extension Center is 195.1 lbs acre$^{-1}$. For each inch of pre-season rainfall (PSR), lint yield is increased by 8.3 lbs acre$^{-1}$. Each inch of in-season rainfall (ISR) increases lint yield by 27.0 lbs. acre$^{-1}$. The $R^2$ value of this equation is 0.405. Cover crops may be on means of elevating the 27.0 lbs. acre$^{-1}$ increase for each inch of in-season rainfall under dryland production practices. However, the time of cover crop termination should allow adequate time for recovery of some stored soil moisture prior to planting.

## Conclusion

This study demonstrated the feasibility of establishing a cover crop in the Lower Coastal Bend Region of Texas. An average of 843 and 1540 lbs acre$^{-1}$ of dry matter was produced by the cover crops during the follow periods of 93/94 and 94/95. The cover crops assimilated 22.4 and 35.4 lbs acre$^{-1}$ of nitrogen during 1994 and 1995, respectively, reducing in this manner the potential leaching of nitrogen out of the root zone. Cover crop enhanced the ability of the soil to capture rainfall by reducing the velocity of the runoff water and by improving its infiltration rate. In 1994, improvements in water infiltration rates caused by the cover crop resulted in higher plant height, green and open boll number and lint yield. In 1995, delayed destruction of the cover crop and lower incidence of pre-planting rainfall resulted in no differences in plant growth and yield between cover and non-cover crop treatments. We concluded that the additional crop residue produced by cover crops can result in season long benefits in water infiltration rates. The increase capture of in-season rainfall can result in significant increases in cotton lint yield in the Coastal Bend Region of Texas.

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Table 1. Annual rainfall and seasonal summary of rainfall received at the Texas A&M Agricultural Research & Extension Center, Corpus Christi.

| Summary | 1993-1994 | 1994-1995 | Average |
|---|---|---|---|
| | inches | | |
| Pre-Season Rainfall August - February | 11.19 | 21.43 | 14.6 |
| March | 2.23 | 3.51 | 1.52 |
| April | 2.26 | 0.30 | 1.66 |
| May | 1.55 | 3.18 | 3.36 |
| June | 3.20 | 2.25 | 3.27 |
| July | 0.70 | 0.64 | 1.87 |
| In-Season Rainfall March - July | 9.94 | 9.88 | 12.04 |
| Total Annual Rainfall | 21.13 | 31.31 | 26.64 |

Table 2. Dry matter yield of oats cover crop. Corpus Christi, TX.

| Rotation Sequence | 1993-1994 | 1994-1995 |
|---|---|---|
| | lbs. acre$^{-1}$ | |
| Continuous Cotton | 875.7 | 1932.1 a[†] |
| Cotton - Sorghum | 918.7 | 1412.4 b |
| Cotton - Soybean | 828.5 | 1554.2 ab |
| Mean | 874.3 | 1632.9 |
| LSD (P=0.05) | 343.8 | 454.7 |
| P>F | 0.6618 | 0.0525 |

[†]Means followed by the same letter within a column are not significantly different according to Duncan's Multiple Range Test ($P \leq 0.05$).

Table 3. Mean nutrient uptake of selected elements. Corpus Christi, TX.

| Rotation Sequence | 1993-1994 | 1994-1995 |
|---|---|---|
| | lbs. acre$^{-1}$ | |
| Nitrogen | 22.3 | 35.4 |
| Phosphorus | 2.2 | 5.7 |
| Potassium | 35.5 | 55.3 |

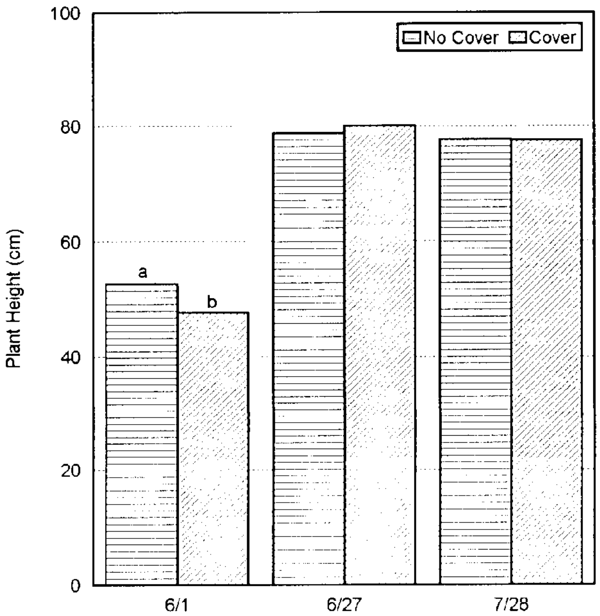


Figure 1. Plant height as effected by cover crop treatment. Corpus Christi, Texas, 1995.

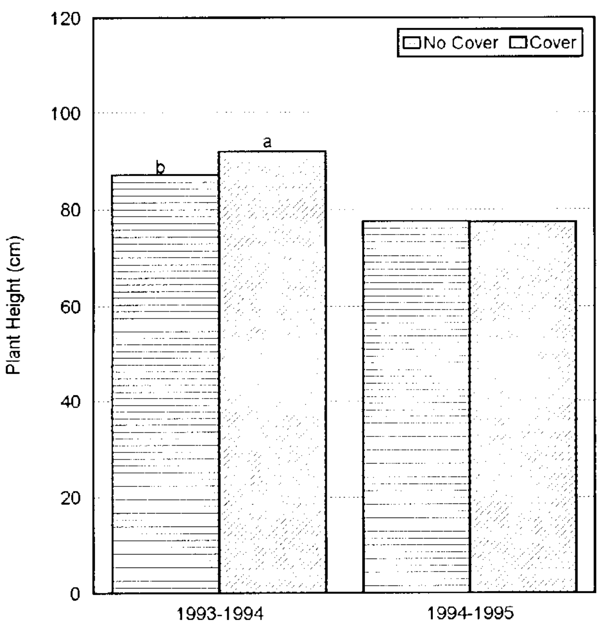


Figure 2. Final plant height as effected by cover crop treatment. Corpus Christi, Texas.

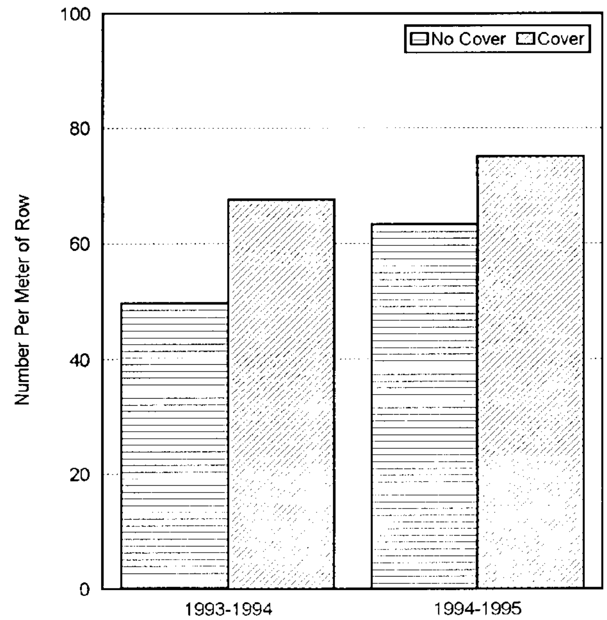


Figure 3. Number of green bolls observed in one meter of row at final mapping date as effected by cover crop treatment. Corpus Christi, Texas.

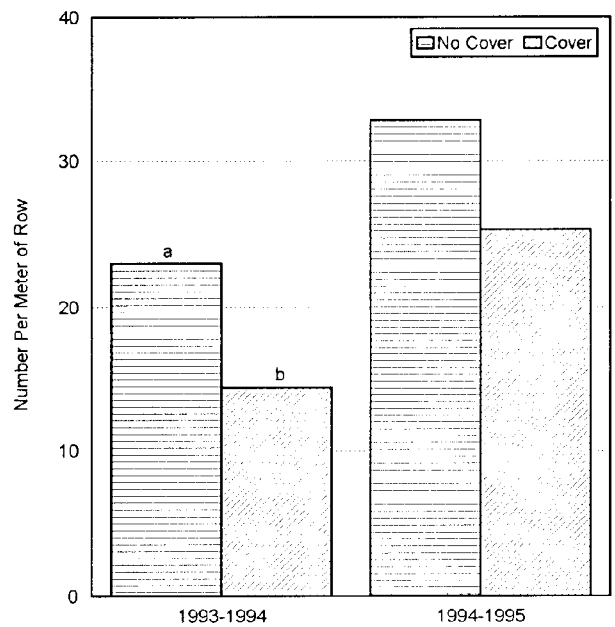


Figure 4. Number of open bolls observed in one meter at final mapping date as effected by cover crop treatment. Corpus Christi, Texas.

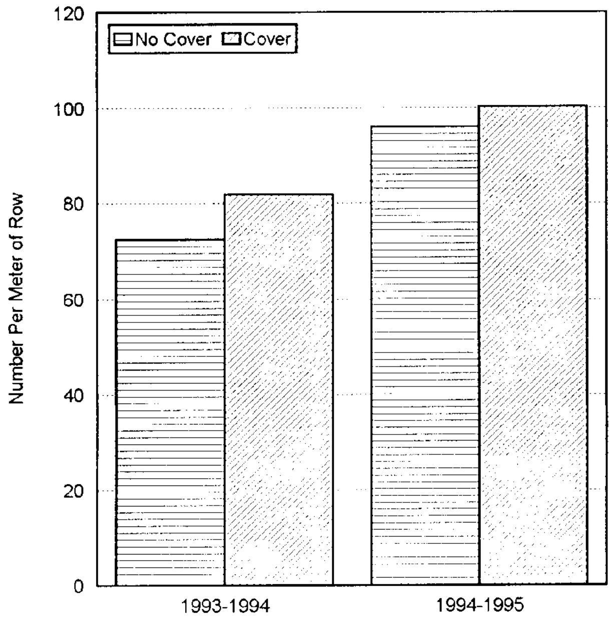


Figure 5. Total number of bolls observed in one meter of row at final mapping date as effected by cover crop treatment. Corpus Christi, Texas.

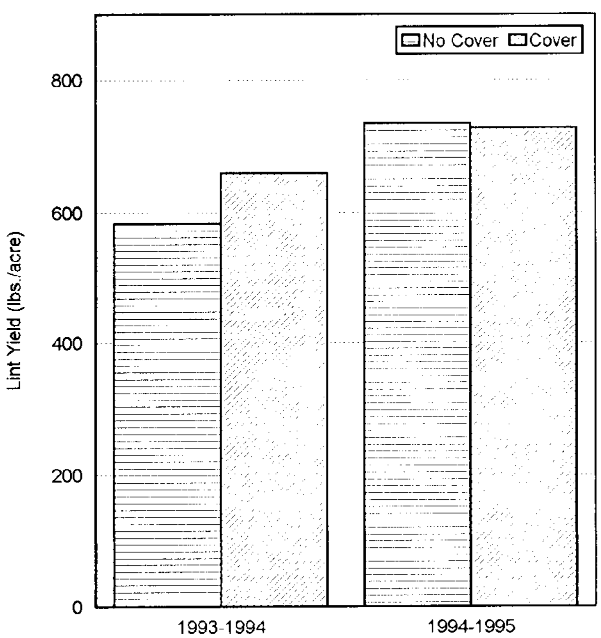


Figure 6. Lint yield as effected by cover crop treatment. Corpus Christi, Texas.

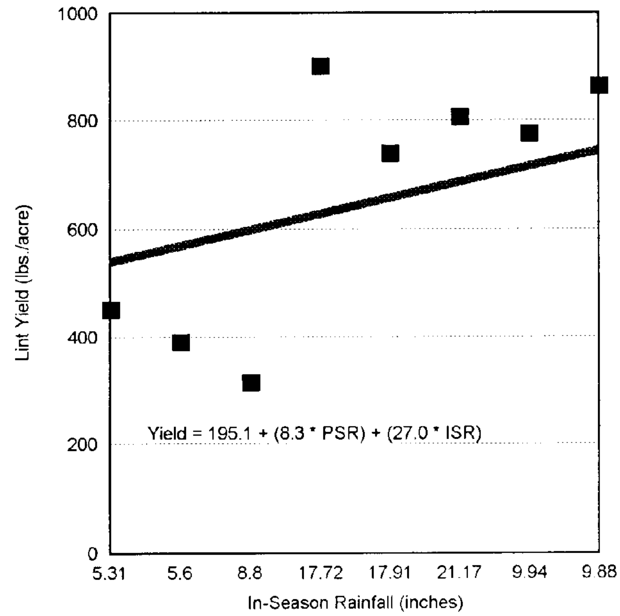


Figure 7. Correlation of inseason rainfall to lint yield for 1988 through 1995 growing seasons. Corpus Christi, TX.