Reduced Tillage Production System Alternatives for Processing Tomatoes and Cotton in California's San Joaquin Valley

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Abstract

Less than 1% of row crop acreage in California is currently farmed using conservation tillage (CT) practices. Adoption of CT systems in California has, however, increasingly been seen as a potential means for improving profitability, reducing energy use, and sustaining resources. Several studies are currently underway throughout the state to explore cropping system options for reducing tillage. In the fall of 1999, we established a 3.2 hectare field experiment comparing conservation and standard (ST) tomato and cotton production systems with and without winter cover crops in Five Points, CA. To date, this work has demonstrated that planting and harvesting these crops with CT systems is possible given some equipment modifications and that yields can be maintained relatively close to those of standard tillage in CT crop residue environments. Data from the second year of this study indicate that tomato yields in the CT ± cover crop systems were similar to those in the ST plots, with an elimination of 3 to 4 tillage operations following the preceding year's cotton crop in the CT plots relative to the standard till systems. This study is the first of its kind in California to systematically compare tillage system alternatives through a crop rotation. Longer-term implications of these reduced till regimes in terms of soil compaction, water use, profitability, soil carbon sequestration, insect, weed and disease pests are being evaluated as the study progresses through an eight-year cycle.

INTRODUCTION

The term "conservation tillage" (CT) generally refers to a variety of crop production systems that deliberately attempt to minimize primary intercrop tillage operations such as plowing, disking, ripping and chiseling. As a result of this reduction in tillage, crop residues tend to accumulate at the soil surface. Conservation tillage has, in

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fact, been defined as a production system in which 30% of the soil surface is covered by residues from previous crops (Reeder, 2000). Several benefits have been reported to result from CT production systems (Phatak, 1992), however the primary motivations that have driven adoption of CT in regions in which they are now common include minimizing soil erosion and reducing costs (Johnson et al., 2002; Triplett et al., 2002). CT production systems addressing these issues are common in the Midwest and Southeast US (Gallaher, 2002), and in South America (Derpsch, 2002; Dykstra, 2002), but they are quite uncommon in any of California's highly productive agricultural valleys (CTIC, 1999).

Other potential positive attributes of CT are, however, gaining attention in recent years in several regions of California (Mitchell et al., In press). These include the possibility that CT systems may reduce surface water, sediment, nutrient and pesticide runoff (Bradley, 2002), sequester carbon (C) both in terms of decreasing CO_2 emissions from the burning of diesel fuel and from storing more carbon in the soil due to less soil disturbance (Lal et al., 1998), and finally, reduce fugitive dust emissions (J. Beyer, personal communication).

Over the last several decades, California's Great Central Valley (CV) has become a region of phenomenal agricultural productivity (CDFA, 1999). It is also an area in which considerable intercrop tillage is customarily used (Mitchell et al., In press). Tillage in CV production systems is typically done in a "broadcast" manner throughout a field, without deliberate regard to preserving dedicated crop growth or traffic zones (Mitchell et al., In press). In a number of studies conducted over the last several decades, however, Carter demonstrated the potential to eliminate deep tillage, decrease the number of soil preparation operations by as much as 60%, reduce unit production costs, lower soil impedance and maintain productivity in the CV using reduced, precision, or what he termed "zone" tillage practices that limit traffic to permanent paths throughout a field and thereby reduce soil compaction and preserve an optimum soil volume for root exploration and growth (Carter, 1985; Carter et al., 1987; Carter et al., 1991). Virtually no work, however, has evaluated the potential of various dedicated traffic CT approaches through typical crop rotations of this region over a number of years. In 1999, we initiated a long-term research study to compare CT and conventional tillage practices in a crop rotation common to the CV's West Side region in terms of productivity and profitability. This study has been the first of its kind in California to systematically compare tillage system alternatives through a crop rotation. It is also the first study to develop information on the use of off-season cover crop surface mulches through a cropping sequence. Findings of the study's first two tomato seasons are reported here.

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 differential tractor operations that were employed in each experimental system. A cover crop mix of Juan triticale (*Triticosecale* Wittm.), Merced ryegrain (*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 the fall of 2000, no irrigation was applied to the cover crops due to the advent of timely early winter rains. The cover crops were then chopped during the second week of 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. The chopped cover crop in the CT + cover crop plots 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 and 2001 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 conservation tillage systems were managed from the principle of reducing tillage to the greatest extent possible. Within the broader crop rotation context of this study, this meant that all tractor traffic was restricted to the furrows between planting beds in the CT systems, that no tillage was done in CT plots following tomatoes and preceding the next cotton crop, and that only two tractor passes were conducted following cotton and preceding the 2001 tomato crop. These operations included shredding and uprooting the cotton stalks in order to comply with “plowdown” regulations for pinkboll worm control in the region.

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 AND DISCUSSION

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 (Table 1). 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.

Data from the 2001 tomato harvest indicate that yields in the CT $\pm$ cover crop systems were similar to those in the standard till plots, with an elimination of 3 to 4 tillage operations following the preceding year’s cotton crop in the CT plots relative to the standard till systems (Tables 1 and 2).

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., 1991), 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.

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?

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Tables

Table 1. Processing tomato yields (t/ha) for 2000 and 2001. Values are mean + standard errors of the mean.

		2000	2001
Standard Tillage			
	No cover crop	130.4 ± 2.1	134.6
	Cover crop	119.3 ± 1.7	142.0
Conservation Tillage			
	No cover crop	126.4 ± 2.2	144.3
	Cover crop	113.4 ± 1.6	135.7

Table 2. Tractor operations used for 2001 processing tomato crops following 2000 cotton crops (number of times over the field.

Standard Tillage		
	No cover crop	8
	Cover crop	9
Conservation Tillage		
	No cover crop	5
	Cover crop	6