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# ROTATION, TILLAGE, AND NITROGEN RATE EFFECTS ON COTTON GROWTH AND YIELD

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## Abstract

Nutrient requirements of cotton [*Gossypium hirsutum* (L.)] may be altered by crop rotation and tillage practices. In a six-year study conducted in south central Texas, the lint yield of cotton rotated with corn was increased by 35% compared to continuous cotton. Lint yield of reduced till continuous cotton was 23% greater than conventional tillage continuous cotton. Nitrogen (N) economy of cotton was also enhanced by rotation or reduced tillage. These practices increased lint yield of the no N controls by 69 and 54%, respectively. Reasons for differences were related to changes in soil chemical, biological, and physical properties.

## Introduction

Nitrogen requirements of cotton are affected by tillage practices and rotation. Crops produced with conservation tillage often have increased N fertilizer requirements upon initiation of this practice, but may require less over the long-term because of increasing soil organic matter content and associated N mineralization (Franzluebbers et al., 1995). Rotation of cotton with other crops, such as corn (*Zea mays*), may positively or negatively impact N fertilizer needs of cotton depending on management practices for the rotated crop.

Much of the Great Plains and western US base N fertilizer recommendations on yield goal and the quantity of residual nitrate in the soil profile prior to planting. Alteration of soil properties by tillage and rotation that may impact crop growth and yield, but not residual soil nitrate, are not normally integrated into fertilization guidelines.

The objectives of this research were to i ) determine effects of rotation and reduced tillage on cotton growth and lint yield compared to conventionally tilled continuous cotton, ii ) ascertain if observed differences are related to changes in soil properties, and iii ) determine the most efficient N fertilization rate for rotated vs. continuous cotton and for reduced vs. conventional tillage.

## Materials and Methods

The study was conducted in south central Texas in Burleson County near College Station from 1998 to 2003. The soil used was a Weswood silt loam and the study was partially irrigated. Cropping sequences used were cotton after corn (Cot/corn) and continuous cotton (Cot/cot). Tillage treatments were conventional (CT) and reduced (RT) tillage. Conventional tillage included stalk shredding, several diskings, chisel plowing, bedding, and in-season cultivation. Reduced till consisted of stalk shredding, hipping beds over old rows, and in-season cultivation. Nitrogen for cotton was preplant subsurface knifed as $NH_4NO_3$. Nitrogen rates were 0 to 160 lbs N/acre in 40 lb. increments. Rotated corn received 80 lbs N/acre preplant subsurface knifed. The experimental design was an incomplete factorial (no RT treatment for Cot/corn) within a randomized complete block design with four replications. Plots were 45 ft by 4, 40 in. rows. Bt-modified picker varieties were planted in early April each year, with the middle two rows of each plot machine-harvested at maturity.

Soil and plant data collected annually included soil available nutrients, soil organic carbon (SOC) (Nelson and Sommers, 1982), soil total N (TN) (Gallaher et al., 1976), mineralizable C and N and soil microbial biomass (Franzluebbers et al., 1996), plant height, plant population, and lint yield and yield components. Additional measurements in 2003 included soil bulk density by the core method, gravimetric water content, and determination of water-stable aggregates (Elliot and Cambardella, 1991). Due to space constraints only the most pertinent information will be presented.

## Results and Discussion

### Cotton Growth and Yield

Cotton emerged more quickly and grew more rapidly in Cot/corn and Cot/cot RT compared with Cot/cot CT, and effects persisted throughout the season. Figures 1 and 2 show these effects for the 2002 season, but results were similar for all years of the study (Fig. 3). Results for plant height at peak bloom for the six years showed tallest plants in Cot/corn, intermediate height in Cot/cot RT, and shortest plants in Cot/cot CT.

Averaged over N rate, rotation and RT increased lint yield by 35 and 19% in 2003 compared with Cot/cot CT (Fig. 4). For the six study years, these treatments increased lint yields by 35 and 24%, respectively (Fig. 5). Effects were even more pronounced in the no N controls where rotation and RT enhanced yield by 70 and 62% in 2003 compared with Cot/cot CT. Increases were 69 and 54%, respectively, when averaged over the six years. Thus, apparent N economy also varied with the different systems and was greater with Cot/corn and Cot/cot RT than with Cot/cot CT. Differences in yield and apparent N efficiencies raised the question as to whether changes in soil properties associated with the various systems could account for the observed differences.

Residual soil nitrate-N to a depth of 24 inches was greatest for Cot/corn, intermediate for Cot/cot CT, and lowest for Cot/cot RT (Fig. 6). Part of the residual nitrate in Cot/corn may be from N fertilization of corn. Why residual soil nitrate increased with increasing added N in Cot/cot CT, but decreased in Cot/corn is not known. Residual nitrate changed little with increasing added N in Cot/cot RT. Lowest values for this treatment may be associated with immobilization of N in the greater quantity of surface residues in this treatment. Greater residual soil nitrate in Cot/corn with no added N might explain part of the higher yield compared with Cot/cot CT, but wouldn't account for the continued yield difference with increasing added N. Higher yield with Cot/cot RT vs. Cot/cot CT was not explained by residual nitrate.

Soil organic C was 28% greater in samples from Cot/corn and Cot/cot RT compared with Cot/cot CT (Table 1). Increases likely were due to slower decomposition of surface residues in RT and greater plant dry matter return with corn. Soil total N followed similar trends and was 33 and 25% greater for Cot/cot RT and Cot/corn compared to Cot/cot CT (Table 2). Increased SOC and TN with Cot/cot RT and Cot/corn might result in improved soil physical properties and increased soil N mineralization, which could translate into greater yield.

Cumulative soil C mineralized during 38 days of incubation was greatest for Cot/cot RT, intermediate for Cot/corn, and lowest for Cot/cot CT (Fig. 7). Fertilizer N addition tended to increase soil C mineralized, though not significantly, and was likely due to increased plant dry matter production with added N. Soil N mineralization was approximately 55% greater for Cot/cot RT compared with Cot/corn and Cot/cot CT (Table 3). At a N mineralization rate of 0.81 ppm N/day for Cot/cot RT, about 62 lbs N/acre-6 inches would be mineralized over 38 days, and may partially account for increased lint yield with this treatment at lower rates of added N compared to Cot/cot CT.

Soil microbial biomass is both the change agent for organic matter decomposition and a source/sink for nutrients. Microbial biomass C was greatest for Cot/cot RT, intermediate for Cot/corn, and lowest for Cot/cot CT (fig. 8). Values tended to be greater in the soil surface compared to deeper depth and increased with N fertilizer application.

Water-stable aggregates were isolated into four size fractions (Fig. 9). The largest was >2000 µm (>2 mm), while the smallest was associated with the silt- and clay-sized fraction (<53 µm). Few differences from rotation, tillage, or N addition treatments were observed. Approximately 50% of the water-stable aggregates were in the 250 to 2000 µm fraction, regardless of treatment.

Soil bulk density was determined to a 9-in. depth in 3-in. increments early in the 2003 growing season. Bulk density was not influenced by treatment, but did increase with depth compared to the near surface (Fig. 10). Soil gravimetric water content was measured to a 9-in. depth in 3-in. increments in mid-May 2003. The sampling occurred approximately six weeks after planting, with no rainfall occurring between planting and sampling. Soil water content was greater for Cot/corn compared to the continuous cotton treatments, and also significantly increased with depth (Fig. 11). Greater soil water content in Cot/corn, even though plants were larger, suggested that increased soil water storage might account for a portion of the increased growth and yield in this treatment.

## Conclusions

Rotation with corn increased average cotton lint yield by 35% during this six-year study compared to Cot/cot CT. Reduced till continuous cotton increased average lint yield by 23% compared to Cot/cot CT. Rotation with corn or reduced tillage also improved the apparent N economy of cotton. Reduced tillage resulted in increased SOC, TN, soil microbial biomass C, and soil C and N mineralization. Rotation with corn increased SOC, TN, residual nitrate-N, and soil gravimetric water content. Fertilizer N application to cotton may be much reduced on this soil when rotated with corn or when using reduced tillage in continuous cotton production.

## Acknowledgment

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Table 1. Tillage and rotation effects on soil organic carbon (SOC)- 2003, Burleson Co., TX.

| Treatment | SOC, % (0-6") |
|---|---|
| Cotton/corn Conventional tillage | 0.82 a |
| Cotton/cotton Reduced tillage | 0.83 a |
| Cotton/cotton Conventional tillage | 0.65 b |

Means followed by the same letter are not different at P<0.05.

Table 2. Tillage and rotation effects on soil total nitrogen (TN)-2003, Burleson County, TX.

| Treatment | **Soil total N, ppm (0-6")** |
|---|---|
| Cotton/corn Conventional tillage | 886 a |
| Cotton/cotton Reduced tillage | 943 a |
| Cotton/cotton Conventional tillage | 707 b |

Means followed by the same letter are not different at P<0.05.

Table 3. Tillage and rotation effects on soil nitrogen mineralized (Nmin)-2003, Burleson County, TX.

| Treatment | Soil Nmin, ppm/d (0-6") |
|---|---|
| Cotton/corn Conventional tillage | 0.53 b |
| Cotton/cotton Reduced tillage | 0.81 a |
| Cotton/cotton Conventional tillage | 0.51 b |

Means followed by the same letter are not different at P<0.05.

Figure 1. Cot/corn rotation in foreground, Cot/cot CT in middle, and Cot/cot RT in background, June 2002.


Figure 2. Cot/corn rotation on right of photo, Cot/cot CT on left.

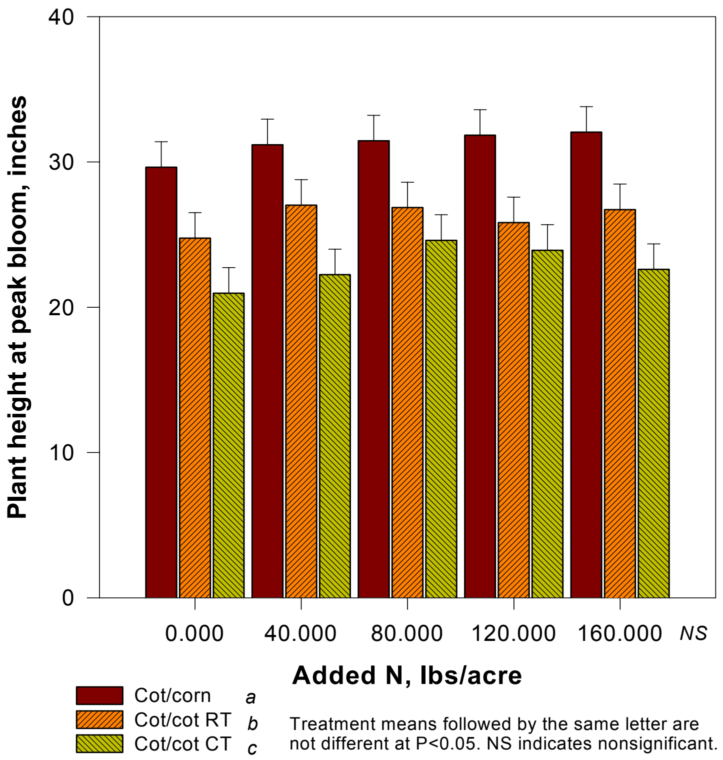


Figure 3. Rotation, tillage, and nitrogen rate effects on average plant height at peak bloom, 1998-2003.

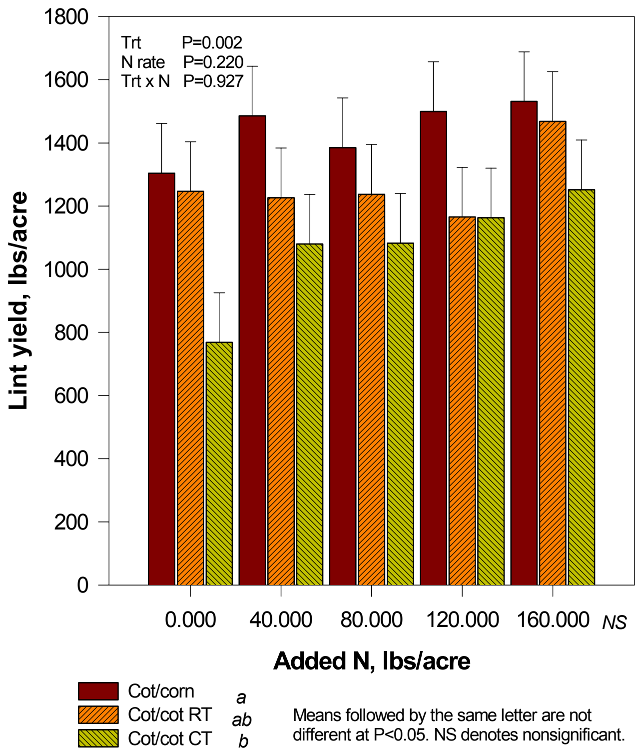


Figure 4. Rotation, tillage, and nitrogen rate effects on cotton lint yield, 2003.

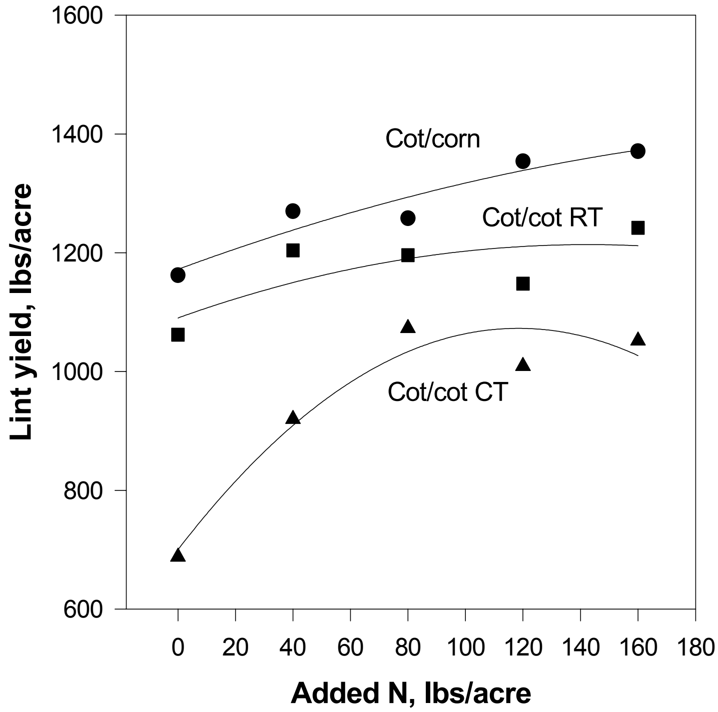


Figure 5. Average lint yield response to added nitrogen as affected by tillage and rotation, 1998-2003.

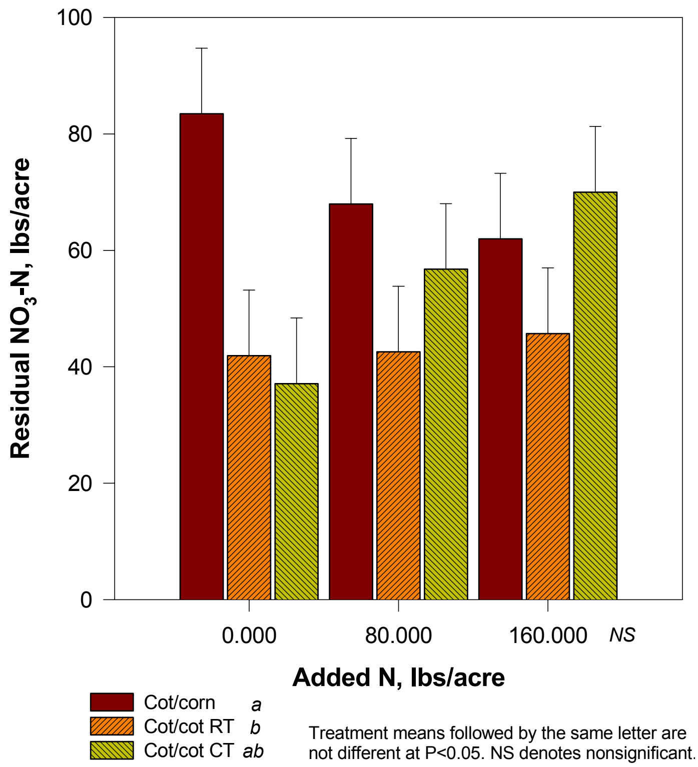


Figure 6. Rotation, tillage, and nitrogen rate effects on residual soil $NO_3$-N to 24 inches, 2003.

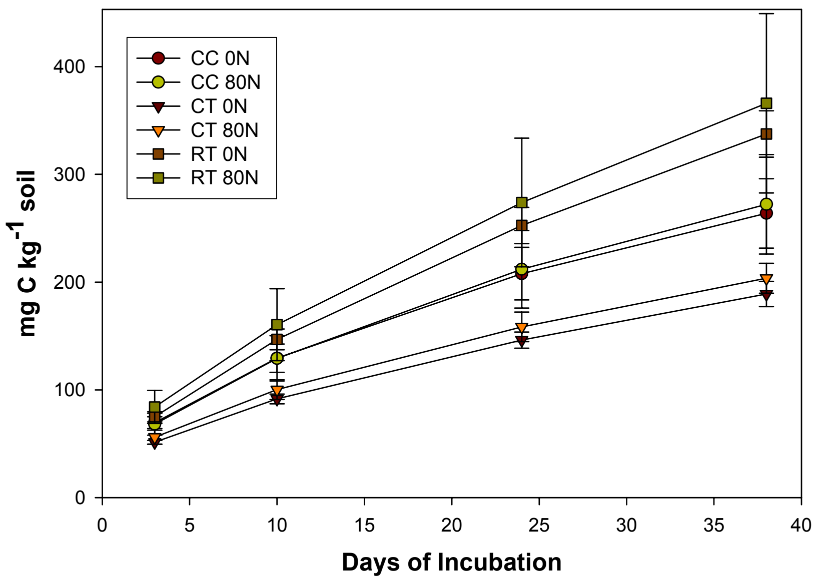


Figure 7. Treatment effects on cumulative soil carbon mineralized, 2003. CC, CT, and RT denote cotton/corn and conventional and reduced tillage continuous cotton. 0 and 80 are added lbs N/acre.

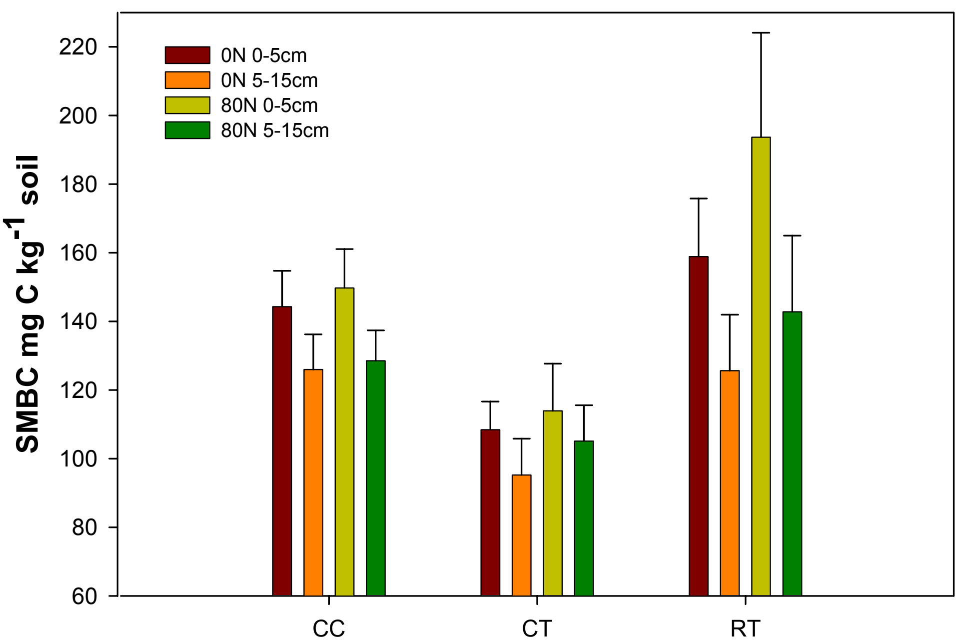


Figure 8. Treatment effects on soil microbial biomass carbon (SMBC), 2003. CC, CT, and RT denote cotton/corn and conventional and reduced tillage continuous cotton. 0 and 80 are added lbs N/acre.

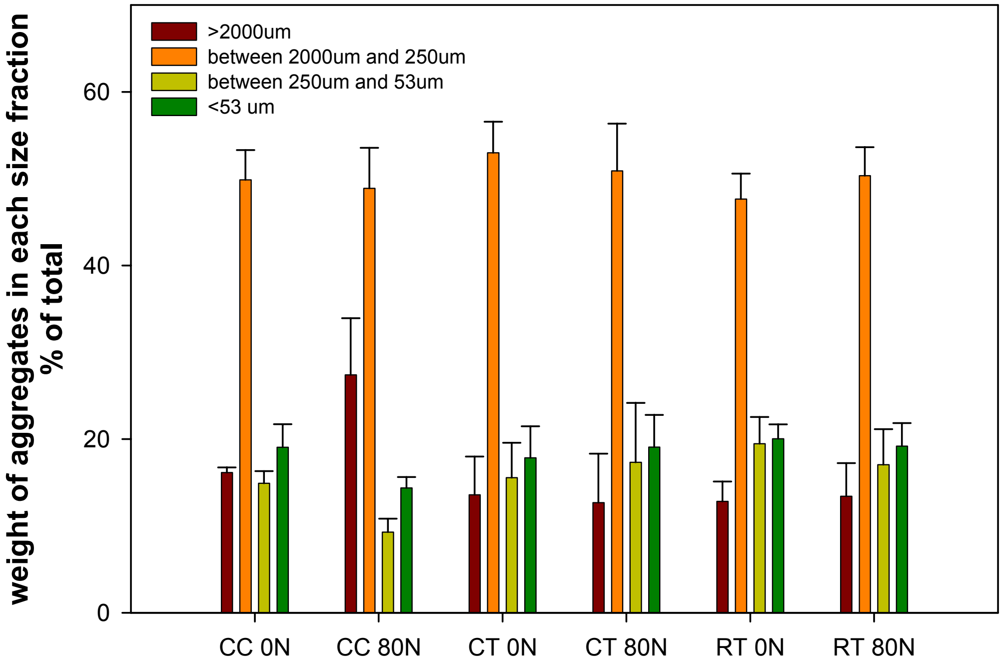


Figure 9. Treatment effects on proportions of size classes of water stable aggregates, 2003. CC, CT, and RT denote conventional and reduced tillage continuous cotton. 0 and 80 are added lbs N/acre.

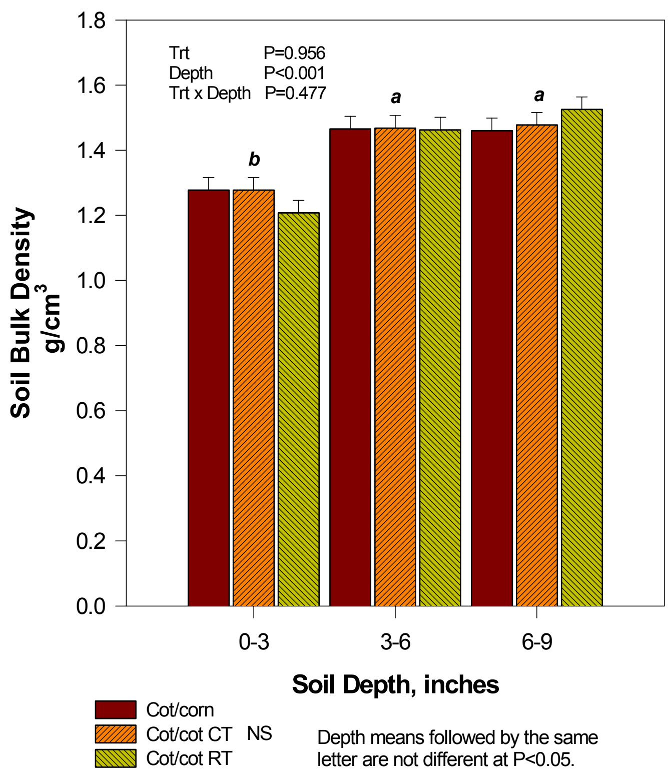


Figure 10. Treatment effects on soil bulk density, May 2003.

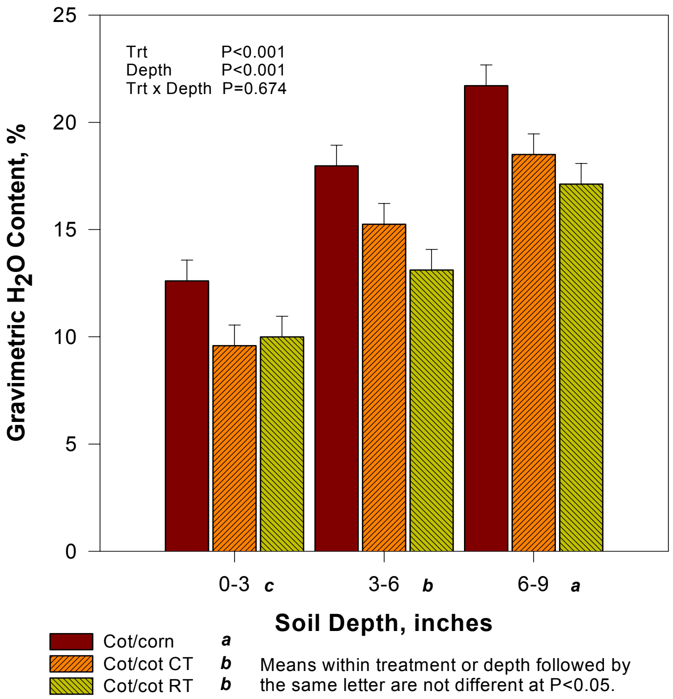


Figure 11. Treatment effects on soil gravimetric water content, May 2003.