ANNUAL REPORT COMPREHENSIVE RESEARCH ON RICE January 1, 1994 - December 31, 1994

PROJECT TITLE: Interaction of Rice Straw Incorporation and Winter Cover Cropping: Demonstration of Energy Savings and Soil Quality Effects

PROJECT LEADER: Stuart Pettygrove, Extension Specialist, Department of Land, Air and Water Resources, University of California, Davis, CA 95616 Phone 916-752-2533

PRINCIPAL UC INVESTIGATORS:

Kate M. Scow, Dept. Land, Air and Water Resources, UCD James E. Hill, Dept. of Agronomy and Range Science, UCD

John F. Williams, Cooperative Extension, Sutter Co.

TECHNICAL SUPPORT:

J. Deng, Staff Research Associate, T. Wirth, M. Hairs;, and S. Goldman, Postgraduate Researchers, D. Bossio, Graduate Research Assistant, and the U.C. DANR Analytical Laboratory.

COOPERATORS:

Ed Sills, Sills Farms, Pleasant Grove, Sutter Co.

LEVEL OF 1994 FUNDING: $7,000

OBJECTIVES AND EXPERIMENTS CONDUCTED TO ACCOMPLISH OBJECTIVES:

Funds were used to continue the Sills Farm straw management-cover cropping rice experiment for a sixth and final year. The work reported here was also partially supported by a grant from the California Energy Commission. Objectives were as follows:

Funds were used to continue the Sills Farm straw management-cover cropping rice experiment for a sixth and final year. The work reported here was also partially supported by a grant from the California Energy Commission. Objectives were as follows:

1. Conduct monitoring activities to document impact of cover crop/straw management on rice yield, rate of straw decomposition, and soil microbiological properties.

2. Put on two field days at Sills Farms long-term rice-cover crop experiment and display poster at the annual Rice Field Day held near Biggs.

3. Publish farmer bulletin on cover cropping in rice. Included will be consideration of straw management method.

The experiment was located on 15 acres of a commercial rice field that has been devoted to this project since the fall of 1988. The soil has a loam or clay loam surface texture and a pH of 4.5 when not flooded. The field is is divided into 15 one-acre plots that have been either fallburned, fall-incorporated, or spring-incorporated. Each of these plots is further divided into 0.5 acre winter fallow and winter cover crop (purple vetch) subplots. The subplots are large enough to use standard farm equipment for cultural practices. The field is one mile west of Highway 99 near the town of Pleasant Grove in Sutter Co.

As in each of the previous four years, following the 1993 harvest, residue was either (1) burned/disced/rolled, (2) disced/rolled or (3) left alone with harvested straw spread over the stubble. On half of the burned plots and on half of the fall-disced plots, purple vetch was broadcast seeded in early November at 60 lb N/acre. On the spring-incorporated plots (i.e. no burning, no fall discing), vetch was sown in September, 1993, at the time of field draining. Previous experience has shown that early fall establishment results in more covercrop biomass production and potentially in greater N contribution to the following rice crop.

To monitor straw decomposition rate, 288 rice straw-filled nylon mesh bags were buried on selected plots in December 1993. Bags were removed, dried, and weighed on seven dates from 12/22/93 to 4/19/94. Several other measurements were made on soil samples collected during the winter and spring to determine whether soil microbial composition and activity were affected by the straw management and cover cropping practices. Procedures included: microbial biomass by fumigation-extraction method; potentially mineralizable N by anaerobic incubation; substrate induced respiration, direct counts of active bacteria numbers and hyphae length, and community analysis using Biolog® plates.

All plots were chiseled, disced, and rolled in late April - early May, 1994. As in past years (except in 1990), the grower did not apply N fertilizer to cover-cropped plots. On the noncover-cropped plots, the grower applied 108 lb N/acre, except in a 30-ft wide strip reserved for N rate subplots to be used for yield and other measurements. On these subplots, N was subsurface banded as ammonium sulfate at 0, 30, 60, 90, 120, 150, and 180 lb N/acre using a Clampco small plot applicator. The 30 straw management-cover crop mainplots were separated from one another with levees and were irrigated from a common supply ditch in order to limit the potential for transfer of fungal pathogens among plots. The experiment was seeded by air with M-202 on 5/27/94. Conventional farming practices were used including use of copper sulfate for shrimp control, Furadan for rice water weevil, and Londax for weed control. In some mainplots, sprangletop and watergrass growth occured, but measurement subplots were not affected.

Fifty rice tillers were sampled on 9/13/94 from three replicates of the 0, 60, 120, and 180 lb N/ac-rate subplots for stem rot and aggregate sheath spot scoring. On 10/31/94 all plots were harvested for yield with a small combine (7.5 ft wide header) equipped with a scale and moisture meter. Grain moisture content, plant height, and percent lodging (visual estimate) were recorded. Samples of grain from the zero N rate plots were collected for determination of N.

SUMMARY OF 1994 RESEARCH BY OBJECTIVE

Objective 1. Determine straw management and cover cropping impacts on rice grain yield, rate of straw decomposition and soil microbiological properties. High grain yields were obtained at optimal N rates -- 95 to 101 cwt/acre, depending on straw management/cover crop practice. These are similar to maximum yields obtained on this experiment in past years. Sprangletop was much worse in 1994, but infestation was not serious on the N-rate subplots used to take measurements of yield and disease. Late planting, cool weather, and fluctuations in water depth may have contributed to the sprangletop growth.

1994 Grain Yeld - No Cover Crop: Rice grain yields were maximized with 120 lb N/acre on the fall and spring straw-incorporated plots and with 150 lb N/acre on the burned plots (Fig. 1, upper left). At all N rates, yields were higher by 5-10 cwt/acre on fall incorporated plots compared to the fall burned plots. Yields on spring incorporated plots were also lower than the fall incorporated plots and at 5 of the 7 N rates were higher yielding than the burned plots. Analysis of variance showed a significant cover crop x straw management interaction, with fall incorporation plots outyielding burned plots where covercropping was practiced, but with the inverse relationship (burned > fall incorporated) on the non-covercropped plots. The yield difference at the 0 N rate suggests that the soil in the straw-incorporated plots supplied an additional quantity of N to the rice equivalent to 10 to 15 lb N/acre of fertilizer. However the differences between those two treatments in maximum yields imply a non-nitrogen effect.

1994 Grain Yeld - Cover Crop: Purple vetch stands appeared uniform in the early winter of 1993-94. However, at the time of incorporation in late April, only modest vetch growth and N yields were observed (Table 1). Vetch leaf P content was 0.16 - 0.18 % compared to a required tissue P content of 0.25-0.30 % , suggesting that vetch growth was limited by low P availability in the pH 4.5 soil.

Table 1. Dry matter and N yield of purple vetch, April 15, 1994, Sills Farm. Vetch was water-sown 9/13/93 on spring incorporated plots, sown post harvest in November in fall burned and fall incorporated plots.

Rice Straw Management	*Vetch biomass*		*Vetch N yield*	
	lb dm/acre	*(s.d.)*	*lb/acre*	*(s.d.)*
Fall burned	1134	(379)	36.5	(12.5)
Fall incorporated	1115	(424)	33.9	(13.9)
Spring incorporated	1129	(487)	35.4	(13.6)

Maximum average rice grain yields were achieved on the cover cropped plots with 60-120 lb N/acre. On fall burned and fall incorporated plots, cover-cropped plots required 60 lb N/acre less than the non-vetch plots. However, estimation of the N fertilizer value of the purple vetch is complicated by variability of data and by the fact that in the burned and spring incorporated plots, maximal yields were apparently somewhat higher on cover cropped plots than on noncovercropped plots (Fig. 1). At the O N fertilizer rate, grain yields on cover-cropped plots averaged 22.8 cwt/acre higher than on non-cover cropped plots. For unknown reasons, maximum yields on the fall incorporated plots were significantly lower on the vetch plots than on the non-vetch plots (Figure 1, lower left). On all straw management treatments, grain N content on the 0 nitrogen plots ranged from 0.86 to 0.90 % N and was not significantly different on vetch and no vetch plots on the burned and spring incorporated treatments, suggesting a nonnitrogen effect.

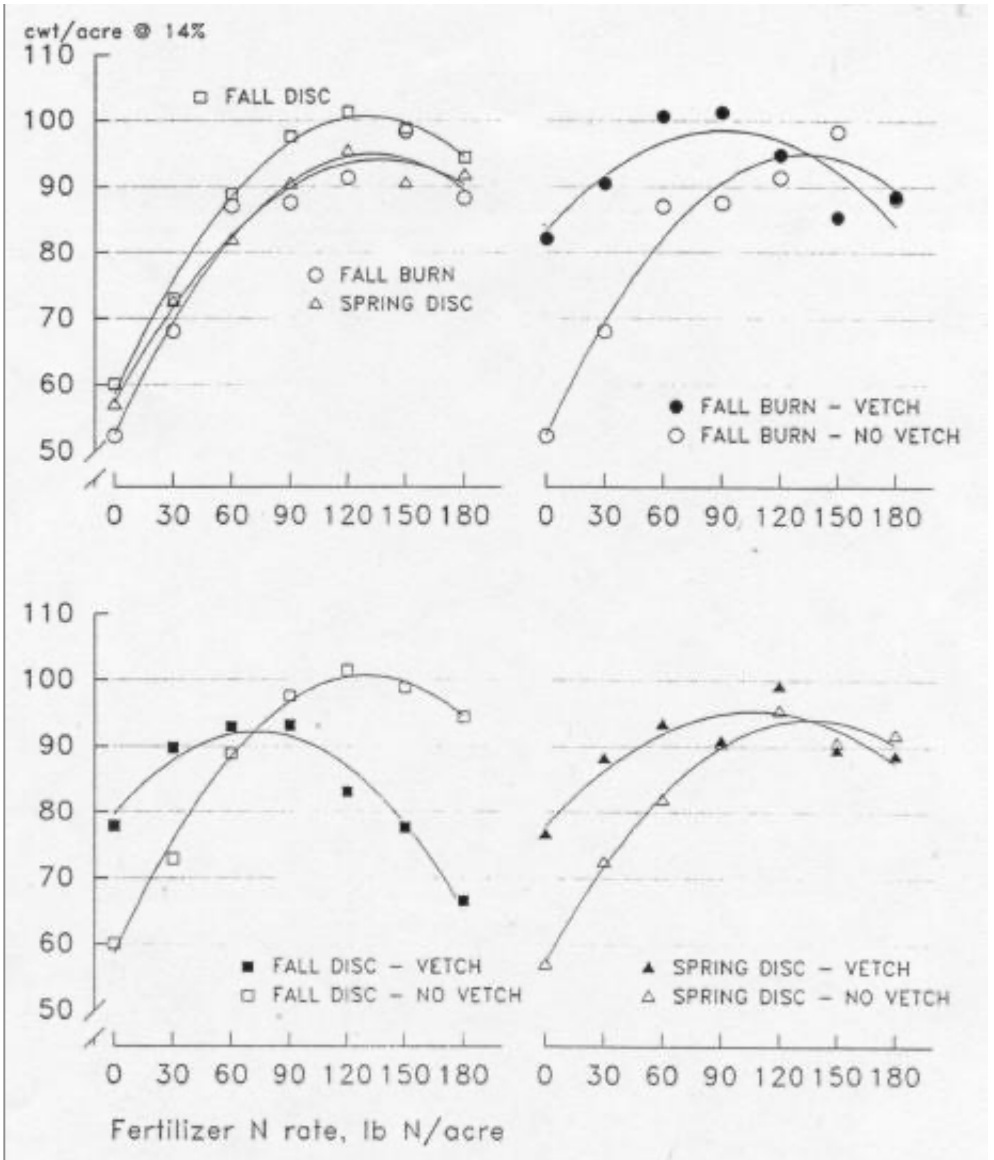

Figure 1. 1994 grain yield of M-202 at Sills Farms as influenced by N rate, straw management, and cover cropping with purple vetch

Rice yields - five year summary, 1990-94: On non-cover cropped plots, fall incorporation of straw produced about 5 cwt/acre (average over 5 years) greater grain yields across N rates than fall burning (Fig. 2, upper left). This yield difference occured each year, but was not statistically significant in most individual years. The higher average grain yield on fall incorporated plots appears to be a non-N related effect, though it is possible that it could be related to the timing of N supply to the crop. Yield difference at the lower N rates could be explained as a nitrogen effect (i.e., N lost during burning is retained in the soil on the nonburned plots), but the higher maximum yield on the incorporated plots implies a non-nitrogen effect. Spring incorporation gave similar five-year average yields to fall burning and required about the same rate of N to achieve maximum yield, suggesting little or no immobilization of N on the spring incorporated plots. n Cover cropping with purple vetch produced an average 60 lb N/acre fertilizer value on the straw-incorporated plots and closer to 90 lb N/acre on the burned plots (Fig. 2). Maximal yields on covercropped versus non-covercropped rice were similar (straw incorporated plots) or slightly higher on the covercropped plots (fall burned system). This conclusion is based on an assumption of the same N fertilizer rate each year. It is realistic to assume that the same N rate would be applied each year to the non-cover-cropped rice, but where cover cropping is practiced, it would be more realistic to assume that N rate would be varied according to the performance of the cover crop. Thus the yield responses for five years shown in Figure 2 may underestimate the five-year average yield that could realistically have been obtained on the cover crop system.

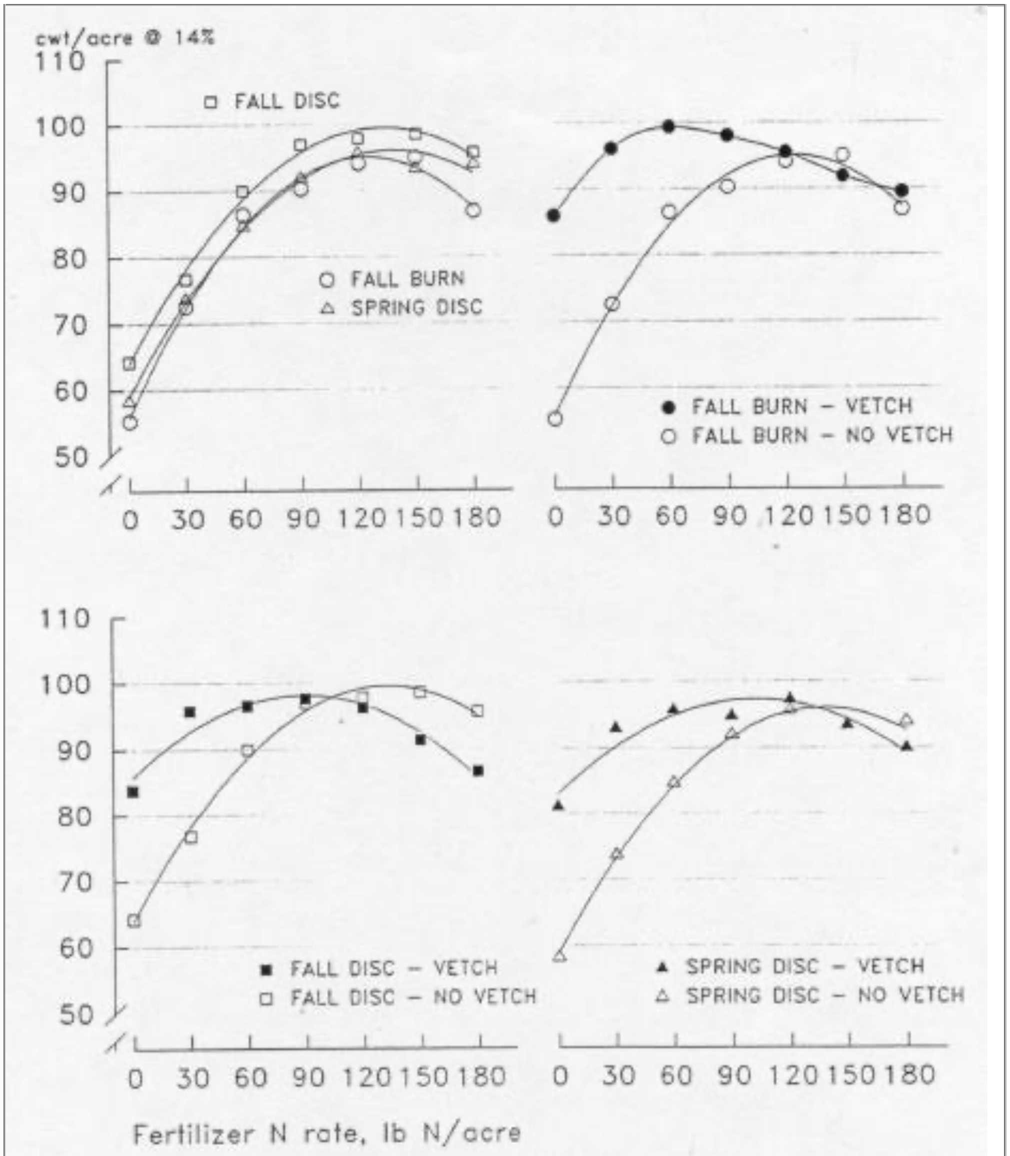

Figure 2. Five-year (1990-94) grain yield of M-202 at Sills Farms as influenced by N rate, straw management, and cover cropping with purple vetch. Straw management and cover cropping treatments were repeated on the same main plots every year. N rate subplots were shifted to different locations within main plots each year.

Disease Ratings - 1994:

Ratings for aggregate sheath spot and stem rot on the covercropped and non-covercropped plots are shown in Fig. 3. Compared to 1993, both diseases were less severe in 1994. Stem rot ratings ranged from 1.2 to 2.2 in 199 compared to 2.0 to 2.9 in 1993; and aggregate sheath spot lesions were present on 25 to 65 % of tillers this year versus 40 to 90 % in 1993. Inoculum for these diseases is plentiful in the soil of these plots (personal communication, R. Webster), but apparently some factor(s) such as the cooler summer and later planting date resulted in later development of disease, which in turn led to less severe infection.

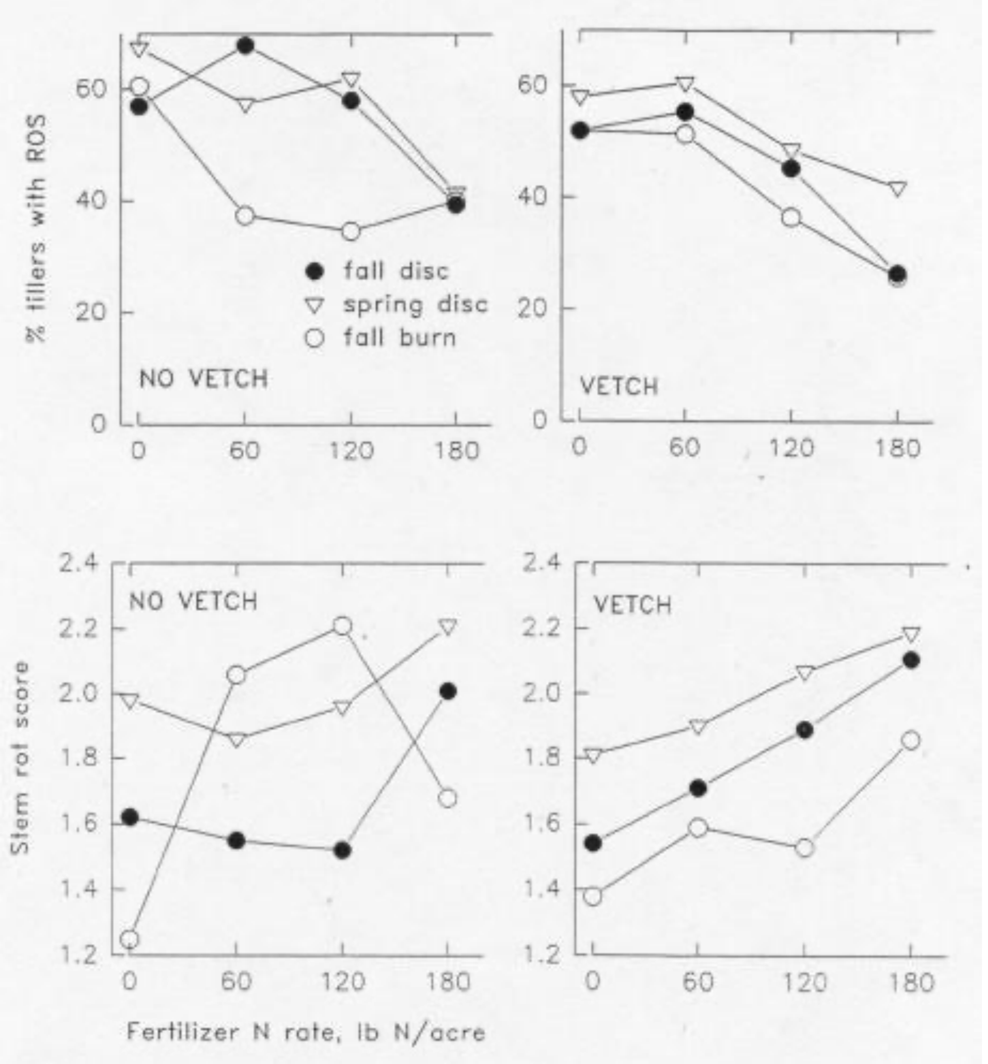

Figure 3. Disease scores on rice at Sills Farm experiment, 9/13/94. ROS = aggregate sheath spot. Stem rot score: 1=clean, 2=sheath infected, 3=sheath penetrated. Each data point represents rating on three replicate plots, 50 tillers per plot. Rice cultivar was M-202.

As in past years, both diseases were affected by N rate, with stem rot somewhat less severe at low N rates, and aggregate sheath spot less severe at higher N rates. The N fertilizer rate effect was clearer on the covercropped plots (Fig. 3, upper and lower right) than on noncovercropped plots.

In 1994, stem rot ratings were slightly higher on fall incorporated plots than on burned plots. This difference was observed at all N rates (0, 60, 120, and 180 lb N/acre) on the covercropped rice and at the 0 and 180 rates on the non-covercropped plots. This is the first time in this experiment that stem rot appeared to be worse on straw-incorporated plots. In the two previous years, stem rot ratings did not differ among straw management methods.

There was no clear effect in 1994 of vetch cover cropping on either disease rating. Straw management method also was not clearly related to incidence of aggregate sheath spot. In 1993, incidence was higher on the spring incorporated plots. This was also observed in 1994, but the differences were much smaller than in 1993 and were not statistically significant.

Straw Decomposition and Soil Microbial Activity: From early December 1993 when mesh bags of straw were buried on burned and spring incorporated plots, to April 19, between 67 and 73 (dry weight) of straw remained, depending on straw/cover crop system. Straw decomposed slightly slower on the burned plots (Fig. 4). Cover cropping did not appear to influence straw decomposition.

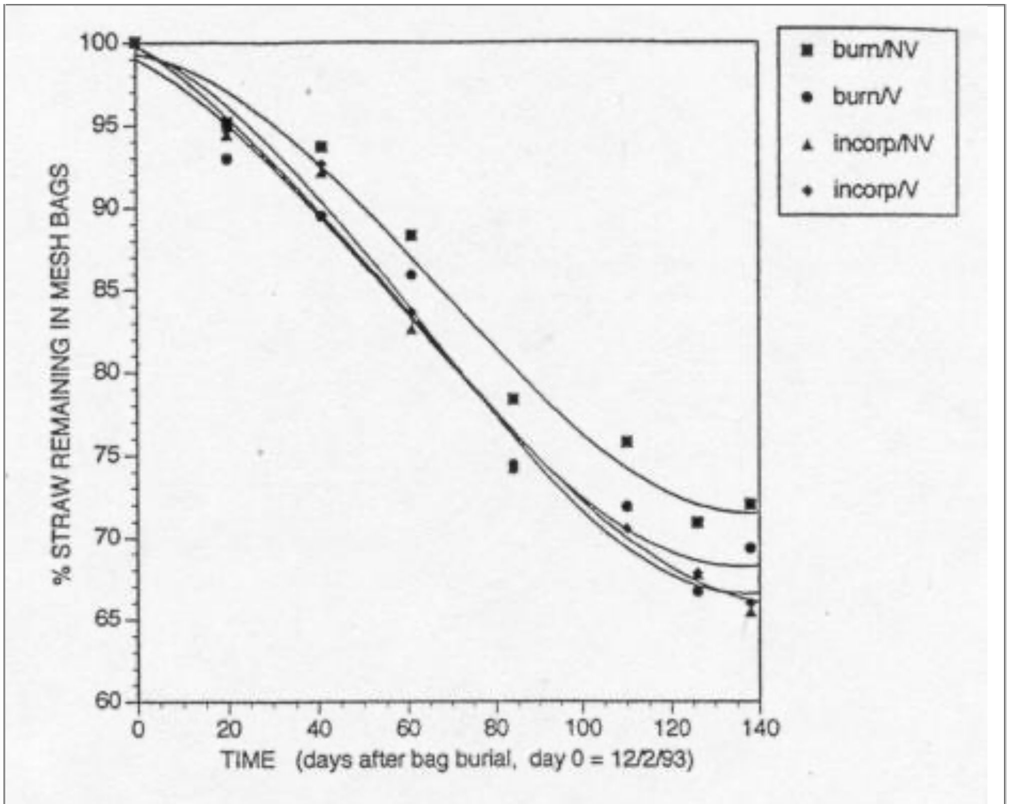

Figure 4. Rice straw decomposition in mesh bags buried 2-4 inches deep 12/2/93 at Sills Farm experiment. Treatments sampled were burned and spring incorporated with and without vetch.

Some soil characteristics related to microbial activity indicated a higher level of activity on straw-incorporated and/or covercropped plots. Substrate induced respiration (SIR) and basal respiration showed greater differences on than direct microbial counts. Both SIR and basal respiration showed treatment effects on the 3/22/94 samples but not on those collected 4/ 19/94 (Fig. 5). Soils data from this experiment are being combined with data from other sites and will be reported at a later date.

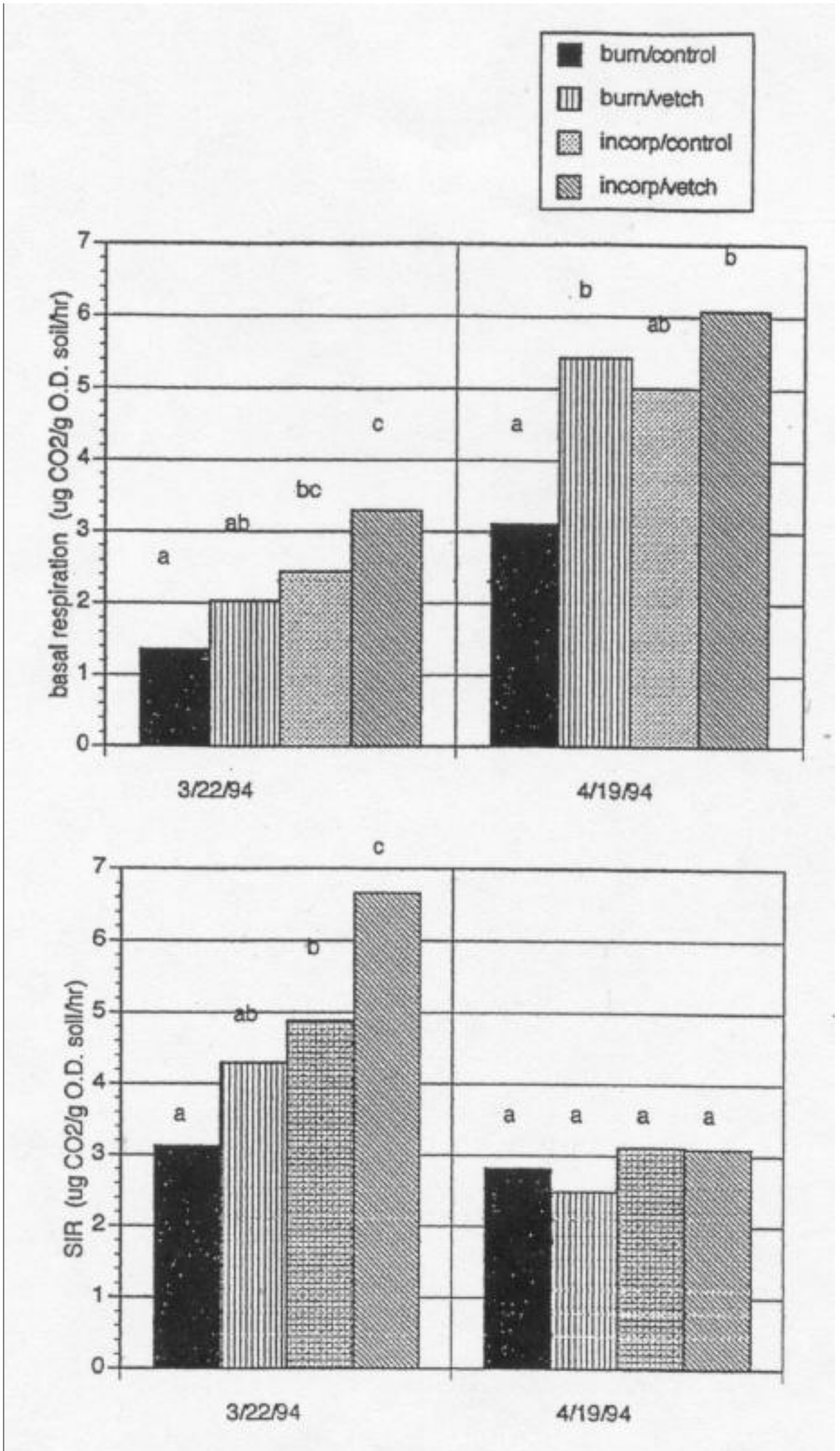

Figure 5. Soil basal microbial respiration (top) and substrate induced respiration (SIR) of soil samples collected from Sills Farm experiment on two dates before spring tillage in 1994.

Objective 2. Hold field days.

Two farmer field days were held at the Sills Farm experiment. The first field day was held on 4/7/94 to allow those attending to view cover crop growth and appearance of straw under the three straw management systems. A handout was distributed. Twenty seven persons attended. Very few farmers attended. Pre-meeting publicity was more than adequate, but apparently most rice farmers were busy with field work. The field day was covered by the press and a story appeared in Ag Alert newspaper. A second field day was held on 8/23/94 with about 35 attending including a large number of farmers. This meeting was also covered by the press and a handout was distributed.

The Sills farm experiment was also visited on 9/ 1/94 by the U. C. Davis Chancellor Larry Vanderhoef and the Dean of Agricultural and Environmental Sciences, Barbara Schneeman.

Objective 3. Publish farmer oriented bulletin on cover cropping in rice rotations

A draft of this bulletin is in preparation for the California Energy Commission and is targeted for release before the 1995 harvest. It will include information on cultural practices, costs and benefits and energy aspects.

1994 PUBLICATIONS

Lauren, J.G., G.S. Pettygrove, and J.M. Duxbury. 1994. Methane emissions associated with a green manure amendment to flooded rice in California. Biogeochemistry 24:53-65.

Pettygrove, G.S., C.M. Wick, J.F. Williams, S.C. Scardaci, D.M. Brandon, and J.E. Hill. 1994. Monitoring rice nitrogen status with a chlorophyll meter. Agronomy Fact Sheet 1994-3. Department of Agronomy and Range Science, University of California, Davis.

Pettygrove, G.S., J.F. Williams, C.M. Wick, S. Scardaci, R.K. Webster, and J.E. Hill. 1993. Interaction of rice straw incorporation and green manuring: Effects on rice straw decomposition, soil tilth, nitrogen nutrition, and stem rot. Annual Report. Comprehensive Rice Research. p. 50-67.