

## **Status of Conservation Tillage Research and On-Farm Demonstrations in California: A 2002 Progress Report**

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### *Introduction*

During the period, 1996 – 2001, an unprecedented increase in research and demonstration activity related to what are loosely termed “conservation” or “reduced” tillage row-crop production systems has been documented in California (UC Division of Agriculture and Natural Resources Conservation Tillage Workgroup Annual Report, 2001). This research has been spurred by a wide range of motivations at a variety of locations. The following overview reports on the status of conservation tillage research in California and summarizes studies and demonstrations currently underway throughout the State.

### *Motivation for Conservation Tillage in California*

At present, no definitive survey has been conducted to gauge the motivation for trying conservation tillage production approaches in California among researchers and producers. Informal interviews with farmers suggest that three factors have driven the increase in interest in conservation tillage options among this group. These include the goals of 1) reducing production costs, 2) preserving soil quality, 3) reducing herbicide and weeding labor input costs, and 4) particularly for organic growers, potential early season opportunities for managing weeds through the use of reduced till surface mulch systems.

### *Cutting Production Costs*

Reducing production costs has become a compelling and critical goal of growers throughout California which has historically been an area of phenomenal productivity (Calif. Dep't. Food and Agri., 1999). Preplant, intercrop tillage operations typically account for 18 – 25% of overall production costs in common annual cropping systems in the Central Valley (Mitchell et al., In press; Carter, 1996). On average, 9 – 11 separate tillage-related operations, each involving heavy equipment are conducted during the fall-spring period to prepare the soil for summer cropping. Deep tillage often is required in these systems to alleviate tillage-induced compaction that may result from frequent tractor traffic. These operations represent not only high energy, equipment and labor costs, but reduce soil organic matter (Reicosky, 2000; Reicosky et al., 1997).

Most current Central Valley agricultural production systems are currently very tillage intensive (Carter, 1996). Tillage in these production systems is typically done in a “broadcast” manner throughout a field, without deliberate regard to preserving dedicated crop growth or traffic zones. Studies by Carter over the last several decades, however, has confirmed 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 a number of San Joaquin Valley cropping contexts, using reduced, precision or zone tillage practices that limit traffic to permanent paths throughout a field thereby reducing soil compaction and preserving an optimum soil volume for root exploration and growth (Carter, 1991; Carter et al., 1991; Rechel et al., 1990). Recent work by Mitchell et al., (1998) also in the San Joaquin Valley evaluating a transplanted processing tomato production system has also demonstrated the potential to sustain productivity under certain residue mulches and increase soil carbon and earthworms using a reduced tillage approach.

### *Improving Soil Quality*

Over the several decades, growers in the Central Valley, as in many other agricultural areas throughout the world, have become increasingly aware of the importance of soil organic matter (SOM) in relation to sustained soil quality or function (*West Side On-Farm Demonstration Project Participant Survey*, 1999; Romig et al., 1995; Magdoff 1992). Soil carbon (C), which typically constitutes about half of SOM, is closely linked to many desirable soil physical, chemical, and biological properties that are associated with enhanced soil productivity and quality (Reicosky, 1996; Ismail et al., 1994). More recently, awareness has also increased concerning the negative impact tillage has on SOM storage (Reicosky, 1995; Jackson, 1998). While moderate tillage may provide more favorable soil conditions for crop growth and development and weed control over the short term, (Carter, 1998), intensive tillage of agricultural soils has historically led to substantial losses of soil C that range from 30 to 50 percent (Schlesinger, 1985). Conventional tillage practices disrupt soil aggregates exposing more organic matter to microbial degradation and oxidation (Reicosky, 1996), and are one of the primary causes of tilth deterioration over the long-term (Karlen, 1990). Micro and macro channels within the soil, created by natural processes such as decaying roots and worms may also be destroyed by tillage (Carter, 1998). Deep tillage, as is customarily done as a routine “soil preparation operation,” is also costly and requires high energy and increased subsequent effort to prepare seed beds. A recent survey by Jackson (1998) documenting a 40% decline in SOM since intensive tillage practices began in the Salinas Valley confirms the conclusion drawn from other long-term crop rotation studies such as the Morrow Plots at the University of Illinois, the Sanborn Field Plots in Columbia, Missouri and the Columbia Plateau Plots near Pendleton, Oregon, that intensive tillage typically leads to decreased soil C via gaseous CO<sub>2</sub> emissions in virtually all crop production systems (reviewed by Reicosky et al., 1995). There is mounting evidence as well as concern that this C source has been a significant component in the historic increase in atmospheric CO<sub>2</sub> (Wilson, 1978; Post et al., 1990), and the potentially associated greenhouse effect (Lal et al., 1998) that is attracting attention worldwide.

Recent pioneering studies by Reicosky and Lindstrom (1993) involving a variety of tillage methods indicate major gaseous losses of C immediately following tillage, but point to the potential for reducing soil C loss and enhancing soil C management through the use of

conservation tillage (CT) crop production practices. Though these practices have been developed over the past several decades primarily for erosion control in other parts of the US, recent concerns regarding the need to sustain soil quality (Abdul-Baki, 1998) and profitability (Mitchell and Goodell, 1999) in areas such as California where CT is virtually nonexistent, as well as potential global climate change have reemphasized the importance of CT and how it might be implemented on a broader scale to help reduce soil C losses (Carter, 1998) and thereby sustain soil quality and agricultural productivity.

Adoption of conservation tillage practices may, in principle, be a viable means for improving profitability and reducing energy use, and improving soil quality in California's Central Valley production systems (Yancy, 1996). In their many and varied forms, conservation tillage systems aim at reducing primary tillage operations such as plowing, ripping, disking and chiseling. As a result of this deliberate reduction in tractor operations, surface residues accumulate and must be managed. Conservation tillage has been defined as a production system in which 30% or more of the soil surface is covered with residue (Reeder *et al.*, 2000). These surface residues may also serve to reduce evaporation from the soil surface and thereby conserve water (Herrero *et al.*, *In press*). The use of conservation tillage techniques in other parts of the US has evolved over the last several decades largely as an effort to reduce soil erosion (Morrison, 2000). Equipment innovations, herbicides and widespread researcher and farmer experience have contributed to the fact that since 1997, on a nationwide basis, more cropland acres are farmed using conservation tillage practices than using standard tillage practices (CTIC, 1999).

Conservation tillage is, however, quite limited in California. There is considerable interest in developing management systems that reduce tillage in California as evidenced by participant feedback from conservation tillage conferences we conducted in Five Points, CA and Davis, CA in 1998 that focused on relationships between soil organic matter, tillage and soil quality and from sessions in 2000 that highlighted conservation tillage success stories from around the US. This feedback indicates that conservation tillage will become more widely adopted throughout the state once successful examples are demonstrated.

### *Recent Research*

Over the last five years, several single-crop, single-season evaluations of conservation tillage practices have been conducted in the Central Valley (Mitchell *et al.*, *In press*; Herrero *et al.*, *In press a*; Herrero *et al.*, *In press b*). To date, these studies have focused on processing and fresh market tomatoes and melons, however, additional evaluations of cotton, corn and beans have been started and we have recently initiated conservation tillage crop rotation studies in both the San Joaquin and Sacramento Valleys. Overall, this work has demonstrated the following outcomes: 1) planting and harvesting crops using conservation tillage systems is possible given some equipment modification, 2) yields can be maintained relative to standard tillage in certain conservation tillage crop residue environments, 3) season-long weed control is generally not achieved with surface residues alone and some sort of in-season intervention is needed, 4) changes in several soil properties occur in sustained conservation tillage production systems, and 5) above and below surface mulch temperatures may be decreased relative to bare soil.

To date, these pilot studies have aimed exclusively at securing equipment and developing *know-how* to produce a given crop using some form of conservation tillage. We have not yet developed and compared information related to energy use characteristics and potential economic benefits of the conservation and standard tillage production systems. Nor have we been able to monitor intercrop opportunities for reducing tillage, energy use, and detailed insect pest issues in any of these preliminary studies. In part, as an outgrowth of these successful preliminary trials and because of rising fuel costs, considerable on-farm, farmer-initiated innovation has also been recently spawned that is now underway at a number of sites in the Central Valley.

### *On-Farm Innovation*

Several wide-ranging, farmer initiated on-farm evaluations or various conservation tillage practices have also been started during the last five years. Brief case studies of a number of these are provided in the summaries that follow. These demonstrations include the following crops:

<b><i>Crop</i></b>	<b><i>Location</i></b>	<b><i>Conservation Tillage Practice Evaluated</i></b>
Cotton	<i>Five Points, CA</i>	Narrow row no-till into wheat residue
Corn	<i>Five Points, CA</i>	No-till into wheat residue
Cotton	<i>Five Points, CA</i>	Ridge-till into corn residue
Cotton	<i>Riverdale, CA</i>	Ridge-till, no-till, strip-till with parabolic shank intercrop tillage
Tomatoes	<i>Le Grand, CA</i>	Strip-till transplants into cover crop residue
Tomatoes	<i>Vernalis, CA</i>	Strip-till transplants into cover crop residue
Tomatoes	<i>Tracy, CA</i>	Strip-till transplants into cover crop residue
Tomatoes	<i>Meridian, CA</i>	Strip-till organic transplants into cover crop residue
Tomatoes	<i>Winters, CA</i>	Strip-till transplants into cover crop residue
Squash	<i>Buellton, CA</i>	Strip-till transplants into cover crop residue

A number of additional on-farm demonstrations have been initiated between several of the companies participating in *CT2001* and individual growers also during this time.

### *Difficulties Encountered in On-Farm Demonstrations*

Growers involved with these demonstrations have encountered various types of issues including:

- 1) Air temperatures above surface mulches are lower which may reduce early season growth and can increase risk of frost damage
- 2) Problems with escape weeds and difficulty cultivating weeds through high levels of residues

- 3) Regrowth of some off-season grown cover crops within the summer crop season
- 4) Increased potential for gopher/rodent problems

Potential insect pest problems of these systems have been largely unexplored and we have very little information on the longer term implications of cropping systems that deliberately maintain surface residues within common California cropping systems. This fact, and the observation that mites became a very serious pest in one of our 2000 surface residue trials, need to be taken into account before proceeding with on-farm investigations. Insect pest monitoring within conservation tillage research studies are now, however, being carefully monitored. Our understanding of the various interrelated functional aspects of conservation tillage systems with the California crop landscape is thus, quite rudimentary.

### *Innovations Needed*

Information on reduced tillage production system alternatives for Central Valley producers is quite sketchy at this point. Many important questions related to the ultimate extent to which conservation tillage practices will become adopted remain unanswered. Carter identified three “obstacles to reduced tillage for cotton” (Carter, 1996). These obstacles were the high costs associated with the development of the cotton harvester, control regulations for the pink bollworm and the lack of inexpensive alternatives for preplant weed control. While these are still issues, recent innovations have made the prospect of developing reduced tillage options for cotton much more achievable. Use of recently-introduced multiple row harvesters with wide-axle spacings permit certain furrows or interplant zones to escape compaction which might be a problem during unseasonably wet harvest periods. Introductions of reduced-pass rebedding equipment that facilitates pink bollworm plowdown compliance also address these concerns. Additional research may be needed, however, to track and document potential pest issues that may result from such approaches. Finally, the advent of various herbicide-resistant cotton varieties as well as the availability of high surface residue cultivators have made the prospect of developing reduced tillage systems for cotton more realizable. The problems associated with the design of reduced tillage systems for cotton will, according to Carter, ultimately have solutions (1996), and a number of very innovative SJV farmers and equipment suppliers are currently leading the development of these systems for the future.

Concerns about soil compaction in conservation tillage crop rotations that may result from heavy harvesting equipment used in crops such as tomatoes, also need to be considered and addressed. Can effective, zone-traffic production systems that permit vigorous rooting and productivity be accomplished in rotations with such crops, and if so, what are modifications in today’s harvesting protocols and equipment that will be needed to accomplish this?

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