EFFECTS OF TILLAGE PRACTICES ON WEED SPECIES IN ROTATIONAL CROPS

Anil Shrestha, IPM Weed Ecologist, University of California Statewide IPM Program
Kearney Agricultural Center, Parlier, CA 93648

Tillage has been an essential component of traditional agricultural systems. Broadly defined, tillage is the mechanical manipulation of the soil and residue to prepare a seedbed for crop planting. The benefits of tillage are multifaceted; it loosens soil, enhances the release of nutrients from the soil for crop growth, kills weeds and regulates the circulation of water and air within the soil (Reicosky and Allmaras, 2003). However, intensive tillage has been found to adversely affect soil structure and cause excessive breakdown of aggregates leading to soil erosion. 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 'conservation tillage'.

Conservation tillage (CT) is an 'umbrella term' that encompasses many types of tillage and residue management systems (Reicosky and Allmaras, 2003). There are several definitions for 'CT'. For example, Allmaras and Dowdy (1985) define it as a combination of cultural practices that result in the protection of soil resources while crops are grown. The Conservation Technology Information Center (CTIC) defines CT as any tillage and planting system that leaves at least 30 percent of the soil surface covered by residue after planting. Several states in the US have been exploring for innovative tillage systems that conserve soil and residue. In California, CT is still in a stage of infancy compared to other states because of climatic and soil factors. CTIC (2002) estimates show that only 16% (964, 064 acres) of the cultivated crop land is under some form of CT in California. This includes 12692 acres under no-till, 43 acres under ridge-till and 951,329 acres under mulch-till.

The development of CT systems has far reaching implications to weed management because tillage has been a major tool for 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. CT is considered as an important change that has taken place in the development of sustainable agricultural systems. However, concerns about weed species shifts and associated crop yield losses have restricted its widespread adoption (Buhler et al., 1994; Derksen et al., 1993).

Some common concerns about weed management under CT include emergence from recently produced seeds that are not being buried deep, prevalence of annual grasses and weed species shifts, interference of surface residue with herbicides, lack of disruption of perennial rootstocks, and a bigger 'window' for weed emergence. Stahl et al. (1999) suggested that a shift in tillage system causes changes in weed seedling microsites and thus affects the weed community composition. However observations on these concerns, especially weed species shifts have been contradictory. For example, Cussans (1976) reported greater abundance of some dicot weeds with increasing levels of cultivation. On the other hand, Wrucke and Arnold (1985) reported similar distribution of broad-leaved weeds in CT and conventional tillage systems. Pollard et al. (1982) reported that most weeds showed no consistent response to tillage. Swanton et al. (1999) found that tillage was an important factor affecting weed compositions. Derksen et al. (1993) suggested that changes in weed communities were influenced more by environmental factors (location and year) than by tillage systems. Shrestha et al. (2002) concluded that long-term changes in weed flora are driven by interaction of tillage, environment, crop rotation, crop type and timing and type of weed management practice. Similarly, the timing of weed emergence also seems to be species dependant. For example, Bullied et al. (2003) found that species such as common lambsquarters (*Chenopodium album* L.), field pennycress (*Thlaspi arvense* L.), green foxtail (*Setaria viridis* (L.) Beauv.), wild buckwheat (*Polygonum convolvulus* L.), and wild oat (*Avena fatua* L.) emerged earlier in CT than in conventional tillage system. However, redroot pigweed (*Amaranthus retroflexus* L.) and wild mustard (*Sinapis arvensis* L.) emerged earlier in the conventional than in the CT system.

For successful implementation of a CT system, it is important to understand how the ecology of weeds is affected. Seeds shed by annual weeds are not buried deep in CT systems. So, initial weed densities may be high if effective weed control is not maintained. On the other hand, weed seeds that are placed deeper in the soil profile are not being brought to the soil surface any more because of lack of soil inverting mechanisms by tillage. Therefore, in CT, we may be dealing with the weed seed bank in the top few inches. So, minimizing seed return can be an important tool for weed management in CT. Lack of tillage and presence of residue may influence soil temperature and moisture thus influencing weed seed germination and emergence. This may make the 'window of weed emergence' bigger or sporadic. Therefore, timing of weed control may have to be altered.

The reproductive structures of perennial weeds may no longer be buried deep or killed in CT systems as in conventional systems. Most perennial weeds are found in patches, so monitoring of weed patches will be essential in CT systems. 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 timings or rates are not adjusted.

Prediction of weed populations and weed species shifts would also help in designing weed management systems in CT. Similarly, information on the effect of crop rotation on weeds may be helpful because crop rotation has been critical for managing problem weeds in CT. There are very few reports on experiences in weed community dynamics under CT systems. Some personal experiences on these aspects from elsewhere and California are shared as follows:

i. A 9-year study in Ontario, Canada comparing the weed flora in continuous corn (*Zea mays* L.) under CT (no-till) and conventional tillage with or without a rye (*Secale cereale* L.) cover crop under varying levels of nitrogen showed that tillage was the most important factor influencing weed compositions. Cover crops and nitrogen rates had no influence on the weed species composition. Species like redroot pigweed and common lambsquarters were associated with conventional tillage systems whereas, large crabgrass (*Digitaria sanguinalis* (L.) Scop.), and common purslane (*Portulaca oleraceae* L.) were associated with CT systems (Swanton et al., 1999).

ii. Nine-year evaluations of three weed management systems under a CT corn-soybean (*Glycine max* (L.) Merr.)-winter wheat (*Triticum aestivum* L.) rotation was conducted in Ontario, Canada. The three weed management systems were: minimum (preplant application of glyphosate + mechanical control), integrated (preplant application of glyphosate + band application of preemergence herbicides + mechanical control), and conventional (preplant application of glyphosate + broadcast application of preemergence herbicides). It was found that, weed densities were greater in the minimum compared to the integrated and conventional systems. Weed densities in the integrated and conventional systems did not differ. There was no apparent 'buildup' of weed density with time in the rotation resulting from weed escapes. This study challenged the current thinking that weed densities increase with time if weed escapes are allowed to go to seed (Swanton et al., 2002). The study also saw distinct differences in weed species composition between the three weed management systems. Further, the weed species composition in wheat differed from that in corn and soybean within a weed management system. Species like common ragweed (*Ambrosia aretemisiifolia* L.), annual sowthistle (*Sonchus oleraceus* L.) were associated with the minimum system in general whereas, common lambsquarters was associated with corn and soybean in the minimum system. Wild buckwheat (*Polygonum convolvulus* L.) was associated with wheat in the integrated system. Similarly, dandelion (*Taraxacum officinale* Weber in Wiggers) was associated with wheat in the conventional system and yellow foxtail (*Setaria glauca* L. Beauv.) was associated with corn and soybean in the conventional system. This study showed that weed communities were associated with the type of crop in the rotation and the type of weed management system even within a CT system.

iii. From a California perspective, initial assessments of weed population dynamics under CT in a small grain (wheat, barley, and oats) – blackeye bean (*Phaseolus* sp.) rotation were made in 2003 at Denair, CA. The weed densities and biomass in both small grains and beans were lower in the CT compared to the conventional system. The dominant weed in the rotation was wild radish (*Raphanus raphanistrum* L.). There was a high occurrence of wild radish in the conventional tillage plots compared to the CT plots. It seems that wild radish prefers disturbance and hence showed a preference for conventional tillage system. Similarly, in the beans, weed density and biomass were greater in the conventional than in the CT plots. Again, the major weed species were similar as in the small grain plots with additional summer weeds like hairy nightshade (*Solanum sarrachoides* Sendtner), large crabgrass, and puncturevine (*Tribulus terrestris* L.) (Shrestha et al., 2003).

From these experiences, it appears that it is difficult to generalize that weed densities will be greater in CT compared to conventional tillage systems. It may also be difficult to generalize weed population shifts and time of weed emergence. Types of crops in the rotation, weed management, and location (e.g., soil, environment) will determine weed communities. However, it can be concluded that, in general, weed communities and species will be influenced by tillage systems; type of crop in the rotation will influence weed communities; and although there may not be more weeds in CT systems, the species present will most likely differ from those in conventional tillage systems. Monitoring these changes and minimizing weed seed return can be an important strategy for the success of CT systems. Similarly, residue management will be important for the success of weed management in CT systems. Failure to adapt to these changes may result in a failure of CT systems.

References:

Allmaras, R. R. and R. H. Dowdy. 1985. Conservation tillage systems and their adoption in the United States. Soil Till. Res. 5:197-222.

Buhler, D. D., D. E. Stoltenberg, R. L. Becker, and J. L. Gunsolus. 1994. Perennial weed populations after 14 years of variable tillage and cropping practices. Weed Sci. 34:29-33.

Bullied, W. J., A. M. Marginet, and R. C. Van Acker. 2003. Conventional- and conservation-tillage systems influence emergence periodicity of annual weed species in canola. Weed Sci. 51:886-897.

Conservation Tillage Information Center (CTIC). 2002. National Crop Residue Management Survey: A survey of tillage system usage by crops and acres planted.

Cussans, G. W. 1976. The influence of changing husbandry on weeds and weed control in arable crops. In Proc. Brit. Crop Prot. Conf. – Weeds, Brighton, UK. pp. 1001-1008.

Derksen, D. A., G. P. Lafond, A. G. Thomas, H. A. Loeppky, and C. J. Swanton. 1994. Impact of agronomic practices on weed communities: tillage systems. Weed Sci. 41:409-417.

Pollard, F., S. R. Moss, G. W. Cussans, amd R. J. Froud-Williams. 1982. The influence of tillage on the weed flora in a succession of winter wheat crops on a clay loam soil amd silt loam soil. Weed Res. 22:129-136.

Reicosky, D. C. and R. R. Allmaras. 2003. Advances in tillage research in North American cropping systems. J. Crop Prod. 8:75-125.

Shrestha, A., S. Z. Knezevic, R. C. Roy, B. Ball-Coelho, and C. J. Swanton. 2002. Effect of tillage, cover crop and crop rotation on the composition of weed flora in a sandy soil. *Weed Research* 42:76-87.

Shrestha, A., R. Vargas, J. Mitchell, and D. Cordova. 2003. Initial experiences in transition from conventional to conservation tillage: a farming systems perspective. *In* the Proceedings of Conservation Tillage 2003: The California Experience. Oct. 7-9, Tulare, Five Points, Davis, CA.

Stahl, L. A. B., G. A. Johnson, D. L. Wyse, D. D. Buhler, and G. L. Gunsolus. 1999. Effect of tillage on timing of *Setaria* spp. emergence and growth. Weed Sci. 47:563-570.

Swanton, C. J., A. Shrestha, S. Z. Knezevic, R. C. Roy, and B. R. Ball-Coelho. 1999. Effect of tillage systems, N, and cover crop on the composition of weed flora. Weed Sci. 47:454-461.

Swanton, C. J., A. Shrestha, D. R. Clements, B. D. Booth, and K. Chandler. 2002. Evaluation of alternative weed management systems in a modified no-tillage corn-soybean-winter wheat rotation: Weed densities, crop yields, and economics. Weed Sci. 50:505-511.

Wrucke, M. A. and W. E. Arnold. 1985. Weed species distribution as influenced by tillage and herbicides. Weed Sci. 33:853-856.