# AN UPDATE OF WEED MANAGEMENT ISSUES IN CONSERVATION TILLAGE SYSTEMS

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## Introduction

Tillage has been an essential component of traditional agricultural systems. However, intensive tillage in some cases has been found to adversely affect soil structure and cause excessive breakdown of aggregates leading to soil erosion in higher rainfall areas. Further, intensive tillage can negatively impact environmental quality by accelerating soil carbon loss and greenhouse gas emissions (Reicosky and Allmaras, 2003). Such concerns have led to the search for tillage systems that minimize negative impacts to the environment while maintaining sustained, economic crop productivity. The tillage systems being developed and studied to address these concerns can be broadly termed as 'conservation tillage' (CT).

Several states in the US have been exploring for innovative CT systems. However, findings of other states cannot be readily adapted to California because of differences in climatic and soil factors, dependence on irrigation and use of various forms of irrigation systems, and the diversity of cropping systems. Although the acreage under CT in California is relatively less than that of several other states of the US; as herbicide-tolerant crop (HTC) varieties, mainly cotton and corn, have increased so has the interest in CT systems in California.

Besides the availability of HTCs, increased fuel prices, access to better CT equipment, GPS technology, and environmental air quality issues have all resulted in an increased interest in CT systems in California. Further, Conservation Management Plans now required by the San Joaquin Valley (SJV) Unified Air Pollution Control District, list HTCs [Roundup Ready (RR)] and the reduction of cultivations as practices acceptable in dust reduction. Therefore, this paper focuses on the weed management issues and suggests some techniques for the successful adoption of CT systems in California.

## Tillage and Weed Management

Tillage affects weeds by: uprooting, dismembering, and burying them to depths too deep for emergence; changing the soil environment and promoting or inhibiting their germination and establishment; and moving their seeds vertically and horizontally. Tillage is also used to incorporate herbicides and to remove surface residues which might otherwise impede herbicide incorporation by sprinkler irrigation. In summary, tillage has been an important weed management tool. Any reduction in tillage intensity or frequency, therefore, poses serious concerns for weed management.

Very little data exists on weed dynamics in CT under California conditions. However, some studies in California showed that most black nightshade (*Solanum nigrum*) emerged from the top ½ inch of the soil whereas annual morningglory (*Ipomoea* spp.) emerged from the top 3 inches of the soil (P. Keeley, personal communication). Further, over 95% control of black nightshade could be achieved with deep plowing (K. J. Hembree, personal communication). Similarly, a significant reduction in annual morningglory emergence was observed following plowing. These results suggest that in the SJV cotton production systems using RR-CT technology, we may have to rely on some level of cultivation for controlling annual morningglory to avoid costly hand weeding. Some other problems associated with this system include the difficulty in controlling nutsedge (*Cyperus* spp.). Therefore, CT systems are still a challenge in RR cotton production systems.

Most perennial weeds are capable of reproducing from organs other than seeds. For example, nutsedge and johnsongrass (*Sorghum halepense*), generally reproduce from underground storage structures called tubers and rhizomes, respectively. These perennial reproductive structures may no longer be buried to unfavorable depths or may not be readily uprooted and killed with the implements used in CT as compared to conventional implements.

Trials of Wright and Vargas showed that most effective purple and yellow nutsedge control in cotton was achieved using a combination of glyphosate in a RR system combined with mulching seed beds and cultivating 2-3 times using sweep type cultivators. Similarly, cultivation was necessary to successfully control field bindweed (*Convolvulus arvensis*) in blackeye beans in a study in Denair, CA (Shrestha et al. 2003). Therefore, some level of cultivation may be necessary for perennial weed control in certain cropping systems in California.

**Weed seedling emergence and timing of weed control operations in CT**

Some weed seeds require scarification and disturbance for germination and emergence. The germination and emergence of such weed species may be suppressed under CT systems. For example, a study in small grains and beans showed a reduction in wild radish (*Raphanus raphanistrum*) emergence under CT than in soil inverting tillage systems (Shrestha et al., 2003).

Presence of surface residue may influence soil temperature and moisture regimes thus affecting weed seed germination and emergence patterns over the growing season in CT systems. Therefore, timing of weed control may have to be altered. Soil surface residue can interfere with herbicides so there is a greater likelihood of weed escapes if residue is not managed properly or herbicide application timing or rates are not adjusted. Again, very little data exists on timing of weed emergence as influenced by CT systems in California.

**Herbicide use and CT**

*Burndown herbicides*

Weeds present at the time of crop planting in CT systems may need to be controlled with nonselective burndown herbicides such as glyphosate, paraquat etc. These herbicides have to be applied prior to crop emergence (Hartzler and Owen, 1997). However, these herbicides lack residual activity. Therefore, applications should be as close to crop planting or emergence, as the label will permit, to avoid further weed emergence prior to the crop. Growers may perceive this burndown herbicide application to be an increase in their chemical costs because tillage would control these emerged weeds in conventional or standard tillage (ST) systems. However, fuel, labor, and energy cost comparison between burndown herbicide application in CT and tillage in ST systems need to be taken into consideration.

*Preemergence herbcides*

In ST systems, residue is generally not present at the time of preemergence herbicide application. However, in CT systems crop residue may be present at the time of herbicide application and this may affect the performance of the herbicide as the residue can intercept the herbicides and affect their distribution (Hartzler and Owen, 1997). Most preemergence herbicides can be surface applied but they must be incorporated either by water or mechanically. Rainfall often is not dependable in the central valley. Therefore, sprinkler irrigation or mechanical incorporation may need to be used in CT systems. Further, the increase in surface organic matter may bind up some of the herbicide and thus rates may need to be increased to achieve adequate control. Cover crops left on the surface present a different situation for preemergence herbicides. Cover crop mulches are seldom uniform and thus it is common to see thick mulch and bare ground in the same field. However, it was observed that a thick mulch may be sufficient alone in controlling weeds, whereas in areas where the mulch is thin or non-existent, the herbicides are effective (Lanini et al., 1989). The planter also moves mulches and crop residue away from the seed line and creates a relatively clean zone for good herbicide action, where it is needed most.

*Postemergence herbicides*

Postemergence herbicides work equally well in CT and ST systems. However, it should be noted that residue on the soil surface in CT systems may interfere with effective herbicide contact with emerging seedlings. Hartzler and Owen (1997) suggest that growers wait until weeds become established and then control them with postemergence herbicides because weed emergence is less uniform in CT than in ST systems. Similarly, crop emergence and development may not be uniform in CT systems compared to ST systems, particularly for plantings made during cool periods of the year, and where there is a lot of surface residue. In spring and summer plantings, this difference in weed emergence timing would be expected to be much less. Adoption of CT systems has been enhanced by the development of HTCs as postemergence herbicides can be applied during the growing season with relatively low risk of crop injury. However, when postemergence herbicides are applied aerially, it must be cautioned that growers should not wait too long because canopy closure by the crops may intercept the aerially applied herbicide thus reducing the contact between the herbicide and the weeds under the crop canopy. This phenomenon was noticed in RR forage corn grown in narrow (15 inch) rows in California. Therefore, identification of the best timeframe for postemergence herbicide application in HTCs is critical in CT systems in California.

*Residual activity of herbicides*

Persistence of residual herbicides for a longer period may be a concern in CT systems. For example, Vargas and Wright found crop injury due to persistence of prythiobac sodium (Staple) in a CT study. Staple was applied to cotton but the following tomato crop suffered considerable stand loss due to carry-over of the herbicide. Among the tillage systems compared, injury was most severe in the complete no-till system. Similar carryover of another sulfonylurea and crop injury was also observed in corn. In CT systems with reduced tillage, residual herbicides may not be diluted sufficiently in the soil profile, as they are in conventional systems. This may lead to injury of the subsequent crop. Therefore, herbicide selection in CT systems is important to avoid losses to subsequent crops in the rotation.

**Herbicide-tolerant crops (HTCs) and CT**

HTCs have allowed growers to begin to transition into CT systems in California and other states. The advantage of HTCs, mainly RR, has been the ease of applying glyphosate over-the-top with excellent crop safety and weed control. Production costs have also decreased as growers have made fewer trips across fields in applying herbicides, reduced cultivations, and hand weeding operations. Reducing cultivation and eliminating hand weeding have reduced costs from $25- 150 per acre depending upon weed species and density. UCCE cotton cost studies indicate an average savings of $60 per acre savings with RR cotton compared to conventional cotton (UCCE, 2003).

Potential for weed resistance to specific herbicides and weed shifts is always a concern with herbicide programs, but with HTCs in a CT system, weed resistance may be of greater concern. HTCs as in the case of RR crops tend to promote the continuous use of glyphosate, this probably may induce species shift or development of herbicide-resistance in weeds. If tillage is also eliminated, an important tool for managing resistant weeds is also eliminated. Studies of Wright have already shown weed shifts in Tulare as more annual morningglory was observed in the CT plots. Although CT systems are often practiced in conjunction with HTCs, conventional varieties, herbicides with different modes of action including residual herbicides, or cultivation will also need to be integrated to prevent herbicide-resistance and species shifts.

**Alternative techniques for weed management in CT**

*Mulches*

Any material that blocks light will suppress or prevent the growth of weeds. Layers of organic residue mulches such as municipal yard waste, straw, hay, wood chips, etc., can be used as mulch, with thicker layers providing the best control of annual weeds (Makus et al., 1994). Organic mulches breakdown with time and the original thickness typically reduces by 60% after one year. Coarse green waste works better as a mulch. Organic residue mulches are rarely used in vegetable production in California because of their costs, as well as the additional hauling and spreading costs.

Cover crops can be grown, under cut and left on the beds to form an organic mulch (Lanini et al., 1989). Plants used to produce organic mulches include various cereals, clovers, vetches and fava beans (Abdul-Baki and Teasdale, 1993). The advantage of growing the mulch in place is that it is rooted and thus will not be blown away in windy locations. Organic mulches provide some weed control, depending on the thickness and ability to block light, as well as other benefits on the growth of row crops. However, thick mulches have created some difficulties in direct seeding of crops (Lanini et al. 1989), but less so with transplanting. Cover crop mulches are currently the subject of a great deal of research in the interior valleys on crops such as processing tomatoes, but at present, their use is limited.

*Cultivation*

Tillage is a time-tested technique to control weeds in crop production. Many approaches and philosophies regarding cultivation exist. A new generation of cultivators has been developed to remove weeds from between the seed rows, and in some situations, from the seed row (Wallace and Bellinder, 1992). Cultivators, such as brush hoes work the soil in a circular direction and thus do not remove surface residues. Knives that run parallel to the soil surface and undercut weeds also preserve surface residues. Use of cultivation to eliminate perennial weeds was discussed earlier.

*Weed Burning*

Flaming is a popular method of controlling weeds in organic production systems. It is used on a wide variety of crops preemergence: peppers, carrots, onions, parsley, potato and parsnips (Melander, 1998). In addition, flaming is used postemergence on young onion (Rifai et al., 1996) and garlic or as a directed treatment to the base of tougher crops such as corn or cotton when they are twelve or more inches in height (Schlesselman et al. 1989). Flaming is one of the more economical methods of controlling weeds in organic vegetable operations with the costs varying from $30 - 35 per acre depending upon the amount of propane that is consumed in the operation (Klonsky et al., 1994). Flaming works best on small broadleaf weeds, and less well on grasses or large weeds. Grasses have growing points at or below the soil surface and often recover following flaming and large broadleaf weeds can often recover after partial top removal.

*Subsurface drip irrigation*

Drip irrigation tape buried 6 – 12 inches below the surface of the bed can provide moisture to the crop and minimize the amount of moisture that is available to weeds on the surface (Grattan et al., 1988). If properly managed, this technique can provide significant weed control during the non-rainy periods of the year. The use of subsurface drip irrigation also eliminates the need to maintain furrows for irrigation.

**Summary and conclusions**

California has very diverse and complex cropping systems than other parts of the US. Therefore, findings on weed management in CT systems from elsewhere may not be readily adapted to California. However, there are several examples of the biology of weeds, seed bank dynamics, and management techniques that can be applicable to our conditions. Several examples of which were presented in this paper. Studies are also being conducted in California to develop weed management in CT systems.   Results of these studies will be shared as they become available.  The principles and philosophy of weed management, however, remains the same in CT and ST systems.  Monitoring weed communities and patch dynamics, timeliness of weed management operations, rotation of herbicides, and minimizing weed seed return are all essential components of CT as in ST systems.  Some alternative techniques to manage weeds were also presented.  Adjustments will have to be made in CT systems for weed management, for example, cultivating some difficult to control weeds.  Finally, proper weed management is essential for the success of CT systems.

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