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REDUCED TILLAGE COTTON AND TOMATO PRODUCTION SYSTEM EVALUATIONS IN CALIFORNIA

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Abstract

A four-year study comparing standard tillage with (STCC) and without (STNO) winter rye/triticale/vetch cover crops and conservation tillage with (CTCC) and without (CTNO) cover crops was conducted in Five Points, CA through a cotton/tomato rotation from 1999 – 2003. In each year of the study, the cotton was no-till planted into previous crop residue ± cover crop residue in the CT systems. A mite outbreak in the first year severely reduced yields in all systems. In years 2 – 4, yields were reduced an average of 5.4% in the STCC, 12.7% in the CTNO system, and 20.2% in the CTCC system relative to the standard tillage no cover crop system. Major difficulties contributing to these yield losses included an inability to establish adequate crop stands and early season vigor in the alternative systems.

Introduction

In the fall of 1999, we established a field comparison of reduced and standard tillage cotton and tomato rotations with and without winter cover crops at the University of California West Side Research and Extension Center in Five Points, CA. The objectives of this study were to compare reduced tillage and conventional tillage practices in crop rotations common to California's San Joaquin Valley in terms of productivity and profitability and a range of other system attributes including soil quality indicator properties, the quantity and composition of dust produced, soil water storage and crop water availability, and pest and crop management requirements.

The reduced, or conservation tillage systems have been managed from the general principle of trying to reduce primary, intercrop tillage to the greatest extent possible. Zone production practices that restrict tractor traffic to furrows have been used throughout the four years in the CT systems. Conventional intercrop tillage practices that knock down and establish new beds following harvest were used in the standard till systems.

Materials and Methods

A 3.23 hectare field experiment comparing conservation and conventional tillage tomato and cotton production systems, with and without winter cover crops was established in the fall of 1999 at the University of California West Side Research and Extension Center in Five Points, CA. Treatment plots consisted of six beds, each measuring 1.4 X 90 m and replicated four times in a randomized complete block design. Six-bed buffer areas separated tillage treatments to enable the different tractor operations that were employed in each experimental system. A cover crop mix of Juan triticale (*Triticosecale* Wittm.), Merced rye-grain (*Secale cereale* L.) and common vetch (*Vicia sativa* L.) was planted at a rate of 112 kg ha-1 (30% triticale, 30% ryegrain and 40% vetch, by weight) in late October in the standard and conservation tillage plus cover crop plots and irrigated once in 1999. In each of the subsequent years, no water was applied to the cover crops due to the advent of timely early winter rains. The cover crops were then chopped in mid-March of the following years using a Buffalo Rolling Stalk Chopper (Fleischer, NE). In the standard tillage + cover crop system, the chopped cover crop was then disked into the soil to a depth of about 19 cm and 1.4 m wide beds were then reformed prior to tomato transplanting and 0.7 m beds were formed ahead of cotton planting. The chopped cover crop in the CT + cover crop plots (CTCC) was sprayed with a 2% solution of glyphosate after chopping and left on the surface as a mulch.

Tomatoes (*Lycopersicon esculentum* '8892') were then transplanted in the center of beds at an in-row spacing of 36 cm during the first week of April in 2000, 2001, 2002 and 2003 using a modified three-row commercial transplanter fitted with a large (51 cm) coulter ahead of each transplanter shoe. All systems were fertilized the same. Dry fertilizer (11-52-0 NPK) was applied preplant at 112 kg ha^{-1}. Additional N was sidedress applied at 150 kg ha^{-1}. The RoundUp Ready™ cotton (*Gosypium hirsutum*) variety, 'Riata," was used each year in all systems. A John Deere 1730 No-till 6 row 30" planter was used in the CT systems. All tractor traffic was restricted to the furrows between planting beds in the CT systems; no tillage was done in CT plots following tomatoes and preceding the next cotton crop, and only two tractor passes were conducted following cotton and preceding each subsequent tomato crop. These operations included shredding and uprooting the cotton stalks using a "Shredder Bedder" implement (Interstate Mfg., Bakersfield, CA) in order to comply with "plowdown" regulations for pinkboll worm control in the region and a furrow sweep operation to clean out furrow bottoms to allow irrigation water to move readily down the furrows.

The time and equipment required for all operations in each plot was recorded for economic comparisons between the tillage / cover crop systems. Crop yields were determined in each year using field weighing gondola trailers following the commercial machine harvest of each entire plot.

Results

Yield results during the first four years of this study show that tomato yields have been maintained in the CT system relative to the ST system in each year (Table 1). Processing tomato yields in 2000 were slightly lower in each of the cover cropped systems relative to both the standard and conservation tillage systems without cover crops. This occurrence may have been caused in part by the slower early season tomato growth that was observed in each of the cover cropped systems in both years and this growth reduction may have resulted from nitrogen immobilization following cover crop termination in each spring, and, in the case of the CT + cover crop system, lower soil and near-surface air temperatures. Additional testing is now underway to evaluate each of these hypotheses. The CTNO system had the highest yield for all systems in both 2002 and 2003. We currently do not have an explanation for this finding. While yield of the CTCC system was slightly lower than the two ST systems in 2002, 2003 yields in the CTCC were actually higher than in either ST plot. At this time, we might only suspect that air temperatures at the time of flowering in systems with higher yields were more conducive to fruit set and that this carried through to increased yield at harvest.

Cotton yields were low in all systems in 2000 due to a devastating infestation of mites in the field that persisted all season and were exacerbated by pesticide resistance that developed presumably because the same miticide was sprayed repeatedly in the field during the 2000 season (Table 2). 2001 cotton yields were reduced 11 and 18% in the CT – cover crop and CT + cover crop systems, respectively, relative to the standard tillage control system, however there was an elimination of 8 or 9 tillage operations in the CT systems relative to the ST approach. Cotton yield was highest in the STNO and STCC systems in 2002, about 13% reduced in the CTNO system, and 37% reduced in the CTCC system. Reasons for the reduced yields in the CT systems as well as in the ST + CC system, we believe, relate largely to difficulties we have experienced establishing the crops in these systems. Further work to refine and improve our planting and establishment of cotton in previous crop residues is underway.

Discussion

The summary findings presented here indicate short-term outcomes and issues related to a conversion to CT production in an irrigated region such as California's CV. These preliminary results suggest that establishing and harvesting processing tomatoes with conservation tillage systems is possible given some equipment modification and that yields may be maintained relative to standard tillage in CT crop residue environments, at least over the short term. A number of possible constraints to the adoption of these high residue production systems were observed during this "transition" period and these require further investigation. First, the continued, long-term accumulation of surface residues may eventually present problems in terms of planting, cultivating and harvesting CT crops such as processing tomatoes. Transplanting and in-season cultivations took more time in the CT + cover crop plots relative to the standard till systems. Second, although we did not attempt to quantify the actual amount of residue that gets picked up by harvesting equipment, there would also seem to be at least the possibility that high surface residue systems may eventually result in greater "material other than tomatoes" being harvested, which will ultimately require increased cleaning effort and expense at the processing plant. Third, although "zone production" theory might suggest that soil compaction constraints may, to a large extent, be avoided by keeping tractor traffic away from "crop growth zones," (Carter et al., 1996), longer-term studies that investigate implications of reduced till regimes on compaction are needed and will continue to be evaluated as this study progresses through its eight-year course. Reductions in the number of operations used in each cotton crop in the CT systems relative to the ST systems did not overcome the revenue losses of these CT systems relative to the ST systems. Overcoming these initial difficulties in sustaining yields in CT cotton systems in now a major goal of our ongoing work.

This project is the first of its kind in California to systematically compare tillage system alternatives through a crop rotation. The extent to which such alternatives are adopted in this region will ultimately depend on the extent to which these systems are economically viable, whether or not weed, insect and disease pests can be adequately managed over time, and possibly, whether processors and ultimately consumers find sufficient value in these types of food production approaches to provide cost offsets to support their adoption (R. Rickert, personal communication).

A number of questions will need to be answered before widespread adoption of these types of production systems is realized in California. These include 1) Do CT systems remain productive over several seasons? 2) Will subsurface soil compaction ultimately limit CT approaches and eventually require deep tillage interventions? 3) Does CT actually serve to sequester C in

California's semiarid, irrigated environment? And finally, 4) Does CT reduce fugitive dust emissions enough to positively impact air quality in this region? These are key questions we are pursuing during the next cycle of this work.

References

Carter, L.M. 1996. Tillage. In Cotton Production Manual. University of California Division of Agriculture and Natural Resources Publication 3352. Pages 175 – 186.

Table 1. Tomato yields 2000 – 2003 (tons/acre)

	2000	**2001**	**2002**	**2003**
Standard tillage no cover crop	58 ± 1	58 ± 1	46 ± 3	42.4 ± 2.3
Standard tillage cover crop	53 ± 1	63 ± 2	45 ± 3	45.4 ± 3.2
Conservation tillage no cover crop	56 ± 1	62 ± 2	56 ± 1	54.4 ± 3.8
Conservation tillage cover crop	51 ± 1	61 ± 1	43 ± 2	51.9 ± 3.2

Table 2. Cotton yields 2000 – 2003 (lbs lint/acre)

	2000	**2001**	**2002**	**2003**
Standard tillage no cover crop	360 a	1783	1975	1249
Standard tillage cover crop	360 a	1405	1949	1314
Conservation tillage no cover crop	200 a	1579	1728	1067
Conservation tillage cover crop	372 a	1454	1249	1183