CALIFORNIA LETTUCE RESEARCH BOARD

April 1, 2004 – March 31, 2005

Title: Mustard Cover Crops to Optimize Crop Rotations for Lettuce Production

Project Investigators: Richard Smith, Steve Koike and Tiffany Bensen, UCCE, Monterey County
Krishna Subbarao and Steve Fennimore, University of California

SUMMARY

Effective rotations are an essential part of lettuce production. Unfortunately, given economic pressures such as high land rents and lower returns for rotational crops, effective rotations are not always possible. As a result, *Sclerotinia minor*, causal agent of lettuce drop, is the key soilborne disease in the Salinas Valley. Mustard cover crops have been researched for a number of years in other parts of the world as a means of suppressing soilborne diseases and weeds. The beneficial effect of mustard cover crops on soilborne pests may be due to toxic chemicals that they release upon incorporation into the soil or due to soil microbiological effects. These studies were undertaken to determine if mustard cover crops are suppressive to lettuce drop and weeds in lettuce production. To evaluate the impact of mustard cover crops we established short-term and long-term trials. A total of seven short-term studies were conducted with cooperating growers in which the mustard cover crop blend Caliente 119 (*Sinapis alba* and *Brassica juncea*) was grown in comparison with Merced Rye or a bare fallow treatment. In addition, a long-term rotational plot was also established in which fall cover crops were grown and followed by two lettuce crops planted the following spring and summer; data herein reflect three years of these field studies. **Lettuce Drop Studies:** A preliminary survey of three cover crop fields indicated that mustard cover crops are susceptible to *S. minor* and may increase the amount of soilborne inoculum. The question arises, does the susceptibility of mustard cover crops to *S. minor* override the suppressive effect upon incorporation? In the short term trials, there was no significant reduction of infected heads in mustard cover cropped over bare fallow plots in individual trials. However, a summary analysis indicates a slight but significant reduction in the level of lettuce drop infection of lettuce at harvest in the mustard cover cropped versus bare fallow plots. The metam sodium equivalent content of mustard cover crops was measured. Mustards contain low amounts (1.7 – 2.3 gal/A) as compared to label rates (37.5 – 75.0 gal/A) of metam sodium. Rye, and white and Indian mustard cover crops increased the yield of the first lettuce crop following incorporation of the cover crop in one trial this year. **Weed Studies:** Total weed emergence was reduced in two of six short-term cover crop trials. However in the long-term trial no effect on weed emergence at thinning was observed and no reductions in the soil weed seed bank were observed. **Other evaluations:** ***Nitrate leaching:*** Nitrate leaching was significantly reduced over the winter of 2003-04 by these fall-grown cover crops in the long-term trial. However nitrate leaching was not reduced in the 2004-05 evaluation and the difference could be due to higher rainfall in the winter of 2004-05. ***Soil characteristics:*** After one cover crop cycle in the long-term cover crop trial there was a significant increase in soil carbon and sodium in the cover cropped plots.

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Objectives:

1. To determine the effectiveness of Brassica cover crops to reduce the incidence of lettuce drop caused by *Sclerotinia minor* in lettuce production.
2. To determine the effectiveness of Brassica cover crops to reduce weed pressure in lettuce production

PROCEDURES AND RESULTS:

Objective 1. To determine the effectiveness of Brassica cover crops to reduce the incidence of lettuce drop caused by *Sclerotinia minor* in lettuce production.

Procedures: ***Short-term plots:*** Four short-term field evaluations were conducted in 2004-05 bringing the total number in the project to seven. Trials were conducted in grower's fields and in each trial the mustard cover crop blend Caliente 119 (combination of *S. alba* and *B. juncea*) was grown in comparison with Merced rye or an uncover cropped control. Lettuce was planted within 4-5 weeks following mustard cover crop incorporation. Samples to determine soil sclerotia were collected prior to and following incorporation of the cover crop, and counts of lettuce drop infected heads were made prior to and at harvest. A preliminary field survey of infection by lettuce drop of mustard cover crops was conducted on three mustard cover cropped fields in the winter of 2004-2005. ***Long-term plot:*** A long-term cover crop rotation trial was established (see Table 2 for varieties). The first cover crop cycle was grown in the fall of 2003. Soil sclerotia were counted prior to planting and following cover crop incorporation and counts of lettuce drop infected heads were made prior to and at harvest. The first lettuce crop was planted on January 17, 2004 (3 months following cover crop incorporation) and the second lettuce crop on June 16, 2004. Analyses of the metam sodium equivalent content of the cover crop were conducted at cover crop maturity (October 25, 2004). Cover crop tops were carefully collected and immediately frozen, freeze-dried and shipped to the University of Idaho for glucosinolate analysis. Glucosinolates are compounds in mustard family plants that are converted to chemicals that provide fumigation action similar to methy isothiocyanate, the active ingredient of metam sodium (Vapam®). A second cycle of cover crops was grown in the fall of 2004 but the lettuce was too immature to conduct evaluation for inclusion in this report.

Results: ***Short-term plots:*** Table 1 summarizes *S. minor* evaluations for seven short-term cover crop plots. Mustard cover crops did not reduce numbers of soil sclerotia following incorporation. There was no significant reduction of infected heads between mustard cover cropped and bare fallow plots in individual trials. However, an analysis of all data from trials 2 through 7 detected a slight but significant reduction in the amount of lettuce drop at harvest following mustard

cover crops versus bare fallow. A preliminary survey of three cover crop fields indicated that mustard cover crops are susceptible to infection by *S. minor* (data not shown), which indicates that mustard can increase the level of inocula during their production period. ***Long-term plot:*** Table 2 summarizes the biomass, nitrogen content and equivalent metam sodium content of mustard cover crops. The cover crops produced more biomass in 2003 than in 2004. The equivalent metam sodium content of the mustards (1.7 – 2.3 gal/A) was low compared to labeled rates of this material used to control diseases and weeds (i.e. label rates = 37.5 – 75.0 gal/A). There were moderate numbers of lettuce drop sclerotia in the soil and they were not reduced following mustard cover crops (table 3). There were significantly more sclerotia in the soil in the Indian mustard treatment following incorporation of the 2003 fall cover crop, but this did not affect the level of infection of lettuce drop of the lettuce at harvest. All cover crop species increased the yield of lettuce of the first lettuce crop. Cover crops had no apparent effect on soil sclerotia, percent infection of lettuce at harvest or lettuce yield of the second lettuce crop.

Objective 2. To determine the effectiveness of Brassica cover crops to reduce weed pressure in lettuce production.

Procedures: ***Short-term plots:*** Weed evaluations (weed number and species per unit area) were conducted at the thinning stage of the lettuce crops in the cover crop trials described in objective 1 above. ***Long-term plot:*** Weed evaluations were conducted of the cover crop trial described in objective 1 above. Weed seed bank samples were collected on September 10, 2003 (baseline sample) and September 24, 2004 to assess the impact of cover crops on the soil weed seed bank after one crop cycle. In addition, weed counts were conducted at the thinning stage of both lettuce crops: first crop – March 4 and second crop – July 9, 2004.

Results: ***Short-term plots:*** Table 4 summarizes weed evaluations conducted in all short-term cover crop trials. Nettle, shepherds purse and purslane emergence were reduced in one trial and total weed emergence was reduced in another. ***Long-term plot:*** There was no significant reduction in the number of emerged weeds at thinning in either the first or second lettuce crop following mustards (Table 5). There were increased weeds in the broccoli plots, but this was probably due to increased weediness in the broccoli while it was growing due to poor growth of broccoli when grown as a cover crop in this trial (Table 2). There was no significant reduction in the soil weed seed bank after one cycle of cover crops (data not shown).

Other evaluations: Evaluations of nitrate leaching and long-term soil effects were made of the long-term cover crop plot.

Procedures: ***Nitrate leaching:*** Nitrate leaching was evaluated by installing anion resin bags in each treatment three feet deep in the soil following incorporation of the cover crops: first cover crop – November 24, 2003 and second cover crop – November 19, 2004. Nitrate leaching was estimated by removing the anion resin bags prior to planting of the lettuce: first cover crop – January 26, 2004 and second cover crop – February 10, 2005. In addition, soil samples taken at one foot increments to three feet following the second cover crop on February 10, 2005 provided an estimate of nitrate leaching. ***Soil characteristics:*** Baseline soil samples were collected on September 10, 2003 and after one cover crop cycle on October 25, 2004. Soil samples were analyzed at the DANR Lab at UC, Davis: pH, EC, C, N, P, K, Na, Ca, Mg and Zn.

Results: ***Nitrate leaching:*** Nitrate leaching was significantly reduced over the winter of 2003-04 in all cover crop treatments except broccoli (Table 6). However, over the winter of 2004-05 nitrate leaching was not reduced by fall-grown cover crops. Rain fall during the 2004-05 evaluation period was 1.5 inches greater than in 2003-04, which may account for the difference between the two years. ***Soil characteristics:*** After one cover crop cycle there was a significant increase in soil carbon and sodium in the cover cropped plots (Table 7). Initial differences between treatments in soil potassium in 2003 were not seen in 2004.

Table 1. Short-term trials: Soil sclerotial counts and infection of lettuce at harvest

Trial	Treatment	Mean Soil Sclerotia Count (100 g soil)		Mean Infected heads per 100 feet row	Mean Infected Heads (percent)
		Pre-Plant	Post-Incorporation		
Trial 1	Mustard			6.5	
	Rye			10.0	
	LSD			*NS*	
Trial 2	Mustard			2.4	1.2
	Bare			5.2	2.7
	LSD			*NS*	*NS*
Trial 3	Mustard			6.3	3.3
	Bare			4.6	4.6
	LSD			*NS*	*NS*
Trial 4	Mustard	9.7	4.3	1.9	<0.1
	Bare	9.3	4.0	1.9	<0.1
	LSD	*NS*	*NS*	*NS*	*NS*
Trial 5	Mustard	37.6	11.9	9.3	5.1
	Bare	30.3	8.8	13.5	6.8
	LSD	*NS*	*NS*	*NS*	*NS*
Trial 6	Mustard	10.2	3.2	38.6	17.1
	Bare	8.6	7.8	34.5	15.6
	LSD	*NS*	*NS*	*NS*	*NS*
Trial 7	Mustard	51.0	14.0	10.1	4.6
	Bare	40.7	14.1	15.7	7.1
	LSD	*NS*	*NS*	*NS*	*NS*
Summary of trials 2-7	Mustard	27.7	9.2		2.8
	Bare	17.7	9.6		4.9
	LSD	*NS*	*NS*		0.4

Table 2. Long-term plot: Two Year Summary of cover crop biomass[1] and equivalent metam sodium content of brassicas

Cover Crop Treatments	Biomass Tons/A		N in tops Percent		N in tops lbs/A		Metam sodium equivalent gal/A[2]
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2004-05
Cereal Rye 'Merced'	3.08	1.84	3.26	3.34	203.7	118.9	---
Broccoli 'DiCicco'	1.33	0.77	5.05	4.61	132.8	71.0	0.11
White Mustard 'Ida Gold'	2.51	1.78	3.91	3.71	194.8	130.8	2.28
Indian Mustard 'ISCI 61'	2.23	1.33	4.46	4.50	199.7	120.5	1.69
Bare Fallow	---	---	---	---	---	---	---
LSD (0.05)	*0.4*	*0.22*	*1.0*	*0.57*	*60.8*	*13.8*	---

1 - Sampling dates: October 13, 2003 and October 25, 2004; 2 - Equivalent content of metam sodium of the cover crops

Table 3. Long-term plot: Sclerotinia and yield evaluations of two lettuce crops following cover crop treatments

Cover Crop Treatments	First Lettuce Crop					Second Lettuce Crop			
	Soil Sclerotia pre cover crop Aug. 28, 03	Soil Sclerotia post cover crop Nov. 6, 03	Sclerotinia infection on lettuce At harvest April 27, 04 %	Yield uncut heads %	Yield Lbs/32 heads	Soil Sclerotia Early lettuce July 9, 04	Sclerotinia infection on lettuce At harvest Aug. 30, 04 %	Yield uncut heads %	Soil Sclerotia post lettuce Aug. 31, 04
Cereal Rye 'Merced'	1.6	1.2	1.83	13.9	46.9	2.0	0.8	53.8	2.6
Broccoli 'DiCicco'	2.6	3.0	2.68	16.2	46.9	2.4	1.0	50.6	4.3
White Mustard 'Ida Gold'	2.2	1.5	2.65	16.2	45.6	2.1	1.0	44.9	3.9
Indian Mustard 'ISCI 61'	0.7	7.3	2.34	14.0	49.0	1.9	1.0	37.8	3.9
Bare Fallow	1.5	2.2	2.55	27.3	42.2	1.9	0.7	58.8	5.0
LSD (0.05)	*NS*	5.1	*NS*	6.3	4.2	*NS*	*NS*	*NS*	*NS*

Table 4. Short-term plots: Number of weeds seedlings per one square meter of bed top

Trial	Treatment	Nightshade	Nettle	Groundsel	Henbit	Sow Thistle	Purslane	Shepherd's Purse	Knotweed	Nettle-Leaf Goosefoot	Other	Total
Trial 1	Mustard	0.98	0.52	--	--	6.55	--	0.14	--	1.02	0.09	9.30
	Rye	0.77	0.34	--	--	8.00	--	1.39	--	0.48	0.11	11.11
	LSD	*NS*	*NS*			*NS*		*0.59*		*NS*	*NS*	*NS*
Trial 2	Mustard	--	0.03	--	--	--	9.62	0.16	--	--	0.08	9.89
	Bare	--	0.70	--	--	--	14.01	0.43	--	--	0.22	14.41
	LSD		*0.75*				*3.68*	*0.27*			*0.22*	*4.25*
Trial 3	Mustard	--	0.17	--	--	--	--	0.12	--	0.22	0.02	0.65
	Bare	--	0.32	--	--	--	--	0.17	--	0.09	0.00	1.51
	LSD		*NS*					*NS*		*NS*	*NS*	*0.76*
Trial 4[1]	Mustard	7.11	--	14.58	0.00	11.99	13.65	7.11	0.00		0.00	54.44
	Bare	0.00	--	0.00	1.41	0.00	0.00	0.00	6.61		7.85	15.87
	LSD	--[2]		--[2]	--[2]	--[2]	--[2]	--[2]	--[2]		--[2]	*NS*
Trial 6	Mustard	--	5.73	--	--	0.19	--	1.77	0.00	--	0.00	7.71
	Bare	--	7.69	--	--	0.26	--	1.84	0.03	--	0.05	9.87
	LSD		*NS*			*NS*		*NS*	*NS*		*NS*	*NS*
Trial 7	Mustard	--	--	--	--	0.10	--	0.02	--	--	0.17	0.29
	Bare	--	--	--	--	0.24	--	0.05	--	--	0.19	0.48
	LSD					*0.64*		--[2]			--[2]	*NS*

[1] - From seed bank analysis, not field count; [2] - No analysis, highly non-normal, many zeros.

Table 5. Long-term plot: Weeds counts per 50 square feet: first lettuce crop on March 4 and second lettuce crop on July 9, 2004

Cover Crop Treatments	First Lettuce Crop				Second Lettuce Crop			
	Chenopods	Burning Nettle	Sow Thistle	Total Weeds	Chenopods	Nightshade	Sow Thistle	Total Weeds
Cereal Rye‘Merced’	0.7	0.4	0.7	2.4	5.1	32.5	3.5	53.8
Broccoli ‘DiCicco’	3.2	1.8	0.9	6.6	15.8	143.8	11.5	188.8
White Mustard‘Ida Gold’	0.7	0.7	0.6	2.2	2.6	80.0	8.1	102.6
Indian Mustard ‘ISCI 61’	1.1	0.7	0.5	2.5	2.9	58.8	4.0	81.4
Bare Fallow	1.1	0.2	0.4	2.1	2.0	47.5	6.1	60.0
LSD (0.05)	0.7	0.6	n.s.	6.6	5.4	n.s.	n.s.	n.s.

Table 6. Long-term plot: Two Year Summary: Soil nitrate evaluation in soil profile the winter following incorporation of the fall-grown cover crop

Cover Crop Treatments	Soil Nitrate-N lbs/A				
	2003-04[1]		2004-05[2]		
	Nov. 24, 2003 Initial nitrogen in soil N/A in soil	Jan. 26, 2004 nitrogen in resin bag N/A	Nov. 19, 2004 Initial nitrogen in soil N/A in soil	Feb 10, 2005 N/A in soil	Feb 10, 2005 nitrogen in resin bag N/A
	0 – 1 foot				
Cereal Rye 'Merced'	72.2	---	83.8	41.7	---
Broccoli 'DiCicco'	112.7	---	67.6	28.6	---
White Mustard 'Ida Gold'	96.92	---	61.7	42.2	---
Indian Mustard 'ISCI 61'	146.2	---	97.9	38.1	---
Bare Fallow	207.6	---	71.7	26.7	---
LSD (0.05)	38.4	---	NS	NS	---
	1 – 2 feet				
Cereal Rye 'Merced'	63.2	---	17.2	59.5	---
Broccoli 'DiCicco'	96.0	---	16.0	78.5	---
White Mustard 'Ida Gold'	74.8	---	11.8	50.4	---
Indian Mustard 'ISCI 61'	54.8	---	10.4	89.6	---
Bare Fallow	172.0	---	50.36	58.8	---
LSD (0.05)	NS	---	1.64	22.2	---
	2 – 3 feet				
Cereal Rye 'Merced'	na	13.6	11.4	78.1	1.79
Broccoli 'DiCicco'	na	39.2	13.4	68.1	0.85
White Mustard 'Ida Gold'	na	12.6	4.7	61.9	0.90
Indian Mustard 'ISCI 61'	na	6.8	6.1	55.2	0.57
Bare Fallow	na	38.3	29.1	82.3	1.76
LSD (0.05)	--	*28.1*	*7.9*	*NS*	*0.84*

1 – rainfall during evaluation = 4.71 inches; 2 – rainfall during evaluation = 6.21

Table 7. Long-term plot: Comparison of trends of changes in soil analyses from the beginning of of the trial (2003) and after one cover crop cycle (2004)

Cover Crop Treatments	Carbon percent 2003	Carbon percent 2004	Potassium ppm 2003	Potassium ppm 2004	Sodium ppm 2003	Sodium ppm 2004
Cereal Rye 'Merced'	1.03	1.06	327.0	394.7	228.0	252.3
Broccoli 'DiCicco'	1.03	0.98	315.7	393.0	233.3	253.0
White Mustard 'Ida Gold'	1.02	1.04	320.7	390.3	222.7	246.6
Indian Mustard 'ISCI 61'	1.03	1.01	330.0	367.7	232.7	242.7
Bare Fallow	1.03	0.87	288.7	335.0	229.3	216.0
LSD (0.05)	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*n.s.*
LSD (0.10)	*n.s.*	*0.18*	*33.7*	*n.s.*	*n.s.*	*30.7*