SUSTAINABLE
AGRICULTURE FARMING
SYSTEMS PROJECT
University of California, Davis
Winter/Spring 2007 VOL.7/NO.2

Equipment options: emphasis on reducing energy consumption

by Dennis Bryant and Israel Herrera

Conventional equipment and tillage operations have long provided growers with proven methods to see their field products through harvest. However, continuously increasing costs associated with skilled labor, fuel and chemical inputs (pesticides, herbicides and fertilizers) have driven the search for additional equipment options. Growers have succeeded in reducing operational costs primarily by 1) accomplishing multiple tasks on each pass through the field, 2) increasing the speed through the field thereby reducing in-field time and 3) reducing overall fuel consumption per pass. Generally, ground-driven and lighter implements require lower operational horsepower and result in a substantial reduction in fuel consumption per acre. The elimination of power take-off-driven implements (PTO) also reduces overall equipment maintenance costs.

Within California and even across individual farms, soil properties and spring moisture conditions can vary greatly. Therefore, attempting to reduce field passes requires that implements be highly adaptable to a wide variety of soils under uncertain weather conditions. Of these, soil moisture in preparation for spring planting can be the most challenging. In wet years with limited existing crop residue, conventional practices often began with a light harrow and furrow-sweeping operation, which effectively dries the soil surface for additional and progressively more substantial tillage operations. An effort to reduce or eliminate these initial field passes has led to an increasing acceptance of strip-tillage and similar methods where only a portion of the soil surface is tilled on each pass. Often spring strip-tillage can be accomplished with lighter tractors when soil conditions may be too wet for heavy tractors and conventional implements. The addition of wheel extensions further serves to distribute equipment weight over greater surface area, potentially reducing furrow disturbance and soil compaction.

The desired trend to increase the use of winter cover crops in California confronts growers with an additional challenge. What are the most effective tools to manage cover crop residue with the uncertainty of spring weather conditions? In conventional production systems, cover crops can potentially reduce winter

photos by Dennis Bryant

runoff and benefit soil properties associated with root mass decomposition. Generally, in these systems the cover crop is "sprayed out" with an herbicide application to reduce pre-plant surface residue to acceptable levels. In contrast, organic producers seek sufficient legume or legume-grass mix cover crop growth to use the residue as a nutrient source for subsequent crops. These systems rely on mowing (Figure 4) or chopping (Figure 1) to initiate "dry down" for incorporation.

In research fields at the UC Davis Center for Integrated Farming Systems (CIFS) site, recent successful cover crop strategies have included legume-grass mixes with an upright growth habit, reducing planting densities and bed-top only plantings. Even so, in years of late spring rains, entry into the field may be delayed, producing greater than optimum biomass. In 2006, a bell bean-wheat cover crop (Figure 2) standing biomass yield was 21.2 tons/acre wet weight (2.5 tons/acre dry weight). This includes approximately 4500 gallons of water per

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acre as plant moisture, and presents a challenge for conventional flail shredding. Ground-driven reel chopping of this crop (Figure 1) was accomplished at speeds of 6-7 mph, which was greater than four times faster than flailing, and used approximately 50 percent less horsepower. The result is different; material is segmented due to the blade spacing of various types of reel-chop equipment. In comparison, flail mowing (Figure 4) generally produces a slurry, as PTO-driven blades shred the crop biomass.

Subsequently, multiple passes with a bed disc (Figure 3) can achieve full incorporation of cover crop residue, which retains the bed location but thoroughly tills residue and soil. Follow-up equipment is typically needed to create suitable planting conditions.

Alternatively, bed centers can be strip-tilled (Figure 5 and 7) or full-bed ground-driven mulched (Figure 6) in preparation for planting. With either strategy, a ground-driven incorporator can be used post-transplanting (Figure 6). In conventional fields, herbicide application (band or broadcast) and precision fertilizer placement can be completed with either strip-till or ground-driven incorporator techniques.

At the CIFS, a ground-driven bed reformer (Figures 8 and 9) was tested following wheat and processing tomato harvest. Depending upon conditions, the bed reformer is designed to cut residue, bed top and furrow rip, till and reshape the existing beds.

All equipment options discussed are suitable for buried drip irrigation fields. A wide array of sizes is available to make best use of growers' existing tractor power options. Various implement width choices make most suitable for use on small fresh-market farms as well as large-scale operations.

The featured implements and tillage options have been tested under field conditions in various crop production systems including winter cover crops, wheat, field corn and processing tomato. Growers should evaluate how this type of equipment fits within the overall management scheme of their particular crop rotations.

Currently, variations of these implements are available from several agricultural equipment manufacturers. Equipment in the photos has been made available by the manufacturers; we would like to thank them for their support of our Agricultural Experiment Station efforts and the agricultural sustainability research programs at the University ofCalifornia, Davis.

We are including these examples of equipment for information to the farm community. When trade names of products have been used, no endorsement of named products by the University of California is intended, nor criticism implied of similar products, which are not mentioned. For more information, contact Dennis Bryant at 530-752-5368, dcbryant@ucdavis.edu.


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Manufacturer contact information

McFarlane Mfg. Co. Inc., 1259 S. Water St., PO Box 100, Sauk City, WI 53589, 608-643-3321, 800-627-8569 *www.flexharrow.com/* (Spiral Reel Stalk Chopper)

David & Greg Wuertz, Arizona Drip Systems Inc., 3227 West Bechtel Rd. Coolidge, AZ 85228, 520-723-7711, *www.azdrip.com/contact.htm* (Sundance Wide Bed Disc)

Hope Lewis, Orthman Manufacturing Incorporated , 75765 Rd. 435, Lexington, NE 68850, 308-324-4654, fax: 308-324-5001, *www.orthman.com/index.html* (1tRIPr Precision Pre-Plant Tillage System)

Ricardo Lopez, Lopez Welding Services, 1955 E. Main St., PO Box 1194, Woodland, CA 95776, 530-666-5531, fax: 530-666-5533, info@woodlandwelding.com, *www.woodlandwelding.com/agequipment.htm* (Non Powered Reformer & All Purpose Non Powered Mulcher)

Clifford Hahn, Hahn Bed Disk, Hahn Tractor Co. Inc., PO Box 2167, Stockton, CA 95201, 209-944-0743, hahncc@aol.com (Hahn Perma Bed Tillage)

FALC, FALC Srl, Via Proventa 41, 48018 Faenza, Italia., info@falc1960.com, tel: ++39 0546-29050, fax: ++39 0546-663986 (Super Alce Series 4000)

Subsurface drip irrigation, cover crops and conservation tillage effects on greenhouse gas emissions.

By Cynthia Kallenbach, Will Horwath, Z. Kabir, and Dennis Rolston

Issue of Concern

California is the second largest emitter of greenhouse gases in the U.S., of which an estimated 8% of total state carbon dioxide (CO_2) and 59% of nitrous oxide emissions (N_2O) are from agricultural activities. Increased pressure on water supplies, water and air quality, and the need to mitigate greenhouse gas emissions necessitates the adoption of more sustainable farming practices to address these issues. Subsurface drip irrigation (SDI) is one promising practice that uses less water, eliminates irrigation tail water return and has the potential to reduce CO_2 and N_2O emissions.

Greenhouse gases in agriculture

CO_2 and N_2O emissions from the soil are primarily the result of the activities of naturally occurring soil microorganisms. On-farm activities such as tillage, irrigation, and high inputs of carbon and nitrogen to the soil are known to influence soil microbial activity and processes related to trace gas emissions. Thus, limiting or changing these activities has the potential to reduce the CO_2 and N_2O emissions from agricultural soils. The majority of soil microorganisms are most active in moist and warm soils, the dominant soil condition in the summer when the fields are irrigated. The most common irrigation practice in California row crop systems is furrow irrigation (FI). Recently, subsurface drip irrigation (SDI) is gaining popularity as prices become more economical and equipment becomes more durable. Under FI, the entire soil profile is wetted to near saturation to achieve uniform water distribution. This can often lead to an excess of water beyond crop needs leading to lower water use efficiency. In SDI, water delivery is minimized to an area of the soil profile directly beneath the crop. The confined spatial delivery of water in SDI limits microbial activity to the small area directly around the drip line. Furthermore, fertilizer can be delivered in small increments through the drip tape (fertigation) directly to the plant roots, increasing nitrogen (N) use efficiency, leaving less N to be transformed to N_2O by microorganisms.

Findings

We are currently wrapping up a two-year study designed to examine the potential of SDI to reduce greenhouse gas emissions. In addition, we are examining the effects of winter legume cover crop (WLCC) and conservation tillage (CT) to reduce soil emissions of CO_2 and N_2O under FI and SDI. These treatments were compared to no winter cover crop (NCC) and standard tillage (ST). Carbon dioxide and N_2O emissions from soil were monitored bi-weekly starting in the winter of 2005.

CO_2 Emission

Annually, the SDI treatments had a 4% lower CO_2 emission rate compared to the FI treatments. During the growing season, total CO_2 emissions were lower in the SDI treatments and were not different during the winter season compared to FI. In general, the FI-CT plots often showed higher CO_2 emissions. This may have been a result of a high density of weeds in the FI-CT plots, adding to the amount of CO_2 from root respiration, as well as sustained higher soil moisture content under CT. In the SDI-CT plots, weed populations were low and there was little difference in CO_2 emissions between tillage treatments.

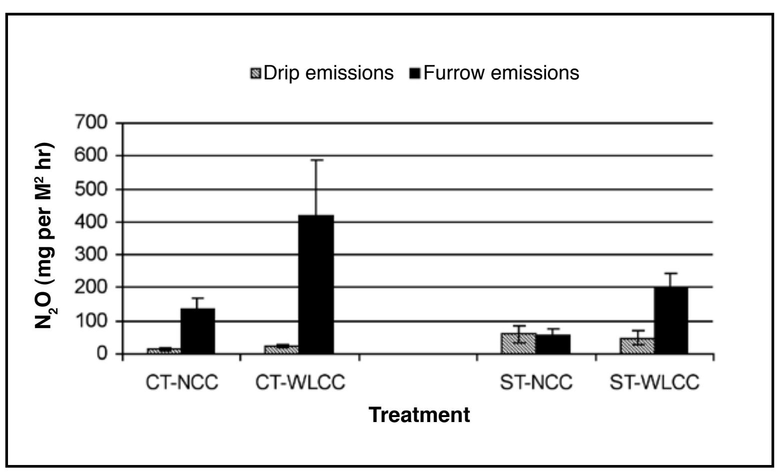

Figure 1.
Nitrous oxide emissions from July 6, 2006 by treatment.

N_2O Emissions

Of the 100 lbs. N/acre fertilizer application, 18% was lost as N_2O from the FI treatments compared to 4% N lost as N_2O in the SDI treatments. The highest N_2O emissions were found in the FI-WLCC treatments, while the lowest N_2O emissions tended to be in the SDI-NCC treatments.

The WLCC treatment across both irrigation types consistently showed higher N_2O emissions compared to the NCC treatment (Figure 1). Cover crops can be crucial in reducing winter runoff and in increasing carbon sequestration. However, this and other studies have shown that they may also increase N_2O emissions. This may be a result of the addition of N to the soil in the form that can then be transformed into N_2O under ideal soil moisture and temperature. Using a non-N fixing cover crop such as cereal may help reduce this effect.

Summary

Our results suggest that the conversion to SDI from FI has the potential to reduce greenhouse gas emissions. Although

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our findings suggest that growing a leguminous cover crop may enhance N_2O emissions, this effect is greatly reduced under SDI and is less than the more common FI-NCC system (Figure 1). The difference in emissions between irrigation treatments was much more profound for N_2O than for CO_2, with SDI having lower emissions. Although both gases are significant contributors to global warming, N_2O is 300 times more potent than CO_2. Agriculture accounts for more than half of N_2O emissions in California and the world. The adoption of SDI technology is increasing in the Central Valley, but still represents less than 15% of all irrigation despite some of the demonstrated benefits of water savings and reduction in greenhouse emissions. The upfront costs and maintenance requirements of SDI may be part of the reason for its slow adoption. We hope that our fall 2007 results on the economics of SDI will help growers evaluate the benefits of alternative irrigation systems.

New rotations

Welcome to the *Sustainable Agriculture Farming Systems (SAFS) Project, Winter/Spring 2007, Vol.7/No. 2* newsletter. Our fall grower and researcher meetings were exciting and productive. Based on input from farmers, UC Cooperative Extension farm advisors and other members of our research team, we have decided to change our long-term rotations from two to three years, possibly four. The change addresses sustainability issues related to enhancing nitrogen use efficiency and incorporation of reduced tillage practices.

We join the statewide UC Sustainable Agriculture Research and Education Program (SAREP) and the new UC Davis campus Agricultural Sustainability Institute (ASI) in welcoming **Tom Tomich** as the new director of both.

Our newsletter is produced in cooperation with SAREP. These articles continue our efforts to provide information on economically and ecologically sustainable agricultural systems research and management practices for California growers.

—Will Horwath, project leader

More information on UC Davis sustainable agriculture farming systems projects is available online at **safs.ucdavis.edu**, including expanded newsletter articles, SAFS/LTRAS updates, and other resources.

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