CROPPING SYSTEM EFFECTS ON COTTON VARIETY PERFORMANCE IN THE PRESENCE OF ROOT-KNOT NEMATODES IN THE SOUTHERN HIGH PLAINS OF TEXAS

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Abstract

The Southern High Plains of Texas (SHPT) is the largest cotton producing region in the world. Water is one of the greatest limiting factors of production for the region, prompting producers to explore more water-efficient production strategies. Furthermore, root-knot nematodes (RKN) negatively affect lint yields and are extremely prevalent in the SHPT. While considerable research has been conducted on crop rotations and RKN partially resistant cotton varieties, little research has investigated a crop rotation, irrigation rate, and cultivar that maximizes profit in the presence of RKN on the SHPT. Thus, the objective of this study was to determine if a cotton-wheat rotation paired with a RKN partially resistant cotton variety was more profitable compared to a continuous cotton system utilizing the same cultivars. Moreover, variable irrigation rates were utilized on both systems to analyze lint yield and profitability differences. Data from a multi-year study from 2014-2019 in the SHPT were compared to evaluate irrigated conventional tillage practices with terminated rye cover crop versus an irrigated wheat-cotton rotational system with multiple cotton varieties. Partial budgets were constructed to analyze profitability differences between the two cropping systems and different cotton varieties. Results indicate that the partially resistant varieties were the most profitable overall in both systems for the six-year period and performed best in the presence of RKN. The cotton-wheat rotation suppressed RKN presence and had greater returns per acre-inch of irrigation water applied during the cotton segment of the rotation.

Introduction

The South Plains region is the largest cotton producing area in the world with acreage in some years exceeding 3 million (AgriLife 2019). Decreasing irrigation water availability has reduced the amount of in-season irrigation water applied and reduced the number of irrigated cotton acres. Increasing input costs and stagnant or declining cotton markets have consequently squeezed profit margins. Disease pressure from root-knot nematodes have further pressured producers to develop production strategies to cope with the ever-changing growing conditions.

As agricultural producers have experienced steady to declining cotton pries couple with increasing input costs, profit margins have become tighter (Wilde, 2008). Cotton prices have been flat to declining for many years while input costs have increased dramatically (Wilde, 2008). Agrichemical, fertilizer, and seed costs have increased 35%, 93%, and 551 % since 1995, respectively (USDA-ERS, 2016). Although these technologies have helped to increase productivity and efficiency, they have consequently squeezed profit margins.

Conservation Tillage

No-till and minimal-till practices, also referred to as conservation tillage, have been implemented to alleviate input costs and increase soil health. Conservation tillage offers other benefits, such as moisture conservation on drought-prone soils, protection of young cotton seedlings from sandblasting, improved soil tilth, reduced soil crusting and more rapid water infiltration. Furthermore, protection of water quality, equipment, labor, and time requirements are reduced due to seedbed preparation being marginal or eliminated (Wilcut et al., 1993). Baumhardt et al. (2012) attributed residue retaining benefits of no-till during the cotton rotation phase of a cotton-wheat-fallow rotation in the Texas High Plains, which significantly increased lint yields (DeLaune et al., 2020).

Cover Crops

To compliment conservation tillage, cover crops grown during the winter months are gaining popularity as they help with erosion and increase organic matter in the soil. Blanco-Canqui et al. (2011) concluded that cover crops could enhance the effect of no-till systems through improved soil physical properties and soil organic concentrations (DeLaune et al., 2020). Consequently, within semi-arid environments, soil water use by cover crops is a potential disadvantage (Dabney et al., 2001; Balkcom et al., 2007). Previous research how shown that small grain cover crops in cotton systems within the Southern High Plains have shown reduced yields, but other studies show no impact on lint yields (Segarra et al., 1991; Sij et al., 2003; Baughman et al., 2007; Lewis et al., 2018 DeLaune et al., 2012, 2020).

Crop Rotation

In the Southern High Plains of Texas, cotton is typically produced in a continuous monoculture setting. The lack of crop rotation stems from the economics returns that cotton produces compared to other crops in the region such as wheat, maize, and corn. Unfortunately, the continuous production of cotton has downfalls that negatively affect producers yields and growing conditions. After harvest is completed, there is little plant residue left that can be returned to the soil and converted to organic matter for future crops to utilize. Crop rotation with winter wheat *(Triticum aestivum L.)* or sorghum *[Sorghum bicolor (L.) Moench.]* is getting more attention lately as the rotation may provide benefits for cotton producers. Over the years, experts have claimed reduced disease pressure, fewer weeds, less insect damage, and improved nutrient levels on fields that farmers routinely rotated from one crop to another (Smith, 2015). Acceptance of crop rotation in the Southern High Plains has relied on the ability of the crop rotation to perform as well economically compared to a cotton monoculture system.

Root-Knot Nematodes

Although cotton performance in the SHP can be mostly attributed to water availability, disease presence also affects performance. Cotton is known for being a host for the southern root-knot nematode *(Meloidogyne incognita)* (Wheeler et al., 2009). Approximately 40% of the area planted in irrigated cotton in the Southern High Plains, is infested with M. incognita (Robinson et al., 1987; Wheeler et al., 2000). Through advancements in cotton seed technology, root-knot nematode partially resistant varieties have been developed. Resistance is defined as a reduction in the ability of the nematode to reproduce on a given cultivar compared with susceptible cultivars but does not include any assumptions of yield performance (Wheeler et al., 2009). Cotton producers on the Southern High Plains are learning to adapt their production techniques given new technological advancements and diminishing levels of irrigation water available. Moreover, producers need information to improve their current strategies and increase their profit margins.

Materials and Methods

To compare revenue, cost, and net returns differences among two different cropping systems on the Southern High Plains of Texas, an economic analysis employing partial budgets was utilized. Data spanning six years of production was collected and analyzed to evaluate the economic advantages and disadvantages of the two different cropping systems to determine the more profitable technique. Utilizing partial budgets and custom rates allows for an individual producer to analyze the results and critique them to their own scenario, thus allowing them to determine which strategy can help maximize their own profits. By following these steps, the objectives of this study were achieved.

Data

For the economic analysis, experimental data was obtained from trails at the Agricultural Complex for Advanced Research and Extension Systems (AG-CARES), a cooperative between the Texas A&M AgriLife Research and Extension Center at Lubbock and the Dawson County Cotton Growers Association near Lamesa, Texas (latitude 32.7375 and longitude -101.9505). The data set spans the 2014-2019 crop years and includes cotton lint yield data and wheat yield data from a wheat-cotton rotation and cotton lint yield data from a continuous monoculture cotton cropping system. Loan value of the cotton lint yield was analyzed for both systems and derived from the quality characteristics (color grade, micronaire, staple length, and strength) each sample possessed. Wheat quality was not analyzed, and $/bushel was determined using AgriLife Extension Budgets for the corresponding year. Variable costs for each cropping system included tillage passes, herbicide/fertilizer applications, inches of applied irrigation water, fertilizer, and seed prices. Crop irrigation water was applied using a Low Energy Precision Application (LEPA) system, more commonly known as a center pivot. Root-knot nematode (RNK) data was also evaluated to determine a correlation with lint production and gross margin.

Location

The AG-CARES research farm is located approximately 60 miles south of Lubbock, Texas just north of Lamesa, Texas (latitude 32.7375 and longitude -101.9505) with an elevation of 2,965 feet in Dawson County on the Texas Southern High Plains. The soil at AG-CARES is classified as an Amarillo fine sandy loam (fine-loamy, mixed, superactive, thermic Aridic Paleustalfs) with a pH of 7.5 (Lewis et al., 2018; USDA-NRCS, 2016). During 2014-2019, AG-CARES received an average rainfall of 12.75 inches during the growing season and had an average air temperature of 79.05 degrees Fahrenheit during the growing season.

Partial Budget Analysis

Partial budgets were constructed using a template from Texas Alliance for Water Conservation (TAWC) to analyze gross margin given the difference variable costs for each tillage practice, variety, and irrigation level. Seed cost for each variety was calculated using Plains Cotton Cooperative Association (PCCA) seed calculator at a rate of 52,000 seeds per acre for the corresponding year. Custom operations rates from Texas A&M AgriLife Extension 2014, 2016, and 2018 agricultural custom rates surveys were averaged and utilized to account for tillage, planting, fertilizer/herbicide application, and harvesting costs. Chemical cost was derived from TAWC chemical cost sheet for the years 2014-2019. Fertilizer cost was calculated using the rate at which it was applied time the cost per pound found on the Texas A&M AgriLife Extension Budgets for District 2 for the corresponding year. Wheat revenue was also calculated using the price per bushel stated on the Texas A&M AgriLife Extension Budgets for District 2 for the corresponding year. A standardized defoliation treatment was employed. Wheat and rye seed cost was derived from averaging cost per pound from three local dealers. Revenue derived from cotton seed produced was calculated using Texas A&M AgriLife Extension budgets for the corresponding year and the $/cwt for the given year. Per acre gross income is a combination of the revenue received from lint production and cotton seed. Gross margin was derived from subtracting per acre total variable cost from per acre total gross income.

Results

When analyzing all available data, the wheat-cotton rotation proves to be the superior cropping system in terms of yield, gross margin, and root-knot nematode pressure. Furthermore, the root-knot nematode resistant varieties outperformed the susceptible varieties on average in yield and gross margin. The resistant varieties also alleviated root-knot nematode pressure compared to the susceptible varieties.

Figures 1 and 2 show how the wheat-cotton rotation out yielded the continuous cotton cropping system throughout all six years. Throughout the six-year period, the wheat-cotton rotation had produced an average yield of 1025lbs/ac of lint. The continuous cotton system produced on average 739lbs/acre of lint resulting in 286lbs/acre less than the rotation. In addition, Figure 2 shows the averages for root-knot nematode resistant varieties compared to susceptible varieties. Susceptible varieties within the continuous cotton system averaged 719lbs/acre of lint while the resistant varieties averaged 774lbs/acre of lint. Thus, the resistant varieties produced 55lbs/acre of lint more on average under the continuous cotton cropping system due to elevated nematode pressure. On the contrary, susceptible varieties utilized within the wheat-cotton rotation averaged 1060lbs/acre of lint and the resistant varieties produced 1035lbs/acre of lint on average. The 25lb difference can be attributed to low nematode pressure resulting from the wheat-cotton rotation allowing the susceptible varieties to perform well. Many producers are leery about adopting a reduced tillage practice because of the assumptions of a reduction in yield, however that proves to not be apparent in this case.

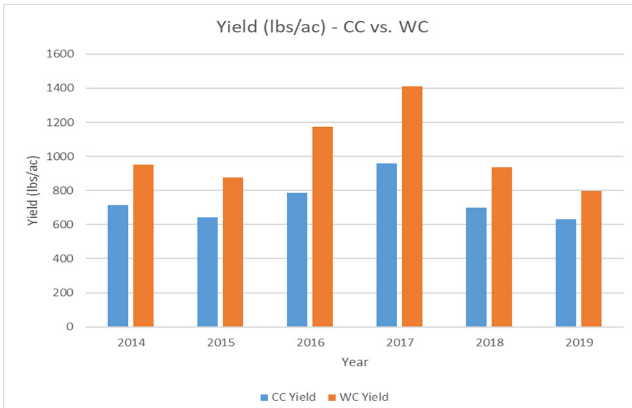

Figure 1. Lint yield comparison between continuous cotton (blue bars) and wheat-cotton rotation (orange bars).

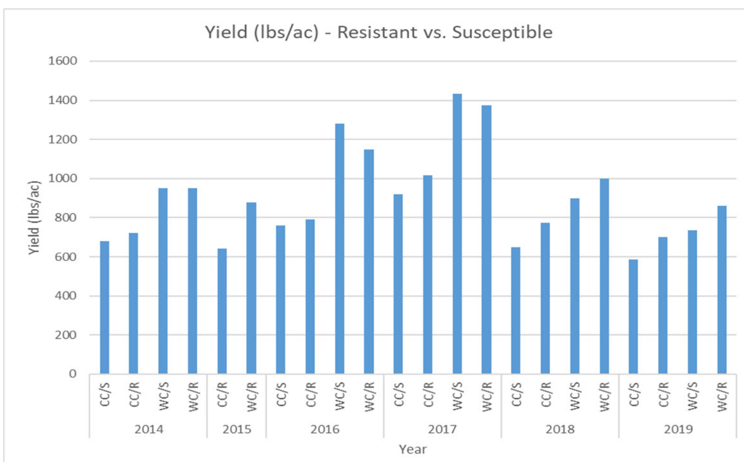

Figure 2. Lint yield comparison between resistant and susceptible cotton varieties.

Figures 3 and 4 show the stark differences in gross margin between the two cropping systems. The average gross margin for the continuous cotton system was -$165/acre whereas the wheat-cotton rotation averaged $36/acre. The $201 different between the two systems can be attributed to substantially less field operations and higher yields. Figure 4 shows the comparison of gross margins between resistant and susceptible varieties within the different practices. The susceptible varieties produced under the continuous cotton setting had an average gross margin of -$173/acre and the resistant varieties averaged $-$147/acre. The $26/acre variance directly correlates to the yield difference between the varieties as all field operations were the same. Gross margins under the wheat-cotton rotation do not deviate as much as the susceptible varieties averaged $44/acre and the resistant averaged $43/acre. The gross margins between the varieties is closer than expected as the average yields varied by 25lbs. However, the closeness in gross margin can be attributed to the resistant varieties producing a higher quality fiber, thus increasing their loan value, and helping to bridge the gap in terms of gross margin.

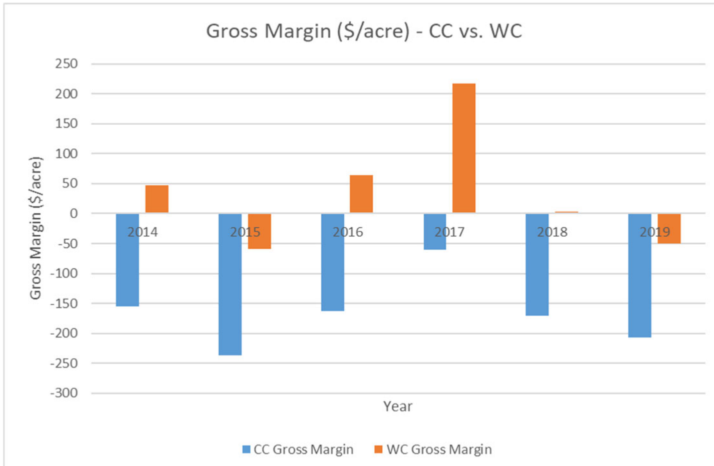

Figure 3. Gross margin comparison between continuous cotton (blue bars) and wheat-cotton rotation (orange bars).

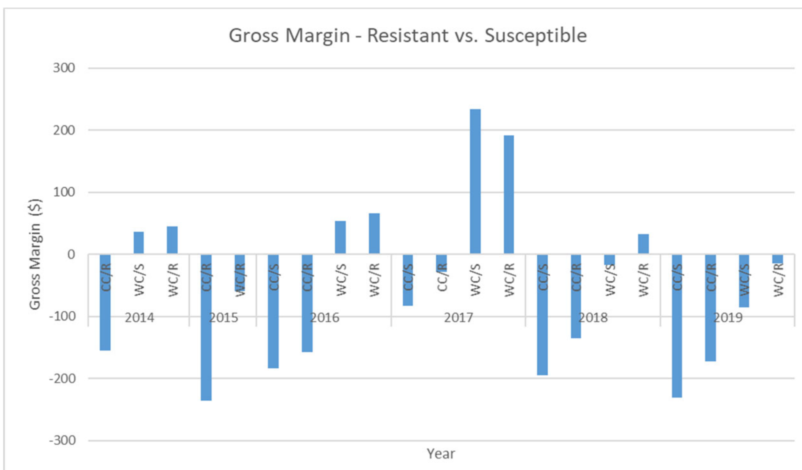

Figure 4. Gross margin comparison between resistant and susceptible cotton varieties.

Figures 5 and 6 illustrate the differences in root-knot nematode densities between the two cropping systems throughout the years of the study. The continuous cotton system averaged 12,344 nematodes/500cc of soil whereas the wheat-cotton rotation contained 1522 nematodes/500cc of soil on average. These numbers show the clear connection that the wheat-cotton rotation has in suppressing root-knot nematodes compared to the continuous cotton system allowing them to substantially reproduce every year. Figure 5 also shows the increase in root-knot nematode pressure through time in the continuous cotton system. Figure 6 highlights the benefits of the resistant varieties as they suppress nematode growth and reproduction between the two cropping systems. The susceptible varieties within the continuous cotton system averaged 17,806 nematodes/500cc of soil and the resistant varieties averaged 6191 nematodes/500cc of soil. While both values are unacceptable in terms of nematode pressure, the resistant varieties actively help to reduce reproduction and growth within a highly populated environment. In the wheat-cotton rotation, the susceptible varieties averaged 2085 nematodes/500cc of soil and the resistant varieties averaged 1155 nematodes/500cc of soil. These values are still slightly higher than what we would like to see but are much more acceptable in terms of nematode pressure when trying to produce a cotton crop. Once again, the resistant varieties reduced the number of nematodes in the soil compared to the susceptible varieties proving that they work to alleviate nematode pressure.

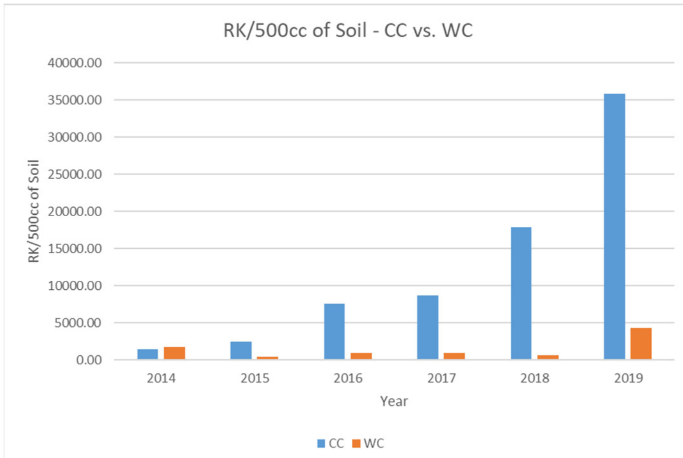

Figure 5. Root-knot nematode density comparison between continuous cotton (blue bars) and wheat-cotton rotation (orange bars).

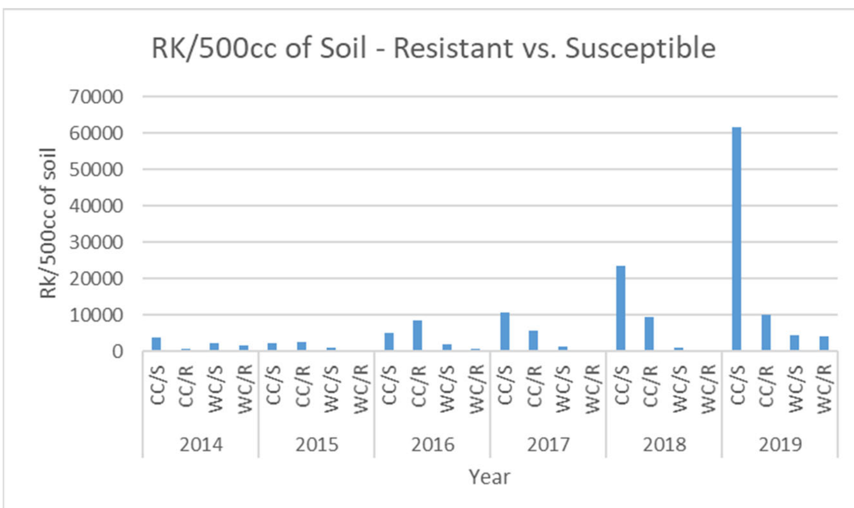

Figure 6. Root-knot nematode density comparison between resistant and susceptible cotton varieties.

Summary

The wheat-cotton rotation outperformed the continuous cotton cropping system in both the agronomic and economic aspects of this experiment. The rotation out yielded the continuous cotton by an average of 286lbs/acre of lint, had higher average monetary returns of $201/acre, and averaged 10,822 less nematodes/500cc of soil. Increases in lint yield can be attributed to the many benefits of crop rotation that increase soil health and productivity. Gross margin is directly affected by the reduction in field operations between a conservation and conventional tillage practice coupled with an increase in crop productivity. The reduction in root-knot nematode density due to the wheat-cotton rotation can be attributed to the wheat segment of the rotation. Nematodes are not as active and do not produce well during the colder and drier months that wheat grown. During the summer fallow period following wheat harvest, dead wheat stubble does not act as a host for nematodes therefore suppressing their ability to reproduce. Therefore, given the conditions that are present on the Southern High Plains of Texas, a wheat-cotton rotation utilizing conservation tillage has proved to be the superior cropping system in both agronomic and economic aspects of crop production.

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