Low Residue Cover Crops for Strawberry Production
(putting "the straw" back into strawberries)

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Objective: Develop strategies to use cover crops for controlling storm runoff in strawberries.

Residue treatments:

1. Bare furrows (untreated control)
2. Barley (UC 603) planted in furrows, killed with herbicide (poast)
3. Low growing triticale (Trios 102) planted in furrows, killed with herbicide (prism)

Trial description: A field trial was conducted on a conventional strawberry field south of Watsonville during the winter of 2006-2007. The soil was an Elkhorn fine sandy loam on 3% slopes. The field was planted with the variety 'Albion' on November 1, 2006; each plot consisted of three 64 inches wide beds that were covered with plastic mulch. The cover crop evaluation area was two 18-inch wide furrows by 300 feet long. Yield evaluations were conducted in the middle bed of each plot on 18 harvest dates.

Cover crop management: Cover crops were hand seeded into moist soil in the furrow bottoms on November 10, 2006. Both triticale and barley were planted at 805 lbs of seed/A. Seed were tilled into the soil with a hand push wheel hoe with a three tined cultivator. Barley 'UC603' was mowed to a 4-inch height on December 21, 2006; it was later sprayed on January 31, 2007 with a 1.0% solution of Poast + 0.25% Dynamic (NIS) in 42 gallons of water per acre to terminate its growth. Barley and Triticale 'Trios 102' were treated on March 2 with a 1.0% solution of Prism + 0.25% Dynamic in 42 gallons of water. The cover crops were evaluated for biomass and N content on February 14 and March 7, 2007. Ground cover was estimated from on February 14, 2007.

Water Quality Evaluations: Storm run-off from 2 furrows per plot was collected in a five gallon sump at the lower end. A residential flow meter connected to a bilge pump and a float switch was used to record run-off volume during storm events. A narrow tube (2 mm diameter) after the flow meter diverted a portion of run-off into a 5 gallon sample container. Run-off samples were collected within 24 hrs after a storm event. Turbidity, pH, and EC were evaluated immediately after collection of samples. A subsample was frozen and mailed to the UC DANR lab overnight with dry ice for nitrate and ammonium analysis. The remainder of the run-off samples was sent to the UC DANR lab for analysis of other water quality constituents (turbidity, suspended solids, pH, ortho-P, total P, total Kjeldahl N).

Results

Cover crops were sufficiently developed by early January, before a majority of the rain fall occurred. Barley and Trios were selected for evaluation in this trial because of their difference in growth. 'UC 603' barley is not winter dormant and grew vigorously over the course of the winter. 'Trios 102' triticale is winter dormant and grew slowly and more prostrate for the first 2 months of the trial. The difference in growth between the two cover crop species affected their subsequent management. Barley began to grow up to a height of the strawberry plants by December 21 and was weed wacked down to a height of 4 inches. The barley regrew vigorously and was killed with a 1% solution of Poast on January 31. 'Trios 102' triticale did not grow up to the height of the strawberry beds until March 2 and it was sprayed with a 1% solution of Prism (Select Max) to terminate growth. Biomass evaluations of the cover crops indicated that the barley produced about 1 ton/A in the furrow bottom on February 14, and that the biomass had declined to 0.87 ton/A on March 7 as it began to decompose (Table 1). 'Trios 102' biomass increased over the same time period as it was initiating spring growth. Both cover crops provided good ground cover (>87%) on March 1.

Run-off, sediments, and nutrients: The cover-cropped furrow treatments did not reduce the average amount of run-off that occurred from the trial (Table 5). Between 45% and 50% of the rainfall was lost as run-off during 11 storm events. The furrow bottom cover crops did reduce the concentration of suspended sediments and nutrients in the runoff compared to the unplanted control treatment (Tables 3 and 5). Suspended sediment concentrations were reduced more than 80% in the vegetated treatments compared to the bare control, which would reduce sediment losses by as much as 200 lbs per acre for each inch of rainfall (Figure 3). Total P and total N concentrations of run-off were also less in the vegetated treatments compared with the unplanted control (Table 3). The reduction in total P was not measured until late January (Table 4), presumably because the biomass cover was insufficient prior to January. Nitrate levels in the run-off were not statistically different among treatments. Ammonium and ortho-phosphate levels in the run-off from the vegetated treatments were elevated compared to the control (Table 3). The elevated levels of these nutrients were highest in the barley treatment, which was killed earliest and may have released these water soluble nutrients as the straw decomposed. Run-off from the barley treatment also had higher levels of total-P, ortho-P, and total-N (Table 3), potassium, and sulfate (data not presented) than run-off collected from the Trios treatment. The vegetated treatments significantly reduced the pH and total dissolved solids in the run-off compared to the bare treatment.

Yield effects: No significant fruit yield effects were measured among the residue treatments between May 1 and June 29th (Table 2).

Economics: Estimated costs of establishment and maintenance of the cover crops were $58 and $52/acre for barley and trios cover crops, respectively (Table 6). Although seed costs were less for barley than trios, maintenance costs were highest for barley due to its aggressive growth (Table 6). Although cover crops increased overall production costs, we estimated that they reduced sediment losses by 1.2 tons per acre under storm

conditions resulting in 6 inches of run-off. We estimated that the cost of removing this sediment from ditches and water ways was an extra $14.2/acre compared to the cover cropped treatments, assuming the cost of removal was $14/yard of sediment.

Conclusions

Once established, low residue cover crops planted in the furrow bottoms provided protection from storm events by reducing loss of sediment by an average of 80%. Once, established, cover crops also reduced losses of total phosphorus and nitrogen by as much as 70%. The cover crops did not affect the total volume of run-off from the strawberry field. The presence of the cover crops in the furrows did not affect marketable fruit yield during the subsequent production period in May and June. Cost of establishment and maintaining cover crops in strawberry ranged from $52-58/acre; however, the cover crop significantly reduced costs associated with removing sediment from water ways and sediment basins.

Figure 1. Bare, barley, and trios treatments on Feb. 17, 2007.

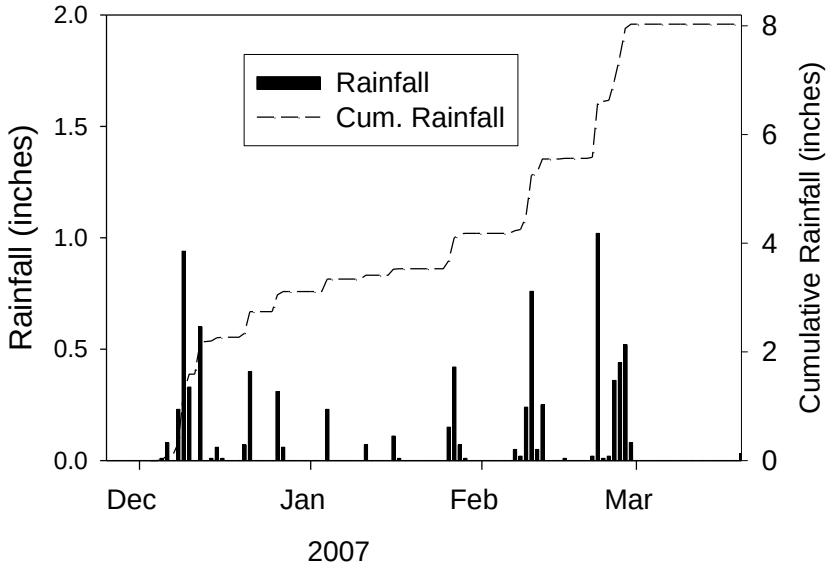

Figure 2. Daily and cumulative rainfall (Strawberry runoff plot 2006-07)

Table 1. 2007 cover crop biomass evaluations.

Treatment	**Biomass T/A[1]**	**Percent N in tops**	**N (lbs/A)**	**Percent C in tops**	**C (lbs/A)**	**% Ground Cover March 1**
February 14						
Untreated	----	----	----	----	----	0.0
UC 603 Barley	1.03	4.17	86.0	39.2	792.6	87.2
Trios 102 triticale	1.07	4.73	100.8	41.7	887.6	93.0
LSD (0.05)	n.s.	0.48	n.s.	n.s.	n.s.	4.35
March 7						
UC 603 Barley	0.87	3.07	53.2	37.83	654.0	----
Trios 102 triticale	1.78	3.57	125.4	41.70	1504.6	----
LSD (0.05)	0.44	0.28	33.2	1.70	386.7	----

[1] Tons/furrow acre (furrows represent 28% of planted area)

Table 2. Strawberry yield evaluations (18 harvests from May 1 to June 29, 2007)

Treatment	Yield (kg/plot)
Control	5.85 a
Barley	6.41 a
Trios (triticale)	6.55 a
LSD (0.05)	1.36

Table 3. Average concentrations of nutrients and sediments in run-off from 11 rain events. Samples were collected between 1/4/07 - 2/28/07. Cumulative rainfall was 4.28 inches.

Treatment	Suspended Sediments	Turbidity	Total Phosphorus	Soluble Phosphorus	Total Nitrogen	Ammonium Nitrogen	Nitrate Nitrogen
	ppm	NTU[x]	---------- ppm ----------				
Bare (control)	2380	3444	3.62	1.0	6.5	0.08	0.50
Barley	415	669	3.20	2.5	5.3	1.38	0.47
Trios	425	742	1.86	1.2	2.3	0.32	0.41
F-test (p > F)[y]	<.0001	0.0002	0.0192	0.006	0.0012	0.004	NS[z]
Treatment contrasts	---------- F-test (p > F)[y] ----------						
control vs vegetation	0.0001	0.0001	0.036	0.019	0.003	0.011	NS
Barley vs Trios	NS[z]	NS	0.024	0.006	0.002	0.005	NS

[x] low NTU (Nephelometric turbidity units) indicate less turbidity

[y] probability of obtaining an F-statistic greater than the computed value

[z] not statistically different at p < 0.10 level

Table 4. Cover crop effects on total phosphorus concentration of run-off for individual rain events

	Total Phosphorus Concentration in Run-off					
Treatment	4-Jan	27-Jan	28-Jan	10-Feb	11-Feb	13-Feb
	---------- mg/L ----------					
Control	1.50	3.90	3.65	2.93	3.48	5.33
Barley	2.48	4.60	2.65	1.95	1.78	2.53
Trios (triticale)	1.23	4.43	1.68	1.35	1.05	1.95
$LSD_{0.05}$	0.71	NS[^]	0.82	1.11	0.89	1.95

[x] differences among means are not statistically signficant

Table 5. Average amounts of run-off and sediment loss during a rain event. Data collected from 11 storm events totaling 4.28 inches.

	Average run-off volume		Average sediment loss	
Treatment	inches	% of rainfall	lb/acre	lb/acre/inch of run-off
Bare (control)	0.17	45	93.6	541.9
Barley	0.19	45	17.0	90.0
Trios	0.20	51	17.1	98.5
F-test ($p > F$)[x]	NS[y]	NS	0.0012	<.0001
Treatment contrasts	---------- F-test ($p > F$)[x] ----------			
control vs vegetation	NS	NS	0.0004	<.0001
barley vs trios	NS	NS	NS	NS

[x.] probability of obtaining an F-statistic greater than the computed value

[y.] not statistically different at $p < 0.10$ level

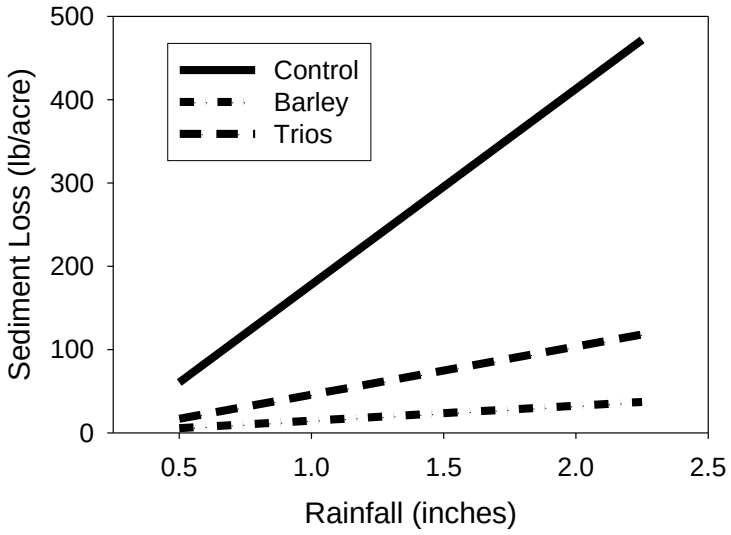

Figure 3. Estimated cumulative sediment loss in run-off collected between January 4th and February 13th 2007

Table 6. Costs for establishment and maintenance of low biomass cover crops in strawberries.

Estimated Costs of Operations	Base cost	Material/A	Cost/A	Total cost/A (adjusted)[1]
Cover Crop Seed				
Barley	0.15/lb	100 lbs	15.0	4.2
Trios 102	0.44/lb	120 lbs	52.8	14.9
Planting			4.5	4.5
Mechanical Management				
Weed Wacking[2]		0.25 gallon (gas)	----	11.4
Cultivation			15.0	15.0
Chemical Control				
Poast	73.60/gal	2 pints	18.4	5.2
Prism (Select Max)	120.33/gal	1 pint	15.0	4.3
Spray application			13.0	13.0
Barley total costs				57.5
Trios 102 total costs				51.7

1 – furrow area is 28% of total area and material costs per acre are adjusted accordingly

2 – based on one acre per hour and $10.35/hour for general labor (including 38% overhead – from *2006 Sample Costs to Produce Organic Strawberries* by Bolda et al.)

Table 7. Effects of cover crops on earth movement costs.

Suspended sediment conc.of Runoff	Sediment loss per 6 inches of run-off	Earth Movement Costs @ $14/yard	Earth Movement Costs @ $6.5/yard
mg/L (ppm)	tons/acre	----- $/acre -----	
2200 (control)	1.49	17.7	8.2
400 (cover crop)	0.27	3.2	1.5