Low residue cover crops for winter fallow vegetable production fields: summary of two years of evaluations

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Cover crops planted in fallow vegetable fields are an effective cultural practice for reducing erosion and protecting water quality during the winter. By reducing run-off volume and protecting the soil from erosion cover crops also minimize sediment and nutrient loads during rain events, and by taking up residual soil nitrate, they minimize nitrate leaching. In addition, cover crops provide needed soil organic matter that improves soil tilth and quality. However, it is difficult to find opportunities to include cover crops in Salinas Valley cropping systems due to the intensive planting schedules and high land rents. Over the past several years we have experimented with the use of low residue cover crops in order to find a way to include cover crops and provide some of the benefits that they provide for vegetable production fields.

Low residue cover crops are planted on listed winter beds and are either planted on the furrow bottom or are broadcasted; in both cases the seed is spread and then lillistoned into the soil. The cover crop is germinated with soil moisture, with rain or is irrigated. Unlike full-maturing cover crops, low residue cover crops are grown for 50-60 days, until they produce 0.5-1.0 ton/A of dry biomass, and then are killed with glyphosate. After being killed with the herbicide, the cover crop residue begins to decompose. The goal is to allow time for the cover crop residue to decompose sufficiently to allow normal bed preparation operations to proceed, thus not causing delays in crop planting schedules (to see video footage of low residue cover crops, go to http://www.youtube.com/watch?v=k0oVVJ_BA7s). To test the impact and practical application of low residue cover crops, we conducted large-scale trials with a cooperating grower on the eastside of the valley over two years: Trial No. 1, winter of 2009-2010 and Trial No. 2, winter of 2010-2011 in fields with 40 and 80 inch beds, respectively. The trials allowed us to test low residue cover crops under diverse conditions and gave an opportunity to see the benefits and disadvantages of this cultural practice.

Table 1 shows the cover crop varieties, planting dates and kill dates. The weather pattern between the two years varied. The weather remained sufficiently wet during Trial 1 to allow good decomposition of the cover crop residue; at the end of the cover crop cycle the residue had broken down sufficiently so that planting operations were carried out normally (see YouTube video mentioned above to see the lilliston pass through the field at the end of the cover crop cycle). However, in Trial 2 two issues reduced cover crop biomass decomposition and disrupted bed preparation operations: 1) due to the presence of an adjacent strawberry field, we used clethodim to kill the cover crop but it was not as effective as we had hoped and the cover crop died slowly. We resprayed the rye by hand three weeks later with glyphosate to speed death of the cover crop. 2) The weather was dry during February which further slowed decomposition of cover crop residue. As a result, too much cover crop residue remained, and due to the approaching planting schedule, it was decided that we could not work the beds with a lilliston, and the field was disced and relisted. As a result of the positive results in Trial 1 and the difficulties in Trial 2 we have a fuller appreciation for benefits as well as the drawbacks of low residue cover crops for winter vegetable production beds.

Methods used for evaluating water quality benefits of cover crops

In both trials, runoff from the plots was measured during all rain events during the winter. Run-off from each plot was channeled through flumes at the lower end of the plots. Flumes were instrumented to measure the flow rate and total volume of runoff. An automatic sampler collected composite samples of runoff during storm events. Run-off samples were analyzed for suspended sediments and nutrients at the UC Davis Analytical laboratory. Three suction lysimeters were installed at a two foot depth in each plot to sample leached nitrate during rain events. A vacuum pump maintained 20-25 cbars of suction in the lysimeters to capture gravitational water during rainfall events. Nitrate leaching was estimated from the concentration of nitrate in leachate samples and by estimating the amount of percolation during storm events from rainfall, soil moisture storage, and evapotranspiration data. Mineral nitrogen in the top foot of soil was monitored on a bimonthly basis over the course of the trial. Nitrate in the soil profile was measured to a depth of 3 feet at the beginning and end of the trial. Cover crop biomass was measured by cutting the biomass from 2 square meter areas in the plots every two weeks during the course over the growth and decomposition cycle of the cover crop. Samples of the cover crop biomass were sent to the UC Davis Analytical laboratory for total nitrogen analysis.

Table 1. Details on the growth and management of low residue cover crop both trials

Cover crop species		Wet date		Kill date	
Trial 1	Trial 2	Trial 1	Trial 2	Trial 1[2]	Trial 2[3]
Rye AG 104	Rye AG 104	Nov. 24	Nov. 16	Jan. 15	Jan. 11
Trios 102	Triticale 888[1]	Nov. 24	Nov. 16	Jan. 15	Jan. 11

1 – the seed was incorporated with a Perfecta and was buried too deep and this treatment; the plots were reseeded with barley UC603 on December 3, 2010 and incorporated with a wheel hoe harrow on the same day; 2 – Sprayed with 2% glyphosate; 3 – sprayed with clethodim @ 1 pint/A and the rye was resprayed on February 7 with 3% glyphosate.

Results

Impact of Low-residue cover crops on runoff, sediment and nutrient loss: In both years of trials, there were intensive periods of rainfall that allowed us to measure differences in the quantity and quality of runoff from the cover cropped and bare treatments. In Trial No. 1, 47% of the rainfall (about 120,000 gallons per acre) ran off of the bare plots. However, low residue cover crops reduced the volume of storm induced run-off by 95% for the rye treatment and by 80% for the triticale treatment (Figure 1). Cumulative sediment loss from the bare plots averaged 1199 lbs of sediment/acre for the winter season whereas rye reduced sediment loss by 99% (2.1 lbs of sediment/acre) and triticale by 94% (73 lbs of sediment/acre) (Figure 2). Losses of sediment were highest during the first major rain events of the season when the fine particles in the soil were most susceptible to erosion. In Trial 2 an early rain occurred before the cover crop was big enough to protect the soil surface from the impact of the rain droplets; as a result, the ground sealed and the effect of the cover crop on runoff was much less than in Trial 1. Additionally, despite having similar soil types, run-off volumes were much less for the bare treatment in Trial 2 which had 80- inch wide listed beds than in the bare treatment of Trial 1 which had 40-inch wide beds. Presumably less run-off was measured from the 80-inch beds because they were essentially flat while the 40-inch beds were peaked. Also there were more furrows in the field with 40-inch wide beds.

Cover cropped treatments also reduce nutrient losses in surface water run-off. Total N and P losses were reduced by 95% for the rye treatment and by 87% for the triticale treatment (Table 2) compared to the bare plots. Soluble nutrient losses were also reduced under the cover crop treatments. Reductions in nitrate-N losses were 92% and 93% for the rye and triticale treatments, respectively, compared to the bare plots. Reductions in soluble P (ortho-P) losses were 84% and 78% for rye and triticale treatments, respectively compared to the bare control. Also a significant reduction in ammonium and potassium losses was measured in the cover crop treatments relative to the bare plots (Table 2). Although the losses in nutrients may not have an agronomic impact on the subsequent vegetable crops, these losses can cause significant impairments to the quality of surface water. Both nitrogen and phosphorus spur algal growth in surface waters which can reduce dissolved oxygen levels.

Impacts of low residue cover crops on nitrate leaching: As mentioned above low residue cover crops decreased surface water runoff. As a result, they increase infiltration of water into the soil. Even minimal cover crop residue such as winter dormant triticale Trios 102 greatly increased infiltration. Increased infiltration removes salts from the soil profile and helps to recharge ground water resources. This is particularly important on the eastside of the Salinas Valley. Unfortunately nitrate is one of the anions (negatively charged ion) that is lost along with sodium and chloride (Table 3). In a separate trial examining the impact of low-residue in comparison with full-term cover crops we observed that nitrate was lost from both cover crop systems during rain events before the cover crop was big enough to absorb substantial quantities of residual soil nitrate. However, once the cover crop was sufficiently established it was able to absorb significant amounts of nitrate from the soil. Full term cover crops can take up 150 lbs or more N/A from the soil. Low residue cover crops absorb less than half that amount, depending on how long they are allowed to grow before being terminated. Another problem is that the nitrogen contained in the cover crop biomass is rapidly mineralized to nitrate and can be lost in winter storms (Figure 3). As such, it appears that low residue cover crops can only reduce nitrate leaching in situations in which there are low to moderate amounts of residual soil nitrate.

Management of low residue cover crops: Low residue cover crops can be broadcast or planted in the furrow only. Normal seeding rates can be used for broadcast plantings. The furrow bottom plantings can be assumed to occupy about 1/3 of the field area and planting rates can be adjusted accordingly. However, given the difficulties of planting the furrow and issues with compaction, it is advisable to plant an extra amount of seed to make sure you get an adequate plant population. One challenge in planting the furrow is getting the seed incorporated, but not too deep. We experienced germination problems when we incorporating seed in the furrow too deep with a Perfecta. In general, cereal cover crop varieties should not be planted deeper than 2 inches deep.

Broadcast plantings of rye grew rapidly, covered the soil and were highly effective in reducing surface runoff as well as sediment and nutrient loss (Photos 1&2). Winter dormant varieties of triticale such as 888 planted in the furrow bottoms were also reasonably effective (Photos 3&4). The winter dormant types were more forgiving as to when they needed to be terminated vs vigorous and rapidly growing standard cover crop varieties such as cereal rye and oats. It is important to carefully plan when and how the cover crop will be terminated. In general, as soon as the cover crop seed begins germinating (either from soil moisture, precipitation or irrigation) it is critical to mark your calendar for 50-60 days in the future and plan for terminating the cover crop in this time frame. The use of grass selective herbicide is helpful for safeguarding adjacent crops, but they do not remove broadleaf weeds which can become problematic. As a result, it is best to use glyphosate or a mechanical means to terminate the cover crop.

Conclusions and Recommendations

- Low residue cover crops are able to significantly reduce surface water runoff, sediment and nutrient loss during in surface water during winter storm events
- Target this technique to soils with high runoff and sediment loss potential (e.g. eastside of the Salinas Valley)
- They greatly increased water infiltration into the soil, thereby providing a cultural practice that can increase ground water recharge and move accumulated salts out of the soil profile
- Establish as early as possible to provide protection from early rains
- They must be killed before they produce too much biomass that would disrupt subsequent planting operations – keep in mind that once killed they still provide effective sediment loss reduction and increased infiltration for a good amount of time
- They are only able to accumulate moderate amounts of nitrate from the soil and may not reduce nitrate leaching in storms later in the cover crop growth cycle
- Planting cover crops just in the furrow bottom may be the safest approach to using these cover crops so that they do not disrupt subsequent vegetable planting operations (especially true on 80 inch beds)

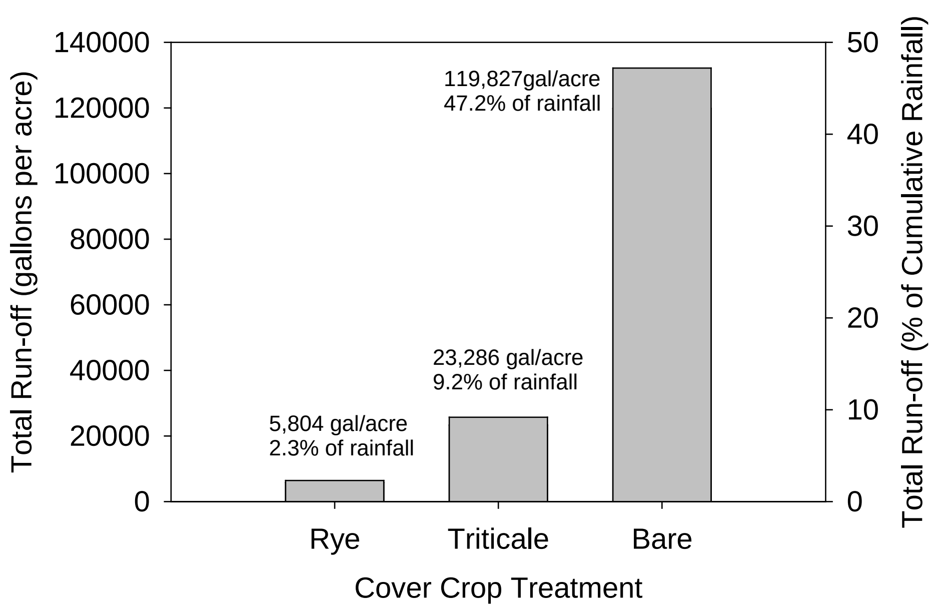

Figure 1. 2009-2010 Trial. Total runoff from cover crop and bare treatments between mid January and March 7, 2010.

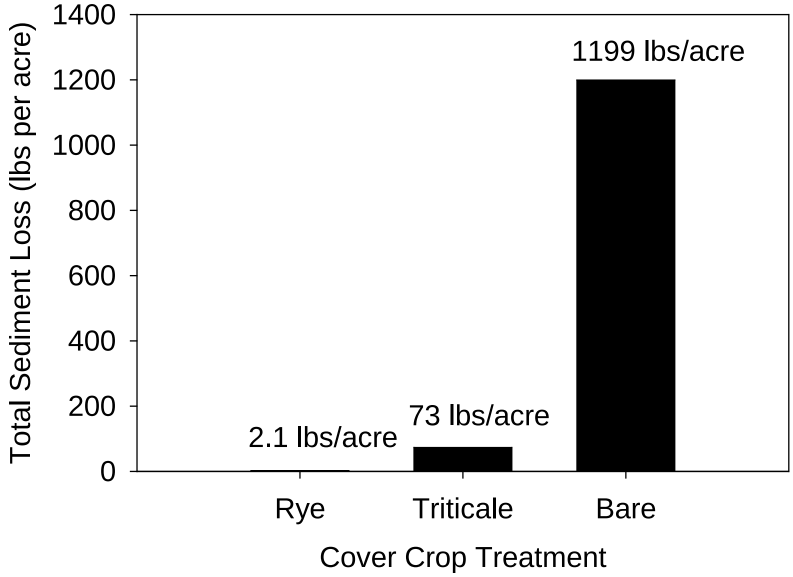

Figure 2. 2009-2010 Trial. Total sediment loss in run-off from cover crop and bare treatments between mid January and March 7, 2010.

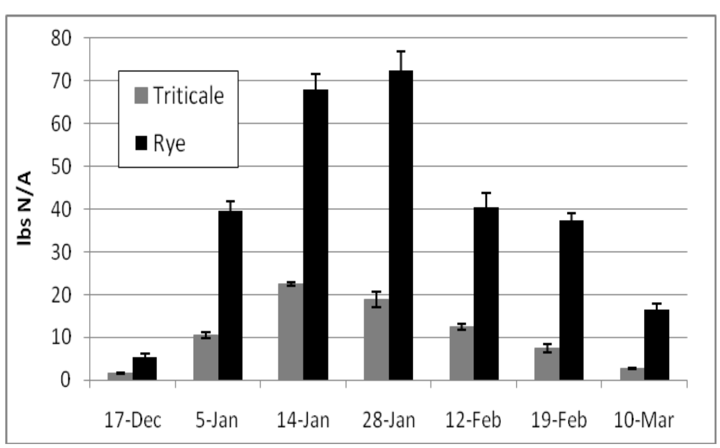

Figure 3. 2009-2010 Trial. Nitrogen in cover crop biomass

Table 2. Seasonal nutrient loss in run-off of cover crop treatments.

Treatment	Total N	Ammonium-N	Nitrate-N	Soluble-P	Total P	K
	---------------------------- lbs/acre ----------------------------------					
Rye	0.21	0.05	0.04	0.17	0.20	0.80
Triticale	0.60	0.05	0.03	0.24	0.47	1.30
Control	4.78	0.12	0.49	1.06	3.71	4.12
	------------ % reduction in loss compared to control ------------------					
Rye	96	59	92	84	95	81
Triticale	87	58	93	78	87	69

Table 3. Estimate of cations and anions leached during November 2009 to March 2010. Greater infiltration in the cover crop treatments leached more cations and anions through the soil.

Treatment	Nutrient leached (lbs/A)						
	Potassium	Calcium	Magnesium	Sodium	Chloride	Sulfate-S	Nitrate-N
Bare fallow	9	133	32	88	158	36	69
Low residue Triticale Trios 102	18	216	55	178	275	60	110
Low residue Rye AGS 104	16	226	63	191	289	69	111
Pr>F treat	0.260	0.179	0.074	0.008	0.062	0.120	0.252
LSD 0.05	NS	NS	27	50	115	NS	NS

 

Photos 1&2. AGS 104 cereal rye broadcast planted. Photo on right is 3 weeks after being treated with glyphosate. Note dense residue covering the furrow bottoms.

 

Photos 3&4. Trios 102 winter dormant triticale planted on the furrow bottom. Photo on right is 3 weeks after being treated with glyphosate. Note dense residue covering the furrow bottoms.