CROPPING SYSTEMS TO ENHANCE WATER AND SOIL CONSERVATION IN SEMI-ARID REGIONS OF TEXAS

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Abstract

As stewards of the land, farmers in semi-arid agriculture production regions are challenged to maintain farm profitability while conserving soil and water resources. When optimized for regional semi-arid conditions, conservation tillage systems incorporating crop rotation and cover crop practices may have the potential to conserve water and soil resources through increased water holding capacity and soil organic matter content. As water is often the most limiting factor in crop production within semi-arid environments, practices that are perceived to reduce stored soil water will hinder adoption. Water use by cover crops may reduce stored soil moisture and yields of subsequent crops. Research in the Southern High Plains of Texas has demonstrated increased returns with winter wheat/summer fallow-cotton rotations compared to continuous cotton planted in terminated rye cover. Implementation of greater biomass producing crops such as wheat in rotation with cotton should provide similar soil quality benefits as cover crops, but unlike rye-cover, a wheat-cotton rotation has been demonstrated to reduce root-knot nematode density. The objective of the research presented was to evaluate and quantify the impact of crop rotation (wheat-fallow-cotton), rye-cover, and reduced tillage coupled with deficit-irrigation management strategies on soil quality (organic C and aggregate formation), root-knot nematode populations and the subsequent effect on cotton (*Gossypium hirisutum* L.) lint yield and economic returns.

Methods

Research was conducted at the Agricultural Complex for Advanced Research and Extension Systems (AG-CARES) in Lamesa, TX (32° 46' 22", 101° 56' 18"). The site is described as a semi-arid environment with a mean annual temperature and precipitation of 60°F and 18 inches, respectively, by the U.S. Climate Data Service. The soil at this location is classified as an Amarillo series and is described as a fine sandy loam (fine-loamy, mixed, superactive, thermic Aridic Paleustalfs) with a pH of 7.5 (USDA-NRCS). The reduced tillage systems of wheat-fallow-cotton rotation and continuous cotton with rye cover were initiated in 2014 under irrigation levels including: base (approximately 60% of evapotranspiration, ET), low (0.33*base), and high (1.33*base). Lint yield, fiber quality, irrigation water use efficiency (IWUE) and economic gross margins were determined for the systems in 2014, 2015, and 2016. Irrigation water use efficiency was calculated using the following:

IWUE (lb lint inch^{-1} irrigation water) = (irrigated yield – dryland yield) / irrigation water amount.

Soil samples were collected in April 2017 at depths of 0-6, 6-12, and 12-24 inches and analyzed for soil organic C (SOC) and mean weight diameter (MWD) of soil particles as an indicator of aggregate stability. Root-knot nematode early season galling and fall soil density were determined in 2016. Analysis of variance of main plot (cropping system) and split-plot effects (irrigation level) and their interaction was determined using PROC GLIMMIX and differences were determined using Fisher's protected least significant difference in SAS 9.3. Lint yield was combined across years ($p = 0.069$).

Results

Cotton lint yield was greatest with the wheat-cotton rotation compared to the continuous cotton with rye cover regardless of irrigation level (Fig. 1). Yield differences did not exist between the wheat-cotton rotation under low irrigation and the continuous cotton with rye cover under high irrigation. This may be the result of the fallow period following wheat harvest which increases water capture and storage, reduces root-knot nematode densities and galling, and likely increases nutrient cycling and availability to the following cotton crop.

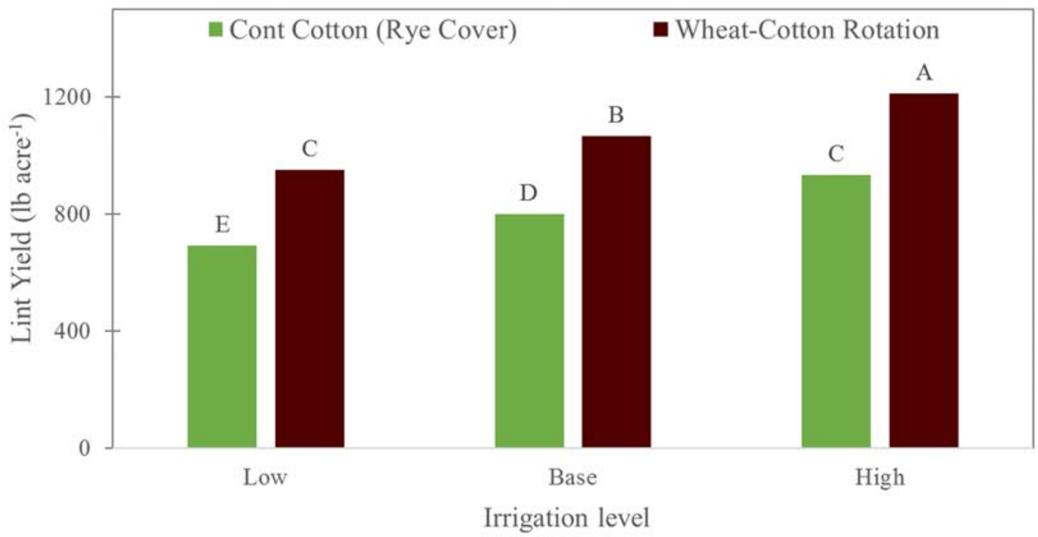

Figure 1. Cotton lint yield for the continuous cotton with rye cover and wheat-cotton rotation under different irrigation levels. Lint yield was combined across years (2014, 2015, and 2016).

Root-knot nematode causes galls to form on cotton roots which reduce root length, and cause the plant to move photosynthates to the infected root cells, reducing the plant of energy needed to increase yield. The wheat/fallow/cotton rotation was very effective at reducing the early season gall formation on the subsequent cotton crop (Fig. 2). During the first year of cotton after the wheat/fallow rotation (2014), root-knot nematode was able to recover and buildup on the cotton, so that there were no differences in cropping systems with regards to nematode density by late season. However, after the second and third years of the rotation, root-knot nematode density late in the season was significantly lower than with continuous cotton. This wheat/fallow/cotton rotation was more effective at reducing nematode density than using nematode resistant varieties.

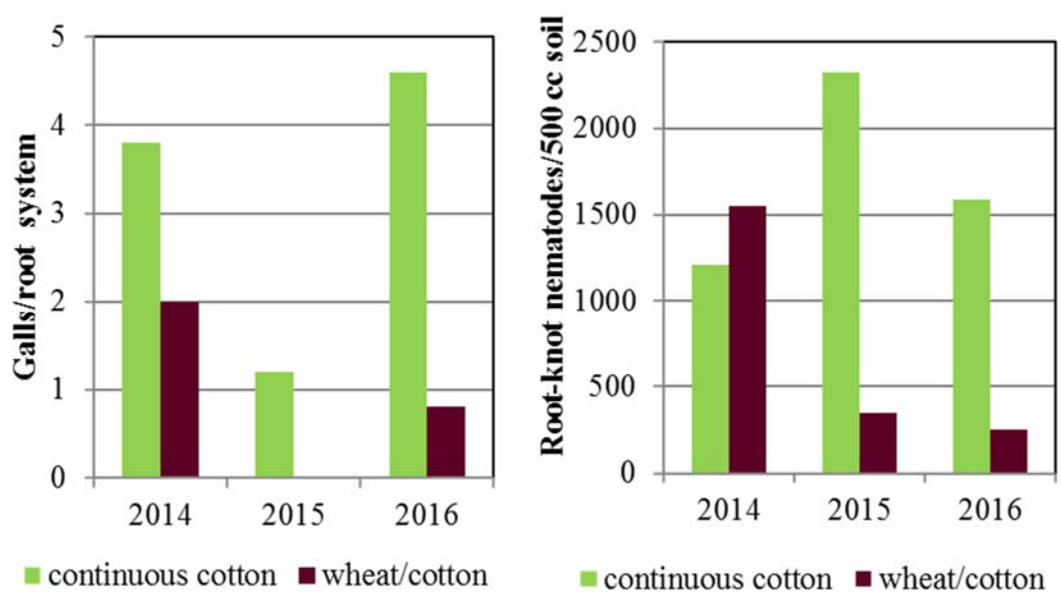

Figure 2. The effect of cropping system on the number of galls/root system (caused by root-knot nematode) at 45 days after planting, and late season density of root-knot nematode.

Differences between treatment interactions were not determined for IWUE in 2014 (Fig 3 a). However, differences were determined in 2015 and 2016. Rainfall likely contributed to these results with less than average rainfall in 2014 (14 inches) and greater than average and close to average rainfall in 2015 (25 inches) and 2016 (17 inches), respectively. In 2015 the wheat-cotton rotation resulted in greater IWUE compared to the continuous cotton with rye cover under low irrigation but not the base and high levels (Fig. 3 b). Also, differences did not exist between the rotation under base irrigation and the rye cover under high irrigation. Regardless of irrigation level the rotation resulted in greater IWUE in 2016 (Fig. 3 c).

Preliminary economic analysis reported as gross margins of the cotton systems being evaluated were greater for the wheat-cotton rotation compared to the continuous cotton with rye cover in each of the three years evaluated. Differences between the systems ranged from $46/acre to $316/acre under low irrigation, $174/acre to $234/acre under base irrigation, and $274/acre to $291/acre under high irrigation. Further, more detailed analysis will be conducted for these systems.

Greater SOC was determined in the 6-12 and 12-24-inch depths under high irrigation with the continuous cotton with rye cover crop system compared to the continuous cotton with conventional tillage and the wheat-cotton rotation regardless of the stage of the rotation (Fig. 4). This is likely the result of greater plant residue being produced on an annual basis with the rye cover crop compared to the wheat rotation. However, under low irrigation using a cover crop did not consistently result in greater SOC as it did under high irrigation. Even though it is expected that an increase in SOC would result in greater aggregate formation and stability, this is not what was determined. While the rye cover crop system increased SOC compared to the conventional tillage system, MWD was not different between the two systems under either irrigation level or at any soil depth.

These results indicate that while cover crops and conservation tillage will likely increase SOC, this type of system may not consistently result in greater lint yield or economic benefits. Cropping systems need to be regionally focused, and in semi-arid production regions, greater biomass producing crops such as wheat rotated with cotton should be the more economically and environmentally sustainable option. This research is being continued with the addition of a conventional tillage winter fallow treatment.

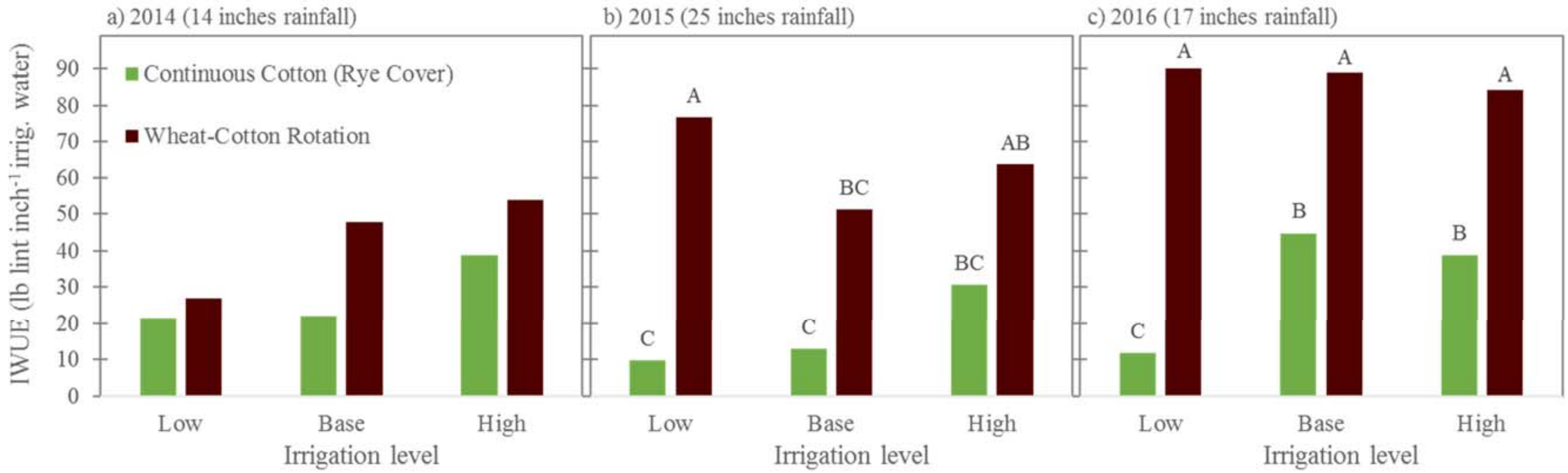

Figure 3. Irrigation water use efficiency calculated for the (a) 2014, (b) 2015, and (c) 2016 cotton crops. Interaction means within year with the same letter are not different at $p < 0.05$.

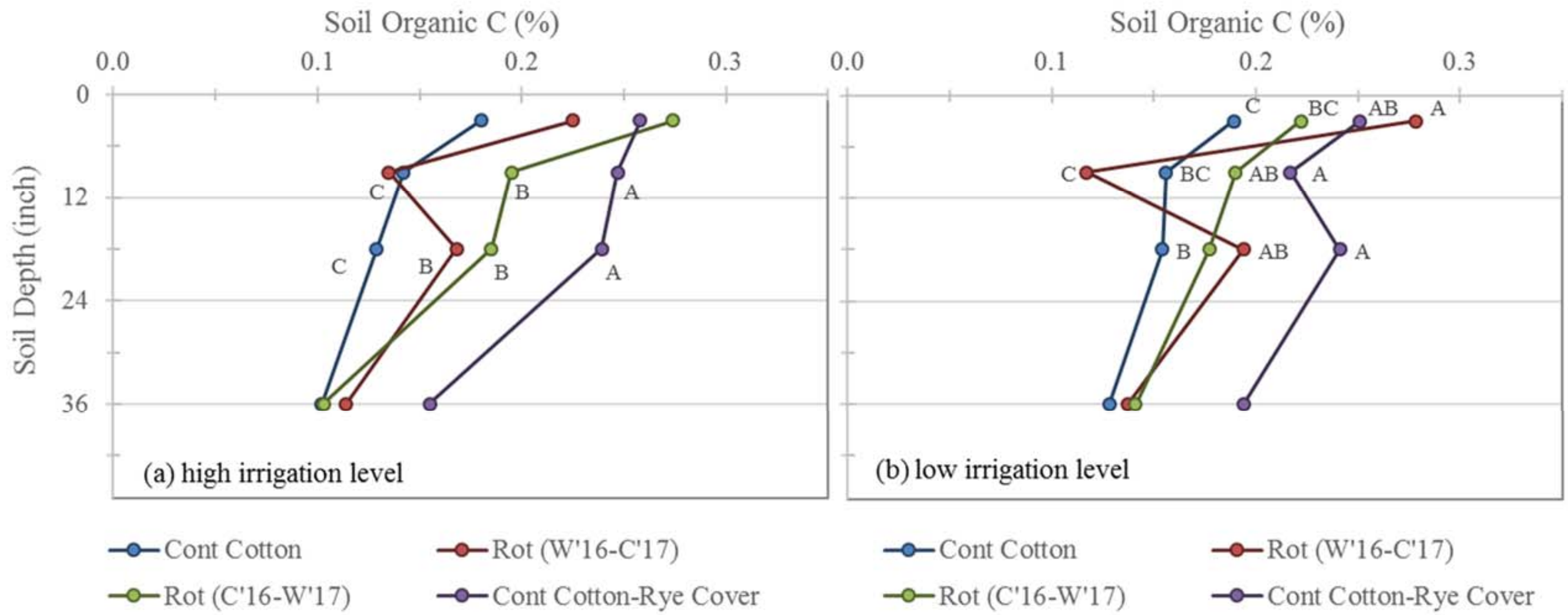

Figure 4. Soil organic C under for samples collected in April 2017 at soil depths of 0-6, 6-12, 12-24, and 24-48 inches under the (a) high and (b) low irrigation levels. Means within irrigation level and soil depth with the same letter are not different at $p < 0.05$.