CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE FERTILIZER RESEARCH AND EDUCATION PROGRAM (FREP)

Final Report Summary
May 2001

Project Title: Winter cover crops before late-season processing tomatoes for soil quality and production benefits

Project Location: Yolo County, CA Project Duration: Jan 1998 - Dec 2000

Project Leaders:

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Project Objectives

1. Document the contribution of a winter leguminous cover crop to plant- nutrition, yield and fruit quality in processing tomatoes in an on-farm field trial.

2. Document the impact of a winter cover crop **on soil** permeability and winter runoff vs. fallow, pre-bedded ground.

3. Educate other growers and support industry about trial results and cover cropping technique.

Executive Summary

A single fall planting of a leguminous cover crop of vetch/pea mixture increased fruit yields of processing tomatoes by 5 to 13%. Nitrogen benefit from the leguminous cover crop appeared limited. Effects on soluble solids fruit quality were inconsistent between years. Rainfall run-off during the early spring was reduced up to 70% compared to the conventional, weed-free bed approach. Some growers have since adopted the planting of a leguminous mix of cover crops ahead of cropping to tomatoes. The yield increases occurred only when grown succeeding tomatoes in the crop rotation. In our Meridian-located test, when tomatoes followed rice in the rotation, we observed no yield benefit from the cover crop program.

Introduction

Planting fall cover crops in fields that will later be planted to processing tomatoes is a departure from the conventional cultural practice among tomato growers of minimizing weed vegetation prior to seedbed preparation. Vegetation-free beds facilitate seedbed preparation especially with direct seeded tomatoes. Fall bedding coupled with clean beds increases rainfall run-off once soils become saturated.

Work Description (note: **annual** work plans were similar for each of the years **as in** year 2000 except with the addition of Sutter trial only in year 2000)

Task 1: Winter Cover Crop Trial

The purpose of this task is to document the nutrient and soil quality and soil conservation benefits of a fall planted leguminous cover crop on an ordinarily winter (allowed field ahead of late-spring-transplanted processing tomatoes on two sites Yolo and Sutter Counties, CA. The product of this task will be ongoing soil and foliar N measurements during different stages of cover crop-and following cash crop development as well as yield and fruit quality data.

Month of initiation: 11/99 Month of completion: 12/00

Subtask 1.1: After bed preparation, sample residual soil nitrate-nitrogen in the Yolo and Sutter fields to 3 feet. Samples will be taker at 1' intervals from soil within each replication and sent to the University of California's Division of Agriculture and Natural Resources (UC DANR) lab for analysis of presence of nitrate-N.. *Task completed by fall of 99.*

Subtask 1.2: At both sites, the cover crop (Common vetch and winter pea mix) will be planted at 60#/A with a grain drill on 60" beds with eight treatments, each 3 rows wide and 100' long and replicated 6 times. *[Treatments are either cover cropped or fallow, with different levels of fertilizer sidedress-banded at layby (after transplanting). The treatments are: 1), no cover crop and no fertilizer; 2) no cover crop with 50#/A of nitrogen applied in spring; 3) no cover crop with 100#/A N; 4) no cover crop with 150#/A N; 5) cover crop with 0# N; 6) cover crop with 50# N; 7) cover crop with, 100#N; and 8) cover crop with 150# N.]* See charts below for the layout of each field. *Task completed by 11/99.*

Subtask 1.3: Tissue sample cover crop contribution from vetch and from peas from each replication. Submit to UC DANR lab for nitrate-N sampled immediately prior to cover crop incorporation. *Task completed by 5100.*

Subtask 1.4: Incorporate cover crop. *Task completed by 5/00.*

Subtask 1.5: Before layby fertilization , soil sample each block amongst cover crop vs fallow bed plots for nitrate N analysis at UC DANR **lab.** ***Task completed*** *by 5/00.*

Subtask 1.6: Growers to transplant tomato crop and UC to sidedress-band fertilize at layby according to treatment plot plan. *Task completed by 6/00.*

Subtask 1.7: Evaluate **irrigation** water for N03 three **times during irrigation season** . *Task completed by 9/00.*

Subtask 1.7a: Sample tomato petioles for nitrate N and whole leaves for % total N from each plot at early bloom stage for tissue nitrogen analysis at UC DANR lab. *Task completed by 6/00.*

Subtask 1.8: Sample tomato petioles for nitrate N and whole leaves for % total N from each plot at full bloom stage for tissue nitrogen analysis at UC DANR lab. *Task completed by 7/00.*

Subtask 18a: Sample tomato petioles for nitrate N and whole. leaves for % total N from each plot at 10% ripe fruit stage for tissue nitrogen analysis at UC DANR lab. *Task completed by 8/00.*

Subtask 1.9: Measure marketable fruit yield and fruit color and brix of plots at harvest with UCCE weighing gondola trailers and growers' **harvester**. *Task completed by 10/00.*

Subtask 1.10: Visually assess peelability of marketable fruit *Task completed by 10/00.*

Subtask 1.11: After harvest, sample soil for nitrate-N analysis at UC DANR lab. ***Task completed by 10/00.***

Task **2: Measure impact of cover crop on soil aggregate stability and water infiltration in field**

The purpose of this task is to assess potential benefits of soil quality as well as erosion control and increased infiltration due to the cover crop. The resulting data will be incorporated into the final report due to CDFA no later than 12/00.

Subtask 2.1: Compare run-off flow rates and sediment load between 3 grouped cover cropped furrows and 3 grouped fallow furrows during winter-storm event. *Task initiated by 1/99 and completed by 4/00.*

Subtask 2.2: Measure infiltration of applied irrigation water through ring infiltrometer and compare inflow and outflow during two irrigation events. *Task initiated by 7/99 and completed by RCD by 9/00.*

Subtask 2.3: Assess relative soil aggregate stability of cover crop vs fallow bed treatments by water stable aggregate measurements. To be performed by Jeff Mitchell of UCCE. *Task completed by 11/00.*

Task 3: Observe cover crop **impact on** winter **and crop season weed management**

The purpose of this task ***is to assess potential*** *benefits* ***and problems associated with weed control in a winter cover crop.***

Subtask 3.1: In both fields, measure and compare dry weights of cover crop and **weeds in 20 1-meter-square quadrats in fallowed and cover cropped portions of the fields** shortly **before incorporation.** ***Task completed*** *by 4/00.*

Task 4: Publish the results of the study in relevant ag media, and develop and conduct field days and tours on the results and information gained on winter cover cropping before late-season tomatoes.

The purpose of this task is to share information with growers, PCAs and processors to add to the existing information base and hopefully encourage by example the adoption of a winter cover. cropping program. Hold two field meetings in spring and summer, followed by a paper to be submitted to agricultural press and results presented at the following Lower Sacramento Valley Tomato Production Meeting in January 2001. Month of initiation: 1/00
Month of completion: 2/01

Subtask 4.1: Plan field meeting for before or after incorporation of cover crop in early spring 2000: 1) outreach/promotion, 2) topics and registration, 3) logistics, and 4) materials development. ***Task completed*** *by RCD by 2/00.*

Subtask 4.2: Present field meeting in spring 2000. The meeting will provide demonstration of planting, management, and incorporation techniques for cover crop as well as current information gathered during the study: N available, infiltration, runoff, soil aggregate stability, weed suppression, and other observations made. The participants will be surveyed to assess their interest in the practice and any change as a result of the field meeting. *Task completed by 6/00.*

Subtask 4.3: Plan mid-season field meeting to allow industry to observe cover crop impact on tomato plant vigor and yield. ***Task completed*** *by 7/00.*

Subtask 4.4: Hold field meeting prior to harvest in July/August 2000 . ***Task completed by 9/00.***

Subtask 4.5: Develop paper from data collected **during trial to submit to agricultural press and local papers and** to be **presented at annual Lower Sacramento** Tomato Production **Meeting in** January 2001. *Task completed by 2/01.*

Field tests in 1998, 1999 and 2000 in the southern Sacramento Valley near Woodland were established with fall plantings of a common vetch-pea mix. Trials were 3-acre plantings in commercial fields with cooperator Blake Harlan of Harlan and Duinars. The cover crop was drilled into dry beds in the fallow period between two consecutive rotations of tomatoes. Field length strips were always planted alongside of our replicated trial to evaluate rainfall run-off. The cover crops were germinated with late fall rains. As expected, in all years, cover crop growth was slow during the winter and early spring. The peas were able to grow and develop during the cooler temperatures, compared to vetch, which grew more rapidly during late February and March. Vetch normally reaches maximum growth by early April in the Sacramento Valley. In all years, greenhouse-grown tomato plants were transplanted between late March to April.

During the late fall, we measured rainfall run-off in field-length runs, tying 3 consecutive furrows into a sump. Boat-type, automated bilge pumps pumped the collected water through flow meters. Four pumping systems, 2 each for the cover crop and the fallow treatments, were used to measure the run-off. The bilge pump system was established too late to collect data in our first year. During the 1St two seasons, a weir-based measurement system (Stevens Stage Recorders®) were set up, but resulted in limited success.

Field plot design was a randomized complete block with 6 replications with each plot 3 beds wide by 100 feet long. Two factors were evaluated: 1) fallow vs. cover cropping with a vetch-pea mix, and 2) spring-applied sidedress nitrogen rates of 0, 50, 100, or 150 pounds of N per acre. Sidedressed N, as urea, was applied soon after transplants were well' established. All other cultural practices were those common to the local area. Irrigation was primarily with the furrow method. Rainfall helped establish the transplants in 1998. Sprinklers were used to establish the transplants in 1999 and 2000 and furrow irrigated thereafter.

We monitored N status of the tomato plants during the season. Plant tissue samples, petiole as well as whole leaf, were collected at 3 separate growth stages and sent to the UC DANRlab at Davis. Tomato yields suffered when grown solely on the nitrogen fixed by the, vetch -peas and without benefit of supplemental applied N. We did not see a substantial fertilizer N benefit from the cover crop nor detect large N differences in tissue levels. Analysis of the cover crop indicated 100 pound of N was fixed in 1998 even with an early plow down in mid March. In 1999 and 2000, over 200 pounds of nitrogen was fixed by the leguminous plants. In 2000, the vetch and peas established well with the fall rains, but suffered with a dry December and January. Vetch was more drought tolerant and became the dominant species.

In the first year, the cover crop was purposely desiccated with a herbicide and incorporated with conventional equipment in mid March to accommodate an earlier planting schedule. In 1999 and 2000, a Wilcox Performer® bed mulcher was specifically designed to incorporate the cover crop. The ease of cover crop incorporation was different between the two years due primarily to soil moisture. In 1999, the bed mulcher chopped & incorporated the cover crop in two passes and repeated a week later in a single pass for final incorporation and bed shaping. In 2000, multiple passes were required in addition to a pre-irrigation. An early termination of the crop may have been preferable. Disking the vetch/pea mix and re-bedding was also an option.

In 2000, a duplicate trial was established near Meridian in Sutter County by UC Farm Advisor Mike Cahn. The treatments and procedures were similar to Woodland, except the crop rotation followed rice (tables 8 -9).

In all years, tomatoes were transplanted about I to 3 weeks after cover crop incorporation.

Results

In 1998, cover cropping resulted in a 5% yield increase and a soluble solids improvement over the fallow-bed treatment (figure 1). Applied N alone did not explain the yield enhancement. We speculate that incorporation of the leguminous biomass may have been important in changing underground factors such as soil microbial activity. Soluble solids were also increased from 4.7 to 4.9% (tables I and 2). Fruit color was reduced from 23.7 to 24.3 as measured by the Processing Tomato Advisory Board. In 1999, yields were increased 7%, although fruit quality was reduced (figure 2 and table 2). In 2000, yields were increased by 13% over the conventional fallow bed practice (figure 3). Fruit quality was not affected (table 2).

Soil N levels were evaluated. At the initiation of the 1998 test, nitrate N levels were -20 ppm in each of the 1s` and 2nd foot following the 1997 tomato harvest (table 3).. The leguminous cover crop was tilled under earlier than planned but still produced 100 pounds of N per acre. At the time of tomato transplanting, soil levels were equivalent in the cover crop and fallow treatments. By mid season, soil nitrate levels were low, but slightly higher in the cover cropped treatment. At post harvest, the residual N levels rose and were higher in the cover crop treatment, 11 vs 7 ppm.

In 1999, residual N soil levels from the 1998 tomato crop was -20 ppm nitrate-N (table 4). N fixed by the cover crop was measured at over 200 pound of N per acre. In the early spring, the nitrate-N levels were slightly higher in the fallow compared to the cover crop treatment, 6 vs 3 ppm. Beyond that point, there were no statistically significant differences between the cover vs fallow treatment. Ammonium levels were low (table 5).

In 2000, residual N was high with over 40 ppm nitrate-N left over in the top foot from the 1999 tomato crop (table 6). N fixed by. the cover crop was again over 200 pound of N per acre. In the early spring through mid season, nitrate levels were higher in the fallow treatment compared to the cover crop, 13 vs 6 to 11 ppm. The post season levels were similar to each other, around 10 ppm nitrate-N. .

In none of the years and sampling periods was petiole nitrate-N or percent N from whole leaf tissue ever higher in the cover crop treatments compared to the fallow although the reverse sometimes occurred (table 1 and 2).

In 1998, during the El Nino weather-related year, our furrow weir-type equipment did not perform in the limited slope in the drain end of the field. Subsequently, rainfall ceased before a new system was designed to overcome the obstacle.

In February and March 1999, we compared runoff from grouped sets of field-length (1300') rows of cover crop and fallow beds. Seasonal runoff from the cover crop furrows was -60% compared to the fallow furrows (figure 4). In year 2000, runoff was -22%, in the cover cropped section compared to the fallow beds on field length runs of 2100 feet (figure 5). The combined two-year rainfall run-off average resulted in over a 50% reduction (table 7).

In the Meridian trial, crop tissue levels were similar between fallow and cover crop treatments (figure 6). Yields only responded well to springtime-applied sidedress nitrogen (figure 7, tables 11-12)). There was no response to the cover crop treatment . The legumes fixed -100 pounds of N per acre (table 10). Soil nitrate N levels were similar between the fallow and cover cropping at the 1 and 2 foot depths (figure 8). No benefit was observed when the tomatoes followed rice in the crop rotation.

Discussion

We anticipate winter-grown cover cropping may be attractive to tomato growers transplanting after late April, This planting period will maximize vegetative growth of the vetch cover crop and leave sufficient time to incorporate the green manure crop. The delay in planting misses only the earliest harvest schedules.
In each of the years of the Woodland-located trials, where tomatoes succeeded tomatoes in the annual crop rotation, yield was increased when a cover crop was grown and incorporated ahead of the cash crop planting. Normal rates of applied N appear to be required rather than relying on the leguminous cover crop to supply a portion of the N. Tomato yields were not increased by cover cropping when tomatoes followed rice in the rotation. The flooded conditions associated with rice production are unique and may be a factor.

Cover cropping reduced winter rainfall run-off from fields and may provide regional benefit to reduce local flooding in high rainfall years . An associated reduction in topsoil sediment loss can also be expected.

The cost of the cover cropping practice . was economically beneficial as expense is estimated at -$75 per acre. A 2-ton tomato gain would pay for the added expense. Timely rainfall is needed to establish the cover crop early in the fall as well as to sustain growth through the early spring. The delay in tomato planting is also a consideration. The additional tillage required to incorporate the cover crop can be costly and less manageable than the clean , fallow bed practice. The program has a better fit for growers who transplant to establish a tomato stand rather than direct seed.

We've disseminated information in a variety of ways. One to two field meetings were held at the Woodland trial sites in each of the 3 years to show the cover crop tillage practices and later to highlight tomato crop development prior to harvest. The cover crop research findings were presented _at UCCE-organized grower production meetings held in the Sacramento Valley and the upper San Joaquin Valley in each of the 3 years, We've participated in FREP annual conferences. We were invited to speak at the California chapter of the Agronomy Society of America. A paper was presented at the International Society of Horticultural Science sponsored Tomato Symposium in Sacramento. Several growers have since adapted using some cover crops in their rotation.

We are enthused that cover cropping for a single winter period provided the yield benefit the following spring as well as reduced rainfall run off. Future plans are to follow how cover crops might fit into a reduced tillage system for California.

Table 1 . ANOVA for Woodland trials, 1998-2000.

	early bloom	early bloom	full bloom	full bloom	1st ripe	1st ripe			
Factor	NO3 PPM	N %	NO3 PPM	N %	NO3 PPM	N	Yield tons	COLOR	BRIX
Year						**	**	**	
Cover			**						**
Year x Cover	**	**	**	*				**	
N rate applied	**	**	**	**	**	**		**	**
Year x N	*		**	**					*
Cover x N			**						
Year x Cover X N			**						
% CV	11	5	1 5	7	32	11	6	5	8

Not statistically significant at 95% confidence level
Significant at 95% confidence level
** Significant at 99% confidence level

Table 2. Averages of tissues N levels, fruit quality and marketable yield,
Woodland trials, 1998-2000

cover	applied rate N	year	early bloom N03-N ppm	early bloom N %	full bloom N03-N ppm	full bloom N %	1st ripe N03-N ppm	1st ripe N %	COLOR	BROC	Yield tons
		1998	17356	4.607	6238	4.332	549	3.377	24.0	4.8	37.5
		1999	6839	4.185	7636	4.501	519	3.395	23.1	5.5	40.1
		2000	10360	4.719	7602	4.611	3070	3.988	25.5	4.8	46.2
Fallow			11469-	4.517	7508	4.524	1578	3.654	24.0	5.1	39.7
Cover			11568	4.49	6809	4.439	1180	3.52	24.4	5.0	42.8
Fallow		1998	16845	4.524	5985	4.296	706	3.457	23.7	4.7	36.5
Cover		1998	17867	4.69	6490	4.367	391	3.298	24.3	4.9	38.4
Fallow		1999	7284	4.243	8543	4.613	617	3.405	22.7	5.7	38.7
Cover		1999	6394	4.128	6730	4.389	422	3.385	23.6	5.3	41.6
Fallow		2000	10277	4.785	7996	4.662	3413	4.099	25.7	4.8	44.0
Cover		2000	10443	4.653	7208	4.56	2728	3.877	25.3	4.7	48.4
	0		7306	4.111	4515	4.162	1172	3.44	24.5	4.9	37.5
	50		12994	4.627	7196	4.495	1275	3.574	24.4	5.0	42.5
	100		12943	4.64	8391	4.609	1340	3.535	24.1	5.1	42.6
	150		12829	4.637	8533	4.659	1730	3.798	23.9	5.1	42.5
	0	1998	12258	4.252	2339	3.786	399	3.161	24.3	4.7	31.6
	50	1998	19475	4.657	5895	4.327	470	3.298	24.2	4.8	38.6
	100	1998	18925	4.777	8047	4.56	514	3.376	24.0	4.9	39.9
	150	1998	18767	4.741	8669	4.652	811	3.674	23.7	4.8	39.9
	0	1999	3308	3.773	4973	4.218	108	3.129,	23.8	5.3	37.2
	50	1999	8152	4.415	8088	4.484	367	3.489	23.2	5.4	42.2
	100	1999	7953	4.227	8753	4.642	713	3.342	22.8	5.6	40.5
	150	1999	7943	4.326	8730	4.661	891	3.62	22.8	5.6	40.7
	0	2000	6354	4.307	6232	4.481	3010	4.03	25.4	4.7	43.8
	50	2000	11355	4.808	7604	4.676	2989	3.934	25.9	4.8	46.5
	100	2000	11952	4.916	8372	4.626	2793	3.887	25.5	4.8	47.6
	150	2000	11778	4.844	8201	4.663	3489	4.101	25.3	4.7	46.9
fallow	0		7354	4.145	5354	4.298	1376	3.495	23.8	4.9	36.3
fallow	50		12907	4.647	7168	4.495	1567	3.642	24.2	5.0	40.9
fallow	100		12986	4.619	8807	4.66	1541	3.616	24.3	5.2	40.3
fallow	150		12628	4.657	8703	4.643	1829	3.862	23.9	5.1	41.4
cover	0		7259	4.077	3676	4.025	968	3.386	25.2	4.9	38.8
cover	50		13081	4.606	7223	4.496	983	3.506	24.7	5.0	44.0
cover	100		12901	4.662	7974	4.559	1138	3.454	23.9	5.0	44.9
cover	150		13031	4.617	8364	4.675	1631	3.734	23.9	5.0	43.6
fallow	0	1998	11632	4.087	2582	3.925	635	3.153	23.3	4.6	30.2
fallow	50	1998	18700	4.602	5103	4.255	755	3.442	23.8	4.8	38.3
fallow	100	1998	18783	4.693	7767	4.489	643	3.559	24.2	4.8	38.2
fallow	150	1998	18267	4.712	8488	4.517	790	3.675	23.5	4.6	39.5
cover	0	1998	12883	4.418	2097	3.647	163	3.169	25.2	4.7	33.0
cover	50	1998	20250	4.712	6687	4.399	185	3.155	24.5	4.9	39.0
cover	100	1998	19067	4.861	8327	4.632	385	3.194	23.8	4.9	41.6
cover	150	1998	19267	4.769	8850	4.788	832	3.672	23.8	5.1	40.2
fallow	0	1999	4433	3.918	7160	4.491	170	3.28	23.0	5.5	38.2
fallow	50	1999	8452	4.521	8245	4.518	443	3.527	23.0	5.5	40.0
fallow	100	1999	8253	4.161	9553	4.736	917	3.254	22.2	5.9	37.4
fallow	150	1999	7997	4.37	9212	4.706	938	3.561	22.7	5.8	39.3
cover	0	1999	2182	3.627	2787	3.945	45	2.979	24.5	5.2	36.2
cover	50	1999	7852	4.309	7930	4.449	290	3.451	23.3	5.2	44.4
cover	100	1999	7652	4.294	7953	4.548	508	3.43	23.5	5.3	43.6
cover	150	1999	7890	4.281	8248	4.616	843	3.679	23.0	5.4	42.2
fallow	0	2000	5997	4.428	6320	4.478	3323	4.051	25.0	4.7	40.5
fallow	50	2000	11570	4.82	8155	4.711	3503	3.956	25.7	4.7	44.5
fallow	100	2000	11920	5.002	9102	4.755	3063	4.036	26.5	4.8	45.5
fallow	150	2000	11622	4.888	8408	4.705	3760	4.352	25.7	4.8	45.5
cover	0	2000	6712	4.186	6143	4.484	2697	4.01	25.8	4.7	47.1
cover	50	2000	11140	4.796	7053	4.64	2475	3.911	26.2	4.8	48.6
	nn	9nnn	11983	4.831	7642	4.497	2522	3.738	24.5	4.8	49.6

Table 3. Soil N levels, Woodland, 1998.

	ppm N03-N pre season	early	mid	post season
fallow		12	3	7
cover crop		12	5	11
		NS	*	*
depth (feet)				
1	18	14	4	16
2	21	12	3	6
3	8	9	4	5
	**	**	NS	**

N rate

0	1 2	4	4
150	1 2	4	1 4
	NS	NS	**
interaction		cover x N rate	cover x N depth x N

Table 4. Soil N levels, Woodland, 1999.

	ppm N03-N pre season	early	mid	post season
fallow	20	6	9	5
cover crop	19	3	7	7
	NS	**	NS	NS
depth (feet)				
1	19.6	2	1 5	1 5
2	-	5	5	2
3	-	7	4	1
		**	**	**

Table 5. Soil ammonium-N levels, Woodland, 1999.

	ppm N03-N pre season	early	mid	post season
fallow	-	0.098	0.202	2.594
cover crop	-	0.102	0.124	2.861
		NS	NS	NS
depth (feet)				
1	-	0.14	0.369	3.875
2	-	0.098	0.073	2.367
3	-	0.062	0.047	1.942

Table 6. Soil N levels, Woodland, 2000.

	ppm N03-N			
	pre season	early	mid	post season
fallow	21	13	13	9
cover crop	22	6	11	1 0
	NS			NS
depth (feet)				
1.	43	8	12	19
2	1 0	8	11	7
3	12	1 2	1 3	4
			NS	t.
			interaction cover slightly higher N on surface	

Table 7. Early Spring, Rainfall Run-off, Woodland.

	(gallons/3 furrows)		
	1999	2000	2-year ave.
fallow	6286	2919	4602
cover crop	3884	657	2270

«

signficant
with log transformation

average of 2 reps per season

Table 8. Field activities at the Meridian trial, year 2000.

Field Activity	Date	Treatment Description	Treatment #'s	Depth
cover crop planted	11/27/99	Vetch **treatments**	1-4	
soil sample (NH4,N03)	2/17/00	Vetch 0#N, Fallow ON	1,5	1,2,3 ft
roundup applied to fallow plots	3/13/00	All Fallow **treatments**	**5-8**	
biomass sampled 0 N plots	4/4/00	Vetch 0#N	1	
soil sample (NH4,N03)	4/4/00	Vetch 0#N, Fallow 0#N	1,5	1,2,3 ft
flail chopped cover crop	4/5/00	All Vetch **treatments**	1-4	
incorporated treatments	4/7/00	All Vetch **treatments**	1-4	
transplanted tomatoes	4/15/00	All treatments	**1-8**	
soil sample (NH4,NO3)	4/25/00	Vetch 0#N, Fallow 0#N	1.,5	1,2,3 ft
sidedressed urea	5/26/00	All treatments	1-8	
soil sample (NH4,NO3)	6/7/00	Vetch 0#N, Fallow 0#N	1,5	1,2,3 ft
petiole/leaf sample (all plots)	7/26/00	All treatments	1-8	
fruit yield and quality data	**9/9/00**	**All treatments**	1-8	

Table 9. Description of cover crop and nitrogen fertilizer treatments , Meridian.

Treatment #	Cover Crop	N fertilizer Rate (lb N /acre)
1	**Vetch/Pea**	**0**
2	**Vetch/Pea**	**50**
3	**Vetch/Pea**	**100**
4	**Vetch/Pea**	**150**
5	**Fallow**	**0**
6	**Fallow**	**50**
7	**Fallow**	**100**
8	**Fallow**	**150**

Table 10. Dry matter, Total N, and Total C of vetch winter cover crop at Meridian, CA.

Block		Dry Matter	Total N		Total C
		lb/acre	%	lb/acre	%
	1	2834.0	4.1	115.0	41.8
	2	2964.3	4.0	117.1	40.5
	3	2404.8	3.8	92.4	40.9
	4	2184.9	3.8	82.3	41.7
	5	2908.1	3.8	109.2	41.0
Average		2659.2	3.9	103.2	41.2
SD		344.7	0.1	15.2	0.6
CV (%)		13.0	3.3	14.7	1.3

Table 11. ANOVA of treatment **effects on marketable** yield, bulk yield, and whole leaf **nitrogen, Meridian.**

		---------------- P > F ------------------		
Source	df	Marketable Yield	Bulk Yield	Whole Leaf N
BLOCK	4	0.0614	0.3110	0.1022
COVERCROP	1	0.7341	0.7102	0.6513
N FERTILIZER	3	0.0001	0.0001	0.0124
COVERCROPxNFERT	3	0.5421	0.9202	0.4066

Table 12. ANOVA of **treatment effects on soil nitrate and ammonium, Meridian.**

		----------------- P > F ---------------------		
Source	df	N03	NH4	N03+NH4
COVCROP	1	0.0380	0.4060	0.4974
BLOCK	4	0.0160	0.0114	0.0063
DATE	3	0.0003	0.0082	0.0044
DATE*COVCROP	3	0.4735	0.1653	0.3019
DEPTH	2	0.5330	0.0092	0.4283
COVCROP*DEPTH	2	0.5855	0.7583	0.7297
DATE*DEPTH	6	0.0265	0.0235	0.0018
DATE*COVCROP*DEPTH	6	0.4294	0.0650	0.2311

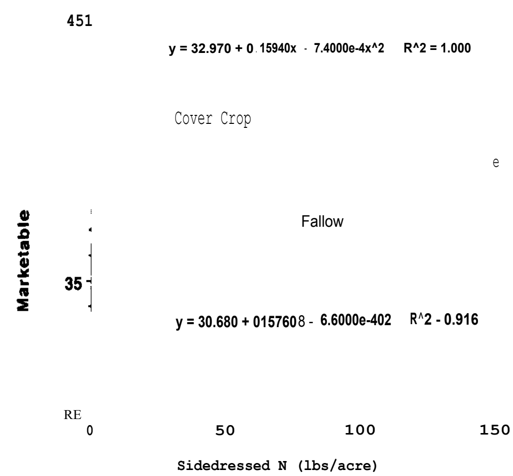


Figure 1. Marketable yield, Woodland, 1998.

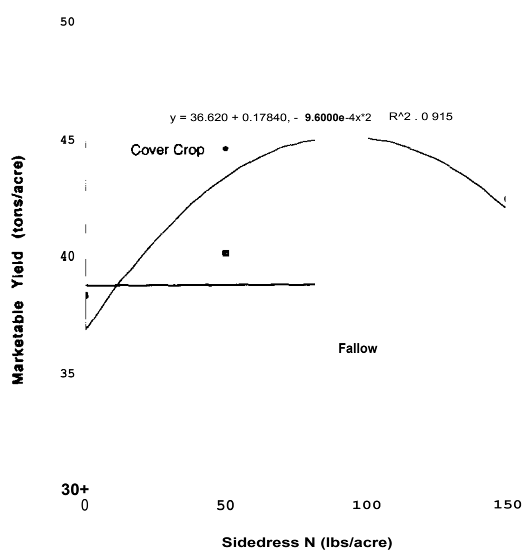
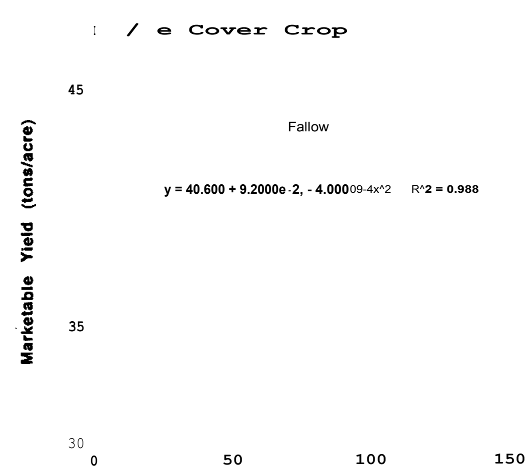


Figure 2. Marketable yield, Woodland, 1999.



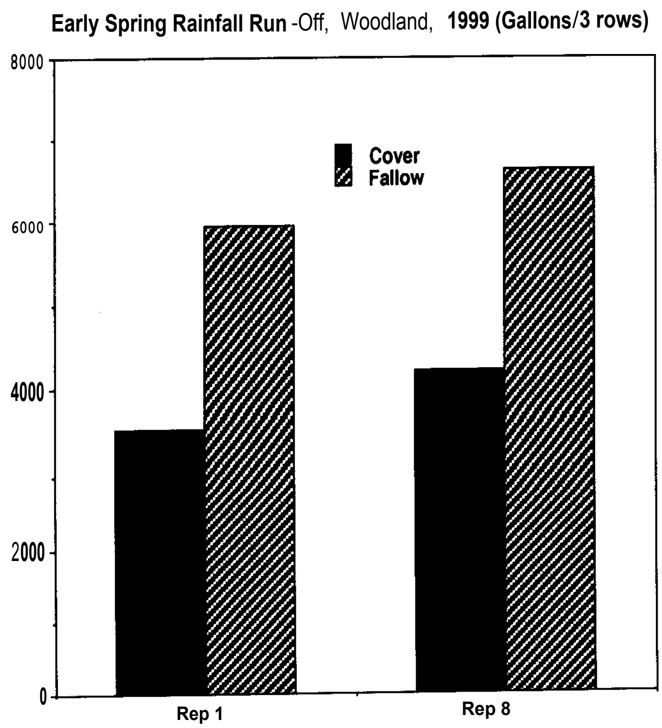
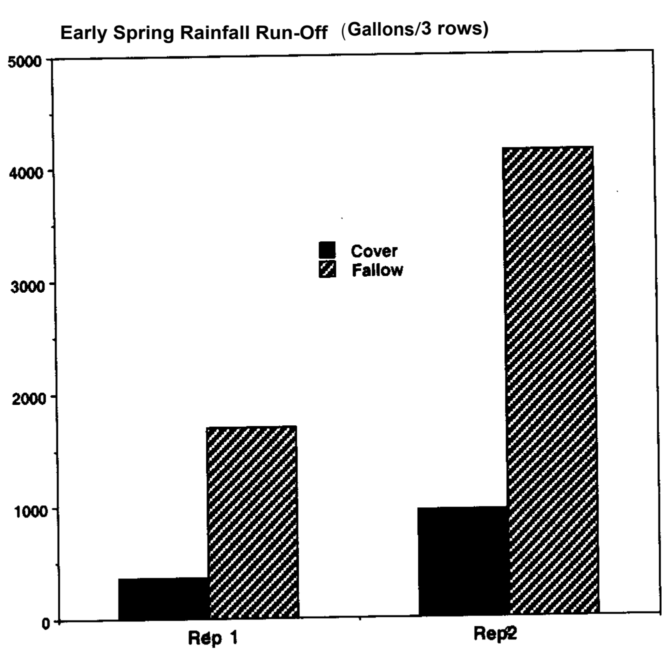


Figure 4. Early Spring Rainfall Run -Off, Woodland, 1999.



re 5 arly Snrina Rainfall Run -Off, Woodland, 2000.

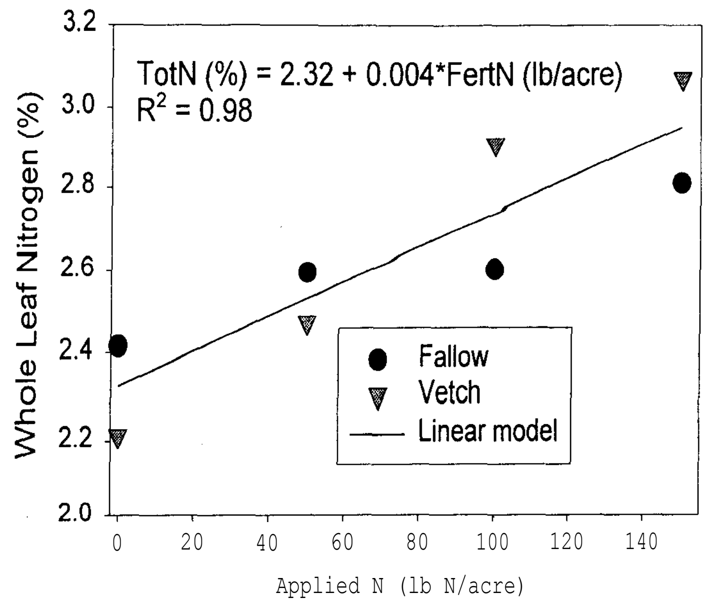


Figure 6. Fertilizer nitrogen effects on % whole leaf N levels of processing tomatoes, Meridian.

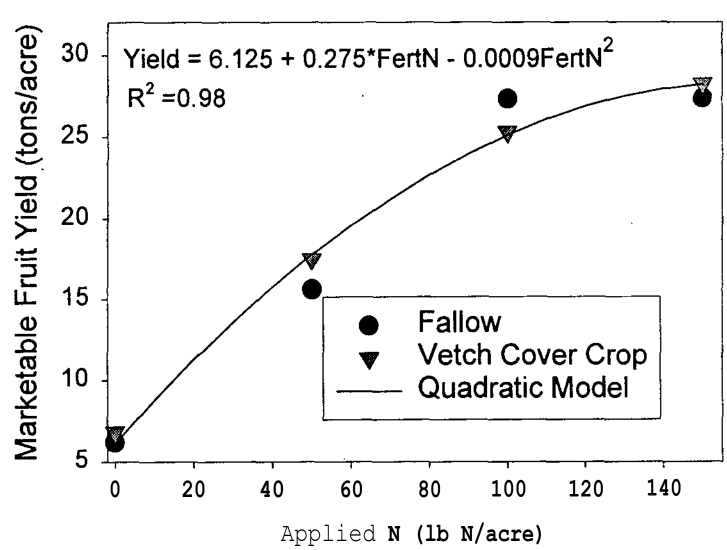


Figure 7. Fertilizer nitrogen effects on marketable yield of processing tomatoes, Meridian.

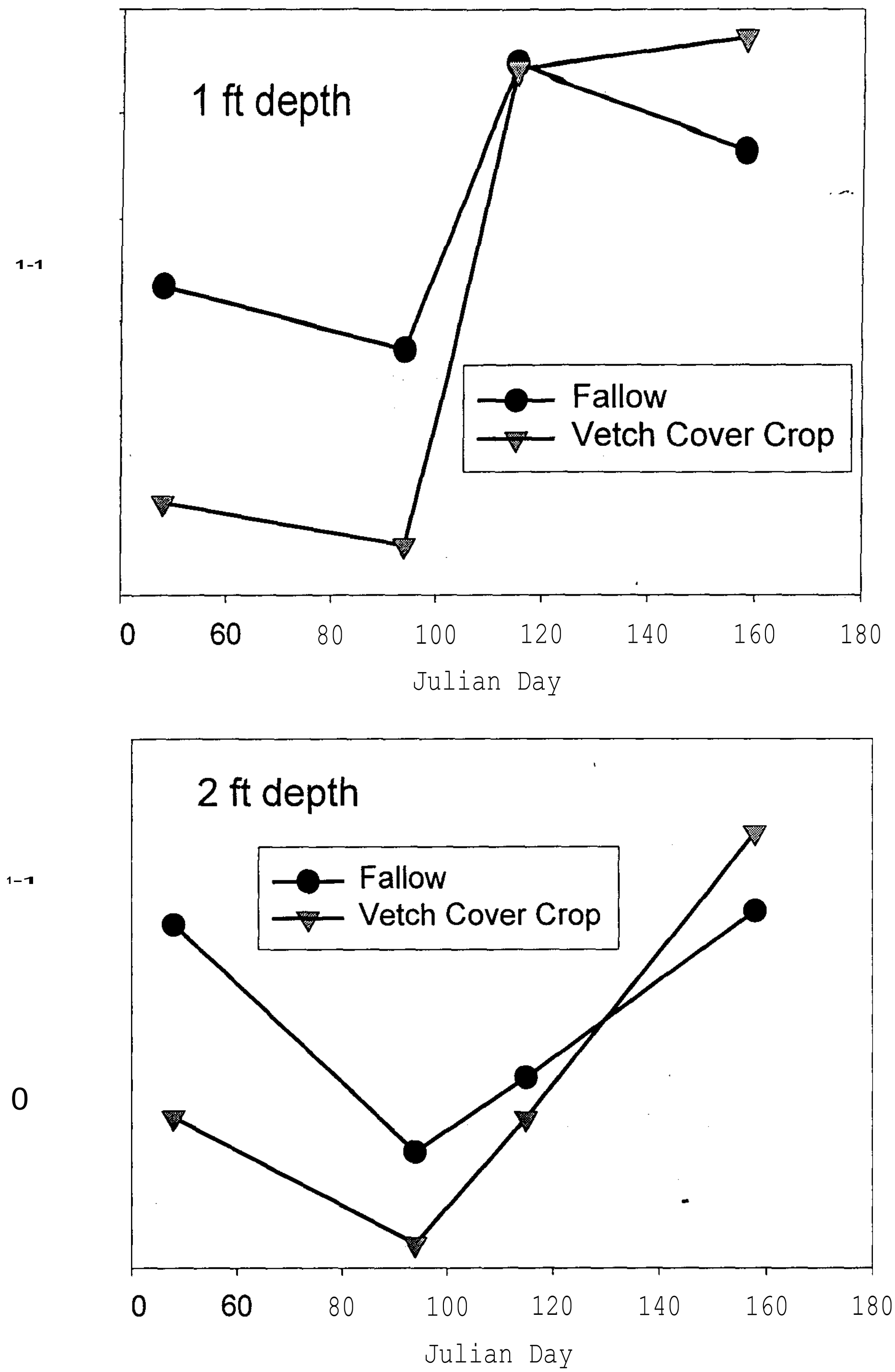


Figure 8. Soil nitrate levels during the 2000 season at 1 and 2 ft depths, Meridian.

ADDENDUM 1. MEETINGS AND PUBLICATIONS

1. FIELD MEETINGS

July 31, 1998, Woodland area, County Road 27-29 x 97, 26 attending,
April 1, 1999, Woodland area, CR 98 x 27, 20 attending,
August 13, 1999, Woodland area, CR 98 x 27, 21 attending.
April 4, 2000. Woodland area, County Road 25A x 97, 38 attending.

II. ABSTRACTS AND PROCEEDINGS

Miyao, G. and P Robins, Winter cover crops before late season processing tomatoes for soil quality and production benefits , CDFA **Fertilizer Research and Education Program Conference**, **proceedings**, **Visalia,** Nov 14, 2000, pages 36-37.

Miyao, G. and P Robins, **Fall cover crops may improve tomato yields, Proceedings**, **Conservation Tillage 2000 Conference**: **Conservation tillage success stories from around** the US, **Feb 10-11, 2000**, **Five Points and Davis,** CA, pages 77-82.

Miyao, G. and P Robins, **Winter-cover crops before late season processing tomatoes for soil quality and production benefits, Proceedings 2000 California Plant and Soil Conference**, **Stockton**, **Jan 20**, **2000**, **pages 105-109.**

Miyao, G. and P Robins, **Winter cover crops before late season processing tomatoes for soil quality and production benefits**, **Fertilizer Research and Education Program Conference**, **proceedings**, **Modesto, Nov 30, 1999.**

Miyao, G. and P Robins, **Winter cover crops before late season processing tomatoes for soil quality and production benefits**, **Fertilizer Research and Education Program Conference**, **proceedings, Fresno, Nov 17, 1998.**

III. POPULAR PRESS

"Winter cover crop experiment underway", CA Tomato Grower Magazine, Sept/Oct 1999, Vol. 42, No 7, pages 4-6.

"Fall cover crops can improve tomato yields", CA Vegetable Journal, October 1998, Vol. 3, No6, p 27-28.

IV. POSTER

UCD Sustainable Ag Field Day,
Oregon Sustainable Ag Conference,
UCD Minimum Tillage Conference,
UC Veg Crops **Continuing Conference**