SUSTAINABLE AGRICULTURE FARMING SYSTEMS PROJECT
University of California, Davis
Fall 2004 Vol.5/No.1

Cover/cash crops in tillage systems

by Steven R. Temple, Kaden B. Koffler, Johan Six, and Francisco Reis

The first and second seasons of experience with tomato and corn in the SAFS Conservation Tillage (CT) treatments at Russell Ranch have produced mixed results, especially in management of water, weeds, and timely nitrogen (N) supply to high-demand summer cash crops. Treatments whose management combines cover cropping with CT present the greatest challenges. Organic and conventional growers at the June 24 SAFS field day panel stressed the value of multiple and diverse cash and cover crop rotation options in responding to the complex problems of reduced till, cover crop production systems, and particularly organic systems.


(photo by Steve Temple)

Fall planting of lupin/chickpea into corn residue.

During the 2003 summer cropping season, several "companion" experiments were initiated at the Russell Ranch as a part of the SAFS effort to improve the performance of the corn-tomato rotation. Efforts are being made to identify cash and cover crop species that perform particularly well in one or more of the SAFS CT systems. An experiment studying the effects of continuous soil food web enrichment under both CT and Standard Tillage (ST) was described by Louise Jackson et al. in the SAFS Spring 2004 newsletter (http://safs.ucdavis.edu.newsletter/v4n2-3-spring2004.pdf). Two other experiments were initiated to evaluate the utility of alternative cover and cash crops under CT management. One concluded in July, and featured the planting of grain lupin line RS 2034 (*Lupinus albus*), and the chickpea variety Sierra, following the fall 2003 harvest of field corn. The other concluded in late September comparing summer and/or winter cover crops grown between the processing tomato harvest in 2003 and field corn planting in 2004.

Cash crop alternatives: Post-corn grain legumes

After flail mowing and two passes with a Buffalo rolling stalk chopper, two winter legumes (lupin and chickpea) were planted into corn residues on Nov. 18, 2003 and Mar. 17, 2004 using a John Deere 1750 No-till planter. Spacing was 30" between rows on the 60" bed, which placed the legume seed in the same location as the maize root residues. No fertilizers were applied. Lupin seed was inoculated with rhizobial inoculant, and chickpea with a granular implant. Fall-planted chickpea was not inoculated and an herbicide mixture of 1.0 lbs/A of Prowl and 0.125 lbs/A of Goal was applied Dec. 3, 2004 over the fall- and spring-plant treatments to reduce weed pressure.

Germination was good for both species at both planting dates, and little predation by seed corn maggot was observed. Fall-planted garbs were retarded in early growth by 0.125 lbs/A of Goal 2XL, but plants recovered in February. Rainfall was good during the 2003-04 December-February winter season, but sharply reduced (with unusually high temperatures) in March. Spring-planted treatments were sown with no additional tillage or weed management. Because of the early cutoff of spring moisture, the fall-planted crops received two supplemental spring irrigations, while the spring-planted crops received three irrigations. Spodnam was applied to lupin during pod-fill to reduce shattering losses. Fall plantings were harvested on June 23, and spring plantings on July 22. Samples of plant dry weight biomass were taken for all treatments on Mar. 30 (mid-flower for fall plant) and May 27 (mid-flower for spring plant). Data for biomass dry weight and grain yield are shown in Table 1.

The same chickpea variety, planted Dec. 3 under ST at the UC West Side Research and Extension Center (WSREC) 200 miles to the southwest of Davis, yielded 3,913 lbs/A. And the same lupin line, planted at WSREC under ST, yielded 1,997 lbs/A. Perhaps the most interesting result was at UC Davis' Field Station, where 2003-crop common bean beds received a single pass of the Sundance bed disc, were ring-rolled, and planted with Rhizobia-inoculated grain lupin. That two-

Fall focus: Cover crops, water

In this issue you will find two articles on our continuing efforts to provide growers information on farming practices and research that address environmental issues in California agriculture. The page one article describes research on the integration of conservation tillage and novel cover crops/cash crops. The page three article updates our research on evaluating practices and monitoring water runoff and quality from agricultural fields.

Please go to *http://safs.ucdavis.edu/Releases/nr-040801.htm* to view a summary of the June 2004 SAFS field day.

—*Will Horwath*

acre block, planted the same day as the "post-corn" experiment six miles west of Davis, averaged 2,287 lbs/A.

Biomass accumulation data (Table 1) show that spring-planted legumes accelerated crop growth rapidly between March 30 and May 27. With the extra irrigation provided to the spring-plant crop, the chickpea continued to produce flowers and fill pods well into June. The result was a respectable 1,873 lbs/A on a plant that was visibly much smaller than those harvested at WSREC. The gross crop value for this 2004 harvest would be nearly $550/A, with very limited cash investment. The late July harvest would nonetheless preclude reasonable chances of harvesting a late-summer crop.

There is an opportunity to select for genotypes of both crops that are better adapted to planting date(s), location, and CT system. Adjusting seed rows (perhaps 3/bed) offset from corn rows appears desirable. In this study, fall-planted chickpea showed more virus than spring-plant, and spring-planted lupin was attacked more by insects and soil diseases. Use of fungicide-treated seed and rhizobial implant gave good nodulation for chickpeas. Supplemental spring irrigation was complicated by corn residues in the furrow. No winter rain runoff was observed from these plots. From other herbicide studies, it seems that Prowl alone would give adequate weed control with no chickpea stunting.

TABLE 1. Dry weight biomass (grams/m2) and yield (lbs/A) of two winter legumes planted in fall and spring at Russell Ranch (RR), UC Davis (UCDFS), and WSREC, 2003-04.

Planting (Location)	Tillage	Crop	Biomass 3/30/04 (g/m2)	Biomass 5/27/04 (g/m2)	Yield (lbs/A)
Fall(RR)	CT	Chickpea	15.9	391.9	"1,076"
Fall(RR)	CT	Lupin	58.7	343.9	680
Spring(RR)	CT	Chickpea	(germ)	186.8	"1,873"
Spring(RR)	CT	Lupin	(germ)	123.2	< 300
Fall(UCDFS)	Sundance	Lupin			"2,287"
Fall(WSREC)	ST	Lupin			"1,997"
Fall(WSREC)	ST	Chickpea			"3,913"

Cover crop alternatives: Summer/winter strategies

Most cover crop management practices currently used in California were developed for intensive tillage systems, and are not transferable to CT systems. To maximize soil and water quality benefits of cover crop-driven CT systems, new cover crop management tools need to be developed.

During the original 12-year SAFS experiment in which all treatments were under ST management, the supply of N from vetch following spring incorporation was found to be well synchronized with the N demands of spring planted cash crops (e.g. corn). The cover crop residues were mixed throughout the plow layer, allowing N mineralization to occur fairly quickly. In CT systems, winter cover crops are often not incorporated to reduce spring tillage operations, but are mowed or killed with an herbicide. This leaves the soil undisturbed and provides a surface mulch layer that enhances winter/spring weed suppression. However, decomposition of the cover crop residues occurs at a reduced rate, and may therefore not satisfy the demand (particularly, early season demand) of N by the cash crops.

Considering these difficulties, the SAFS group decided to lightly incorporate cover crop residues in the CT main plots in spring 2004. Although this should increase the availability of cover crop-derived N to the corn, spring operations add to farmer costs and disrupt the changes in soil composition and quality developed during the preceding period of CT. Is this compromise between spring tillage and N turnover from cover crops a necessary component of cover crop-driven CT systems? Or can we develop new cover crops and management schemes that will allow us to avoid spring cover crop residue incorporation and tillage, while capturing cover crop benefits? We hope to address these questions by gaining a better understanding of how the benefits of cover crops can be maximized at the interface of CT, soil fertility/water/weed/disease management, and farming operations.

Specifically, we are exploring a cover crop component that would occupy the niche between processing tomato harvest and corn planting the next spring. Several cover crop candidates were screened during the original SAFS experiment and sub-tropical legume/ C4 grass mixtures were found to effectively tie up "luxury" N unused by the tomato crop and fix significant amounts of N before being winter-killed in December. We hypothesized that this late-summer cover crop component could benefit the SAFS CT treatments by providing N demanded by corn and surface coverage to reduce winter/spring weeds. Since the cover crop is winter-killed the surface residue begins decomposing a full four months earlier than a winter cover crop

Immediately following tomato harvest, seven rows per 60" bed (spaced 7" apart) of the summer cover crop mixture (lablab/cover crop cowpea/ sorghum-sudan hybrid) with or without lana vetch was seeded into tomato residue using a 15' John Deere 1560 No-till drill. On Nov. 14, vetch was seeded with the

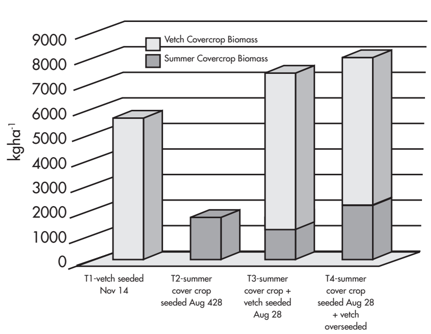

Figure 1: Summer/winter cover crop biomass comparison among treatments (kg ha-1)

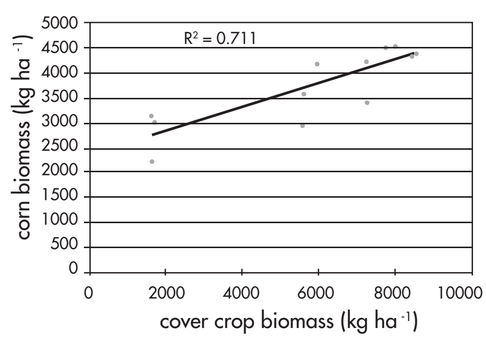

Figure 2: Regression of the effect of total cover crop biomass on corn biomass 54 days after planting (Each rep x treatment is represented by a data point).

same spacing/drill into 1) beds that were left fallow following tomato harvest and 2) beds with standing summer cover crop biomass. All treatments that had vetch were flail mowed Mar. 31, left on the surface, and any surviving vetch in the furrows was killed in April. Field corn was planted in all treatments on May 2 with the same John Deere 1750 No-till planter used in the "post-corn" experiment. Corn germination and seedling survival were unacceptable, largely due to improper sealing of the seed planting line. Moisture loss preceded the germination of many seeds, and others were plucked out by birds. Summer 2003 cover crop biomass production was disappointing, especially when compared to the vetch biomass produced by spring (Figure 1). More than likely, the lack of bed uniformity resulting from CT management contributed to uneven and unpredictable cover crop seeding depth and germination, and with a late seeding date (Aug. 28), the growing season was insufficient to allow for cover crop recovery and "fill in." Preliminary data suggest the additional summer cover crop biomass nonetheless may have boosted early corn growth in 2004. Corn biomass less than two months after planting was higher in treatments that had both summer and winter cover crops than treatments with just one or the other (Figure 2). Additionally, the summer cover crop biomass protected soil by "softening" early winter raindrops better than winter vetch, which was in an early stage of growth.

Summary

CT systems have the potential to improve soil and water quality, but only with the addition of compatible cover and cash crops to enhance production. With appropriate genotype selection and management, it appears N-fixing winter grain-legumes could provide an opportunity for continuous, low input cropping in CT systems. Summer cover crops can be used to cycle forward nitrates that would otherwise contribute to a growing water pollution problem. Seeding earlier in August would extend the growing season, allowing the cover crop to accumulate more biomass to supply crops like corn with adequate N, suppress winter/spring weeds and protect the soil from winter runoff and erosion.

With loss of ag wavier looming, SAFS researchers shed light on runoff dilemmas

by Sam Prentice, Aaron Ristow and Will Horwath

Much has been done since the federal Clean Water Act took effect in 1972 to mitigate end-of-pipe point source pollution (PSP). Much attention to assessing and mitigating non point sources of pollution (NPSP), including groundwater and surface water discharges from industrial, municipal and logging activities, has been done since the Act's inception. Noticeably lacking in early efforts is the assessment of NPSP from agricultural land, which historically has been exempted from the Clean Water Act under a clause known as the "ag waiver." In California, however, the Porter Cologne Water Quality Act does regulate agricultural runoff, and local institutions have recently implemented monitoring programs aimed at limiting water quality degradation from agricultural sources.

In January 2004, the shift toward NPSP management led to the elimination of individual ag waivers. By 2005, agricultural operations must comply with comprehensive new water quality regulations, embodied in a new "conditional waiver" enacted by the Central Valley Regional Water Quality Control Board (Water Board). The conditional waiver covers all irrigated farmland in the Central Valley. The Water Board, which is charged with developing and enforcing new NPSP standards, has presented three options to regional growers: join a regional water quality coalition group and apply for a group discharge waiver; apply for an individual waiver; or submit a complete application for a permit. The majority of growers appear to be choosing the first option, in which coalition group members are held jointly accountable for pollutants coming off of their collective land.

Developing solutions

The shift toward ambient water quality standards necessitates a rethinking of methodologies on monitoring. By definition, NPSP impairments are spatially and temporally diffuse, making them difficult to identify, quantify, and regulate. Analyses of pollutant loading based on protection of beneficial uses as described in the Basin Plan and Total Maximum Daily Loads (TMDL) require some form of watershed-scale monitoring that captures transport processes and relates them to land use practices.

The model currently adopted by some groups places downstream TMDL monitoring at its core; in this model, corrective actions are triggered when downstream pollutant loading exceeds (as yet undetermined) thresholds. While this model satisfies the legality of NPSP monitoring, technically it requires backtracking excessive pollutant loads upstream – a laborious process in which it is difficult to quickly identify pollution "hot spots" within the watershed.

To achieve effective NPSP reductions, however, the development of conceptual models that correlate water inputs and load reductions with progressive agricultural management practices would be useful and would provide the credible scientific information required to extend these models into the realm of ambient water quality standards and monitoring protocols.

Promising SAFS data

One year ago, a SAFS research team implemented the first large-scale, long-term, replicated field trials aimed at addressing the universal concern of growers statewide: the loss of the agricultural discharge waiver. Using state-of-the-art flow monitoring equipment, the SAFS team has collected extensive data on both winter and summer runoff events from agricultural fields in Yolo County. Our efforts include determining

Table 1. Runoff Values from CC and non-CC Farm Fields (2003-04 Rain Season)

	Non Cover Cropped	Cover Cropped
Total Precipitation Discharged as Runoff	16.3%	0.9%
Average Suspended Solid Conc.	2.14g/L	0.58g/L
Average Runoff Velocity	0.52m/s	0.24m/s

flow velocities and volumes and water quality indicators including organic and inorganic nitrogen and phosphorous, dissolved organic carbon, turbidity and suspended sediment.

Initial results show a stark contrast in runoff quality and quantity between a field planted in a winter legume/oats cover crop and a field with no plant cover (see Table 1). Notably, the quantity of runoff discharged from a winter cover-cropped field was less than one-tenth the runoff of winter-fallowed fields, or about 1% of total rainfall. In addition, yields between treatments showed no significant difference. The results support previous research showing increased infiltration and decreased nutrient losses through the use of cover crops. We are also examining practices that take advantage of residual plant cover, such as reduced tillage practices, as means to reduce runoff and NPSP. We believe these practices may be as effective as cover crops in meeting Water Board requirements.

In addition to analyzing nutrient and sediment loading, the SAFS water quality project team is determining relationships between rainfall intensity and runoff under winter cover-cropped and fallowed fields. Using minute-by-minute resolution of flow velocities, project hydrologists Wes Wallender and Bellie Sivakumar aim to build and refine models that predict the response of a particular cropping system, soil type, slope, drainage area, or other field-level parameters to rainfall intensity. Such models will aid farmers and policy makers in evaluating management practices and policies that conserve water and soil resources.

Significant impact

Overall, the influence of alternative management practices such as reduced tillage and cover cropping can have a significant positive impact on runoff quantity and quality. Our initial findings suggest that coalition groups can meet (and perhaps even exceed) their legal responsibilities to NPSP mitigation by encouraging their grower-members to adopt some aspect of alternative practices discussed here. Technical pitfalls that accompany winter and summer season monitoring provide an even greater incentive to focus on preventative solutions, which avoid TMDL violations. During the second and third years of the CALFED water quality project, we will continue to analyze the effects of tillage and winter cover crops, focusing on relationships among rainfall intensity, runoff flow velocities, and nutrient loading potentials. In keeping with the SAFS research paradigm, the economic feasibility of using alternative practices in California row crop agriculture will be an essential component. Ultimately, this project aims to develop a "toolbox" for growers and regulators to predict the effects of multiple land use management systems at the field and watershed scale.

SAFS Principal Investigators

Crop Ecology	Louise Jackson, lejackson@ucdavis.edu
Crop Production	Steve Temple, srtemple@ucdavis.edu
Economics	Karen Klonsky, klonsky@primal.ucdavis.edu
Entomology	Frank Zalom, fgzalom@ucdavis.edu
Hydrology	Wes Wallender, wwwallender@ucdavis.edu
Nematology	Howard Ferris, hferris@ucdavis.edu
Plant Pathology	Lynn Epstein, lepstein@ucdavis.edu
Soil Microbiology	Kate Scow, kmscow@ucdavis.edu
Soil Fertility	Will Horwath, wrhorwath@ucdavis.edu
Soil & Water Relations	Jeff Mitchell, mitchell@uckac.edu
Weed Ecology	Tom Lanini, wtlanini@ucdavis.edu

SAFS Technical Staff

Research Manager	Z. Kabir, kabir@ucdavis.edu
Crop Production Manager	Dennis Bryant, LTRAS associate director dcbryant@ucdavis.edu
Web Development	Sam Prentice, seprentice@ucdavis.edu

SAFS Technical Advisors

UC Cooperative Extension Farm Advisors, Yolo & Solano Counties	Gene Miyao, emmiyao@ucdavis.edu Kent Brittan, klbrittan@ucdavis.edu

Growers

Jim Durst, jdurst@onemain.com; Scott Park, parkfarm@syix.com;
Bruce Rominger, brrominger@ucdavis.edu; Ed Sills, esills@earthlink.com;
Tony Turkovich, tturk@bigvalley.net

UC Sustainable Agriculture Research & Education Program (SAREP) Cooperating Outreach Staff

Publications Editor	Lyra Halprin, lhalprin@ucdavis.edu
Web Development	James Cannon, safsweb@ucdavis.edu
PowerPoint Development	Linda Fugitt, llfugitt@ucdavis.edu.

http://safs.ucdavis.edu

SUSTAINABLE AGRICULTURE FARMING SYSTEMS PROJECT

Department of
Land Air & Water Resources
University of California, Davis
One Shields Avenue
Davis, CA 95616