OPVC PROJECT REPORT: 2015 **PROJECT YEAR**: 1 of 2

1. OPVC RESEARCH REPORT COVER PAGE

PROJECT TITLE: Interseeding of Cover Crops to Improve Cover Crop Establishment and Performance

OPVC Project Number:

BUDGET TOTALS
TOTAL BUDGET REQUEST (all years): $33,760
Year 1: $20,890 **Year 2**: $12,870

PI: Ed Peachey
Organization: Oregon State University
Telephone: 541-740-6712
Email: peachey@hort.oregonstate.edu

Co-PI: Dan Sullivan
Organization: Oregon State University
Telephone: 541-737-5715
Email: dan.sullivan@hort.oregonstate.edu

Other project participants: Aaron Heinrich, Horticulture Dept. OSU, Ryan Clark, Olsen Farms, Suver; Scott Setniker, Setniker Farms, Independence; Ernie Pearmine, Pearmine Farms, Gervais; Jeff Ediger, Ediger Farms, Dayton; and Scott Zielinski, Windsor Island Farms, Salem.

2. Summary

This project is evaluating interseeding of crop crops to improve cover crop establishment after late harvested crops such as sweet corn and processing squash. In **Project 1** at the OSU Vegetable Research Farm, a cover crop of oat and crimson clover produced the most cover crop biomass when interseeded at V4 compared to V6 and V8 plantings but may have reduced corn yield slightly because of competition for water or nutrients. Applying Laudis herbicide immediately after interseeding of the cover crop had no impact on cover crop establishment, even when seeds were broadcast on the soil surface and incorporated lightly. Clover did not emerge well in interseeded plots, possibly because it was planted too deeply. Clover establishment was best when seed was broadcast on the soil surface and incorporated with shallow tillage. Cover crop biomass in mid-December averaged less in interseeded plots than in fall-planted plots because the oat cover crops began to senesce. In the on-farm demonstration plots **(Project 2),** triticale produced the most biomass and accumulated the most nitrogen in squash. Winter peas and oats had completely winter killed by mid-December. At a 2nd site in organic sweet corn, triticale and oats interseeded at V6 produced more cover crop biomass than lana vetch and clover at corn harvest. Sediment losses in runoff were slightly lower from plots with interseeded oats than from plots with corn residue on the surface and no cover crop. **Project 3** demonstrated that increased seeding depth may help to avoid soil applied herbicide injury to small grain cereals and large seeded legumes, but that great seeding depths of red and crimson clover did not avoid vulnerability to herbicide injury.

3. Full Project Report

Background

This project will develop and evaluate new cover crop planting strategies to improve cover crop establishment after late harvested crops. Cover crops add organic matter to the soil, improve soil tilth, capture soil nitrate that is susceptible to leaching into ground water, fix nitrogen (if legumes are planted), and suppress winter weeds. But here is the conundrum. Cover crop establishment for producers of processed vegetables in the Willamette Valley of western Oregon is a huge challenge because harvest of several important crops, including sweet corn, squash, and cauliflower, occurs late into the fall. Soil may already be saturated from fall rains, and the combination of wet soil and crop residue on the soil surface precludes tillage that is needed so that cover crop can be drilled. Late harvests also limit the diversity of cover crops that can be planted; legumes do not establish well if planted after September 15 in typical years and legumes are essential cover crops if farmers want to produce nitrogen and improve farm soils. The upshot is that it is simply too risky to plant cover crops after late planted crops.

A potential untested solution is to interseed (sometimes called relay plant) a cover crop into corn or other vegetable crops before the vegetable crop canopy becomes too tall or dense in mid to late summer. This strategy is particularly useful for late planted and/or late harvested crops. We believe that successful interseeding with specialized drills will enhance cover crop dry matter accumulation in the fall and winter (especially if planting legumes) and nitrate recovery from the soil. Interseeding of cover crops also minimizes soil disturbance associated with fall tillage and seedbed preparation for cover crops that often contributes to soil loss during fall and winter rains.

OBJECTIVES

- Demonstrate the capability of interseeding with a high-clearance direct-seed planter to improve cover crop establishment and growth compared to conventional tillage and direct-seeding of cover crops after sweet corn is harvested.
- Determine the optimum time to interseed cover crops so that the cover crop does not compete with the sweet corn crop for nutrients and water and reduce yield

SIGNIFICANT FINDINGS

Project 1 (Pg 4)

- at the OSU Vegetable Research Farm, a cover crop of oat and crimson clover produced the most cover crop biomass when interseeded at V4 compared to V6 and V8 plantings but may have reduced corn yield slightly because of competition for water or nutrients.
- Applying Laudis herbicide immediately after interseeding of the cover crop had no impact on cover crop establishment, even when seeds were broadcast on the soil surface and incorporated lightly.
- Clover did not emerge well in interseeded plots, possibly because it was planted too deeply.
- Clover establishment was best when seed was broadcast on the soil surface and incorporated with shallow tillage.
- Cover crop biomass in mid-December averaged less in interseeded plots than in fall-planted plots because the oat cover crops began to senesce. In the on-farm demonstration plots

Project 2 (Pg 10)

- Triticale produced the most biomass and accumulated the most nitrogen in winter squash. Winter peas and oats had completely winter killed by mid-December.
- In organic sweet corn, triticale and oats interseeded at V6 produced more cover crop biomass than lana vetch and clover at corn harvest.
- Sediment losses in runoff were slightly lower from plots with interseeded oats than from plots with corn residue on the surface and no cover crop.

Project 3 (Pg 12)

- Increased seeding depth helped to avoid soil applied herbicide injury to small grain cereals and large seeded legumes such as common vetch.
- Seeding depth of red and crimson clover did not influence vulnerability to herbicide injury.
- Clover was tolerant to Reflex herbicide

PROJECT 1. Effect of postemergence herbicides and interseeding strategy on cover crop and corn yield (OSU Vegetable Research Farm, Corvallis).

Methods. Sweet corn var. Owatonna (Sh2) was planted in June 6 at a density of 32,000 seeds/a with Outlook herbicide (18 oz/A) banded over the corn row on a 10 inch band. A series of interseeding treatments were applied to the corn based on cover crop planting strategy, growth stage of the corn and postemergent (POST) herbicide application timing (see table below) to plots that are 10 ft by 50 ft wide. Cover crops of crimson clover (10 lbs/A) and Cayuse oats (60 lbs/A) were interseeded with a high clearance direct-seed planter into sweet corn on July 9th (V4), July 15th (V6) and July 27 (V8).Treatments were replicated 4 times in a randomized complete block design. The herbicide Laudis (topramezone, 4-HPPD) and Basagran (to control purslane) (3 and 16 oz/A respectively) were broadcast applied to control weeds on select treatments after the cover crop was seeded to simulate the application being made with the interseeder. Cover crop emergence was measured at silking, and cover crop and weed biomass samples were harvested from all plots before corn harvest on Sept. 14 from an area 36 by 30", dried for 48 hrs and weighed. Cover crops biomass was measured again in mid-December as the cover appeared to senesce, probably due to saturated soils. Nitrogen content is being determined in the mid-winter cover crop.

Table 1. Treatments planned to evaluate cover crop planting strategy

	Cover crop planting system	Cover crop	Sweet corn growth stage when seeding cover crops	Post herbicide timing
1	Interseed	Clover+wheat	V4	V3
2	Interseed	Clover+wheat	V6	V3
3	Interseed	Clover+wheat	V8	V3
4	Interseed	Clover+wheat	V4	N
5	Interseed	Clover+wheat	V6	N
6	Interseed	Clover+wheat	V8	N
7	Broadcast	Clover+wheat	V4	V3
8	Broadcast	Clover+wheat	V6	V3
9	Broadcast	Clover+wheat	V8	V3
10	Direct-drill	Clover+wheat	After harvest	V3
11	Conventional	Clover+wheat	After harvest	V3
12	None	-	-	V3

Corn was harvested by hand from 20 ft of row from all plots to assess yield. Following hand harvest, the entire plot was commercial harvested to remove all remaining ears and simulate soil cover typical of commercial fields.

Following harvest, the direct-drill (Tr 10) and conventional tillage (Tr 11) plots were flailed. Tr 11 plots were disked twice after flailing, then followed two times over with vertical tine tillage. Cover crops were planted in both treatments with a notill John Deere drill on Sept 21.

Penetration of the corn canopy by Photosynthetically Active Radiation (PAR; wavelengths in the 400-700 nm range), was measured with an AccuPar-LP 80 PAR/LAI Ceptometer. The PAR values are represented as the ratio of below canopy light over above canopy light interception, with PAR being measured in units of micromoles per meter squared per second (umol/m^2/s). Low PAR ratios correspond with more crop canopy coverage and high PAR ratios correspond to less crop canopy coverage.

Soil moisture was monitored with 3 different instruments in one replicate of four primary treatments: no cover crop, relay planting at V4 growth stage (V4), relay planting at V6 growth stage (V6) and relay planting at V8 (V8) growth stage.

1. Tensiometers: Four 12" IRROMETER tensiometers were used to monitor water use between Owatonna sweet corn and a mix of cayuse oats and crimson clover cover crop interseeded (relay) during the growing season. Tensiometers were placed 10 ft into the plot, in the seed line, between rows two and three. Tensiometers were buried to a depth of 10", using a JMS 36" soil sampler to make each hole.

2. Gypsum blocks: Four Delmhorst GB-1 gypsum blocks were used in conjunction with tensiometers. Each gypsum block was attached to a 3'x 0.5" PVC pipe to ensure both better sensor stability and ease of cable location. Gypsum blocks were installed using the same protocol as the tensiometer. A Delmhorst KS-D1 moisture meter was used to measure soil conductivity. Values were converted from resistance to kPa using the reference chart from Delmhorst, then soil matric potential converted to volumetric water content using hydrologic release curves from soil samples collected at the site.

3. 10HS Soil moisture sensor: Two Decagon 10HS Soil Moisture Sensors were used to monitor volumetric water content (VWC) directly. Sensors were placed in two plots; no cover crop and relay planting at V6 growth stage. Sensors were buried, at a downward angle, to 10". Data was monitored automatically by a HOBO-U30 Weather Data Station.

Results

Cover crop growth and yield

The cover crop of oat and crimson clover produced the most cover crop biomass at corn harvest (mid-September) when interseeded at V4 compared to V6 and V8 plantings (Table 2). Applying Laudis and Basagran herbicide immediately after interseeding of the cover crop had no impact on cover crop establishment, even when seeds were broadcast on the soil surface and incorporated lightly. Clover did not emerge well in interseeded plots, possibly because it was planted too deeply. Clover establishment was best when seed was broadcast on the soil surface and incorporated with shallow tillage. Cover crop biomass in mid-December averaged less in interseeded plots than in fall-planted plots (whether direct-drilled or conventionally planted) because the oat cover crops began to senesce in plots that were interseeded. Oats in the V4 treatment flowered and began to produce seed.

Sweet corn response to cover crops

No differences were noted in corn ht. at silking due to interseeding treatments (Table 3). Corn yield trends indicated that interseeding cover crops at V4 may have reduced sweet corn yield slightly (Fig.1, Table 3), even though variability in yield data was large enough to preclude statistical significance. The correlation between N uptake of the cover crop and crop yield indicated that cover crops interseeded at V4 scavenged sufficient nitrogen from the soil to suppress yield (Figure 1 and 2). Additionally, two of the three soil moisture monitoring systems indicated that interseeding at V4 may have reduced volumetric water content of the soil compared to interseeding at V6 and V8 plantings (Figure 3). Unexpectedly, corn yield appeared to be greater in plots that were broadcast seeded rather than interseeded. Cover crop biomass was less in these plots because of poorer seed to soil contact, but yield still should have been similar to the plots without cover crops. These plots did not have the additional traffic from tractor and interseeder, but neither did treatments 10, 11 and 12, and yield in these treatments appeared suppressed as well compared to the broadcast cover crop treatments (Tr 7, 8 and 9).

Table 2. Effect of cover crop planting date, method, and rate on cover stand, drymatter accumulation, and N uptake.

	Cover crop planting system	Cover crop	Cover Crop Seeding Rate	Timing	Date	Post herb-icide	Cover crop stand (24-Jul)		Cover crop biomass and N Uptake (14-Sept)				Cover crop biomass (15-Dec)			
							Oat	Clover	Oats	Clover	Weeds	N uptake	Oats	Clover	Weeds	Total
			lb/A				*no/7.5 ft sq*		*lb DM/acre*			*lb/A*	*tons DM/acre*			
1	Relay	Cr. clover + oat	10+60	V4	9-Jul	V4[1]	80	11	803	17	6	19	0.34	0.04	0.00	0.39
2	Relay	Cr. clover + oat	10+60	V6	15-Jul	V6[2]	80	18	368	0	313	10	0.45	0	0	0.45
3	Relay	Cr. clover + oat	10+60	V8	27-Jul	V8[2]	19	10	269	0	0	9	0.39	0	0.01	0.39
4	Relay	Cr. clover + oat	10+60	V4	9-Jul	N	94	10	857	0	525	21	0.22	0.01	0.01	0.24
5	Relay	Cr. clover + oat	10+60	V6	15-Jul	N	81	7	384	0	92	10	0.41	0.01	0	0.43
6	Relay	Cr. clover + oat	10+60	V8	27-Jul	N	22	11	109	0	1171	5	0.34	0.09	0.01	0.44
7	Broadcast	Cr. clover + oat	10+60	V4	9-Jul	V4[1]	148	36	240	19	3	7	0.84	0.06	0.01	0.91
8	Broadcast	Cr. clover + oat	10+60	V6	15-Jul	V6[2]	101	11	115	0	0	3	0.48	0.02	0.01	0.50
9	Broadcast	Cr. clover + oat	10+60	V8	27-Jul	V8[2]	42	45	94	17	6	3	0.39	0.18	0.01	0.58
10	Direct-seed	Cr. clover + oat	10+60	Post har	21-Sept	V6[2]	0	0	0	0	0	0	0.53	0	0.01	0.53
11	Conv.	Cr. clover + oat	10+60	Post har	21-Sept	V6[2]	0	0	0	0	0	0	0.61	0	0	0.61
12	Check	None			-	V6[2]	0	0	0	0	0	0	0	0	0.08	0.08
	FPLSD (0.05)						18	17	209	NS	605	5	0.31	0.10	0.02	0.30

[1] Laudis 3 oz/A

[2] Laudis (3 oz/A) + Basagran (1 pt/A)

Table 3. Effect of cover crop planting date, method, and rate on corn growth and yield.

	Cover crop planting system	Cover crop	Cover Crop Seeding Rate	Timing	Date	Post herb-icide	Corn hts (8/11, ~800 GDD)	Proportion of Photosynthetically Active Radiation (PAR) reaching cover crop canopy			Corn harvest		
								31-Jul	6-Aug	25-Aug	Ear no.	Fresh wt	Avg ear wt.
			lb/A				*ft*				*ear/A*	*T/A*	*lb*
1	Relay	Cr. clover + oat	10+60	V4	9-Jul	V4[1]	5.3	0.33	0.25	**0.23**	25483	11.6	0.91
2	Relay	Cr. clover + oat	10+60	V6	15-Jul	V6[2]	5.5	0.43	0.20	**0.13**	26136	11.9	0.91
3	Relay	Cr. clover + oat	10+60	V8	27-Jul	V8[2]	5.4	0.44	0.17	**0.12**	27443	12.3	0.90
4	Relay	Cr. clover + oat	10+60	V4	9-Jul	N	5.3	0.25	0.20	**0.18**	27007	12.2	0.90
5	Relay	Cr. clover + oat	10+60	V6	15-Jul	N	5.2	0.33	0.22	**0.11**	27661	12.7	0.91
6	Relay	Cr. clover + oat	10+60	V8	27-Jul	N	5.3	0.37	0.19	0.10	24829	11.2	0.91
7	Broadcast	Cr. clover + oat	10+60	V4	9-Jul	V4[1]	5.4	0.33	0.15	0.09	28314	12.9	0.91
8	Broadcast	Cr. clover + oat	10+60	V6	15-Jul	V6[2]	5.5	0.34	0.17	0.09	28967	13.7	0.95
9	Broadcast	Cr. clover + oat	10+60	V8	27-Jul	V8[2]	5.2	0.35	0.13	0.10	30710	13.7	0.90
10	Direct-seed	Cr. clover + oat	10+60	Post har	21-Sept	V6[2]	5.4	0.36	0.19	0.06	26354	12.4	0.95
11	Conv.	Cr. clover + oat	10+60	Post har	21-Sept	V6[2]	5.4	0.38	0.16	0.09	26572	12.2	0.91
12	Check	None			-	V6[2]	5.3	0.36	0.15	0.06	26789	11.9	0.89
	FPLSD (0.05)						NS	NS	NS	0.04	NS	NS	NS

[1] Laudis 3 oz/A

[2] Laudis (3 oz/A) + Basagran (1 pt/A)

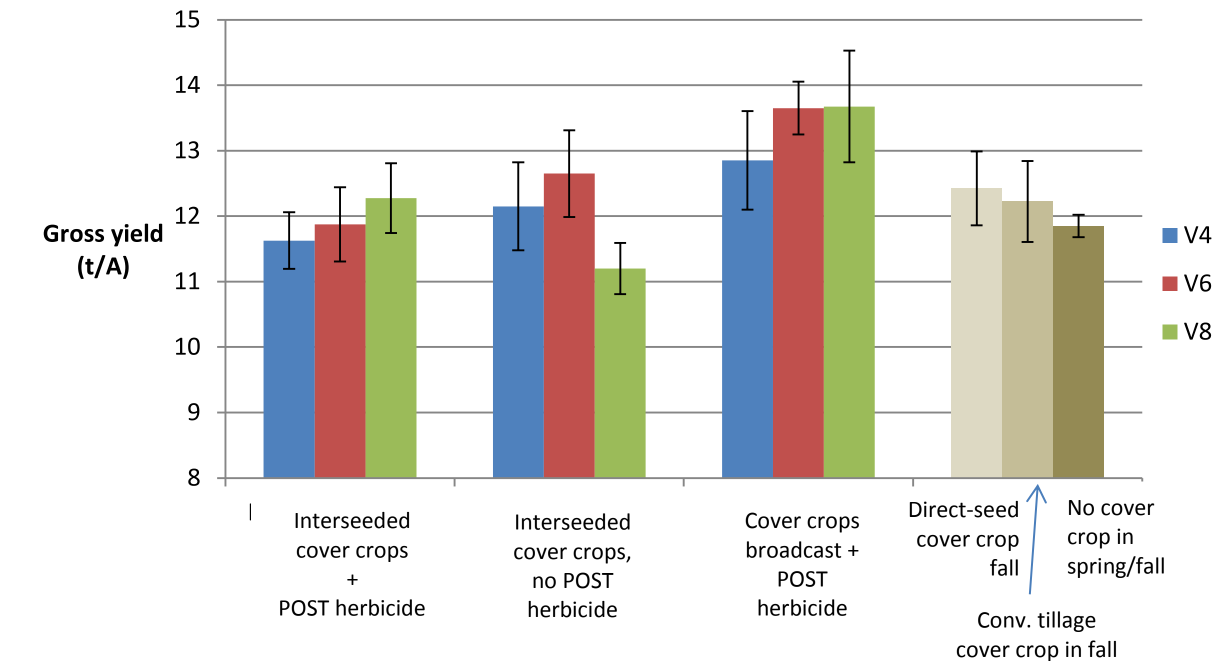


Figure 1. Response of sweet corn gross ear yield to interseeding.

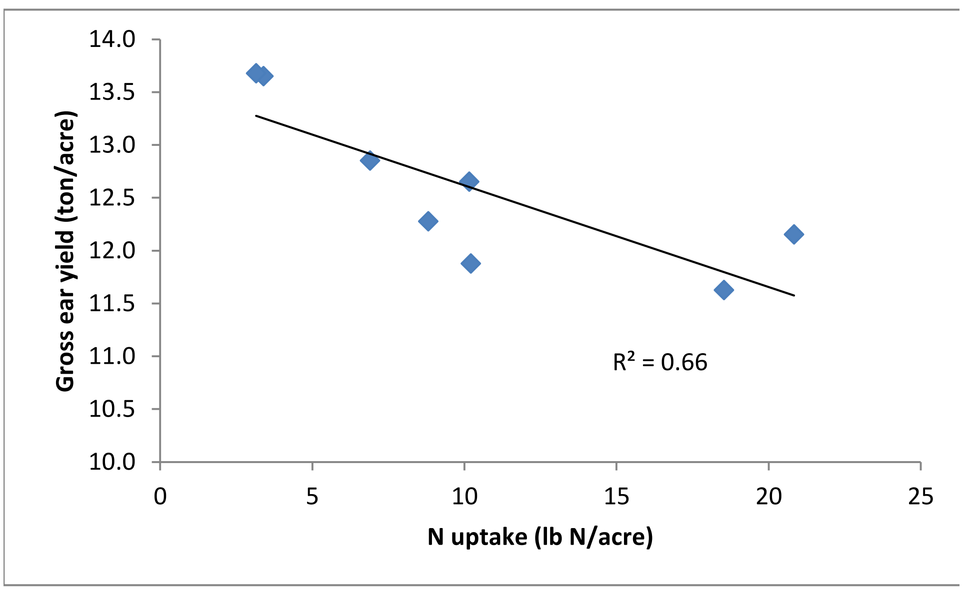
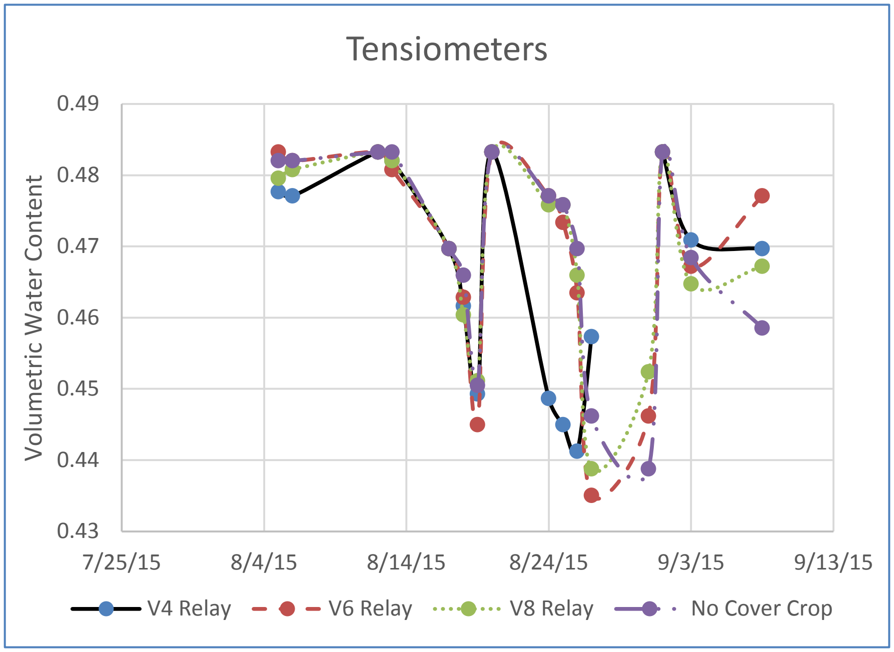


Figure 2. Relationship between N uptake and gross ear yield. Relay V8 (Tr. 6) was removed from the analysis due to high weed pressure that suppressed oat growth and N uptake.



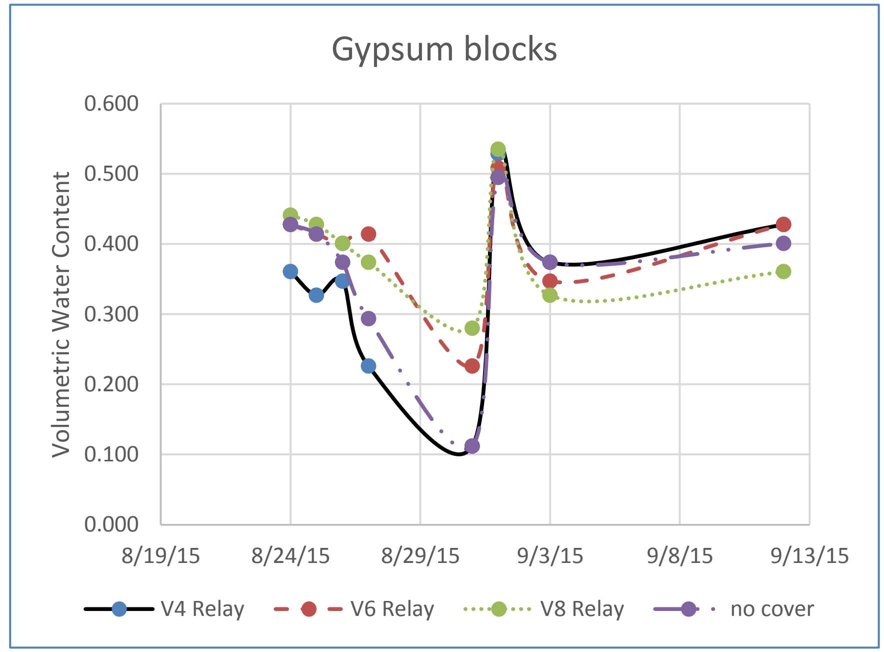
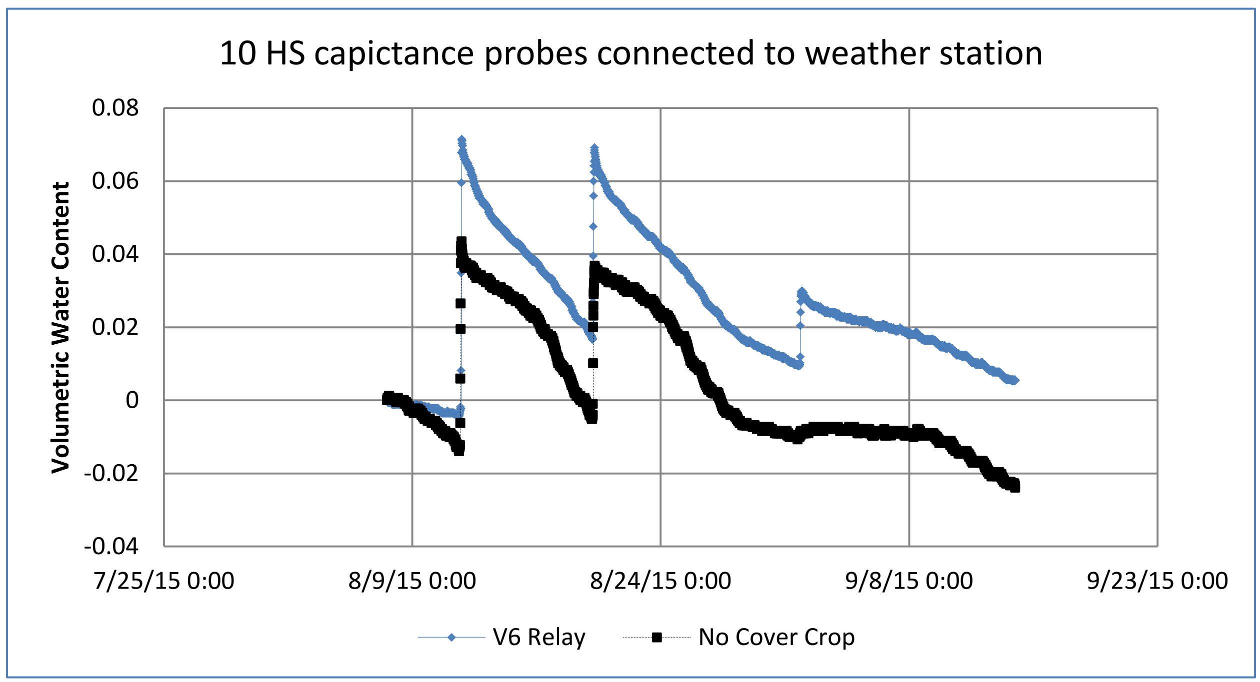


Figure 3. Soil moisture measurements from one replication in treatments 1, 2, 3 and 12 from mid-August until harvest with three different monitoring systems.



Project 2. On-farm testing and demonstration of interseeding strategies for cover crop establishment

Squash, Buena Vista. Golden Delicious processing squash was planted on May 18 and cover crops interseeded on June 25 when the squash had 2- 4 true leaves. Cover crop plots were 200 ft by 20 ft wide, and divided into 3 herbicide treatments plus an area that cover crop seed was broadcast onto the soil surface rather than drilled with the interseeder. Urea was applied by air on July 9 at 50 lb/A. Crop yield and cover crop biomass was estimated by harvesting two subsamples within each cover crop strip and herbicide treatment.

Cover crop establishment was nonexistent where seeds were simply broadcast on the surface. Irrigation was erratic and the summer very warm and dry, causing long intervals between soil wetting. Red and crimson clover did not establish in any of the plots, whether interseeder or broadcast, possibly as a response to the herbicides applied, but more likely because of infrequent watering or too deep planted. Outlook only plots were very weedy with poor cover crop stands; Reflex plots had the best looking cover crop stands and the most biomass; Outlook+Reflex had good stands but slightly smaller cover crops and biomass. Plots were interseeded earlier than anticipated because of the very warm spring and early summer, thus oats produced seed early with significant rust development on leaves that probably suppressed growth. Observations in mid-December found that peas had completely winter killed, that oats had all but disappeared, but that triticale was still holding significant biomass, with substantial resistance to soil erosion.

Table 4. Effect of cover crop planting strategy and preemergence herbicide on cover crop growth and squash yield (n=2).

Cover crop, Interseed strategy and herbicide treatments	**Cover crop growth and N**			**Squash yield**	
	Stand counts (July 27)	Cover crop drymatter (Sept 15)	Cover crop biomass N (Sept 15)	Avg. fruit wt (Sept 15)	Yield (Sept 15)
	No./3 ft	*t/a*	*lb/a*	*kg*	*t/a*
Oats					
Broadcast Outlook+Reflex	10	0.02	1	2.6	28.0
Interseed Outlook	138	0.39	18	3.9	20.6
Interseed Outlook + Reflex	139	0.31	14	2.7	22.9
Interseed Reflex	110	0.54	25	3.0	18.6
Peas					
Broadcast Outlook+Reflex	8	0.03	2	2.8	21.6
Interseed Outlook	45	0.17	10	3.1	22.2
Interseed Outlook + Reflex	61	0.43	26	2.3	20.1
Interseed Reflex	70	0.64	39	2.9	22.4
Triticale					
Broadcast Outlook+Reflex	5	0.02	1	2.2	24.7
Interseed Outlook	46	0.92	59	3.9	24.9
Interseed Outlook + Reflex	93	0.73	46	3.1	20.9
Interseed Reflex	100	1.14	72	3.2	30.7

Sweet corn (organic), Lukiamute Landing State Park. Organic sweet corn was planted on July 08, 2015 in corn at V6-7 that averaged approx. 29 in. tall. Cover crops were interseeded with the specialized drill on August 3 and 4 using organically produced cover crop seed. Cover crop stand counts were taken on August 20 and cover crop biomass estimated by direct sampling on October 6, just before corn was harvested. Corn was picked from 3 sites in each cover crop plot to estimate yield. Runoff collectors were installed Oct 21-23 in select treatments. A soil sample as taken to 12 inches in the vetch, oats and corn residue-only plots and tested to 5 ppm for all treatments. Most of the plots went under water for a short period on Dec. 9. The river receded on Dec. 17, but overtook the plot again on Dec. 19.

Triticale and oats interseeded at V6 produced more cover crop biomass than lana vetch and clover at corn harvest. Nitrogen scavenged in the cover crop was very low. Sediment losses in runoff were lower from plots with interseeded oats than from plots with corn residue on the surface and no cover crop.

Table 5. Corn and cover crop growth and yield, Lukiamute Landing State Natural Area, 2015.

Date inter-seeded	Cover crop	Seeding rate	Seeding depth	Avg corn plant ht. at interseeding	Cover crop stand	Cover crop plant stand, biomass, and N (Oct 6)			Gross ear yield	
				3,4-Aug	Aug 20	Drymatter	N in tissues	Biomass N	Avg	SE
				in	*no/7.5 ft sq*	*lb/A*	*%*	*(lb/acre)*	*t/A*	
3-Aug	Oats (Cayuse)	120	¾	28	6	126	3.4	4.2	14.1	1.2
3-Aug	Triticale	120	¾	28	89	130	3.2	4.4	10.9	0.5
3-Aug	Lana Vetch	50	¾	28	14	62	3.9	2.4	9.4	0.8
4-Aug	Red Clover	15	1/4 to 3/8	31	36	14	-	-	10.9	0.7
-	No cover crop	-	-	-	-	-	-	-	11.9	0.6

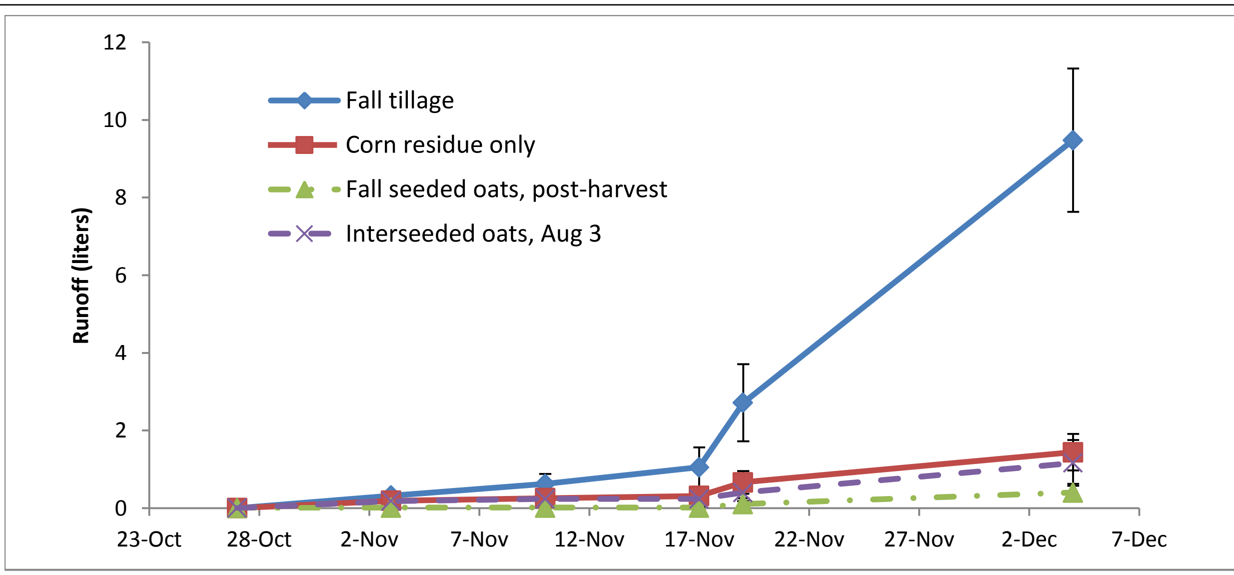


Figure 3. Soil sediment loss from soil water collected in each cover crop treatment (n=3).

Project 3. Effect of cover crop planting depth on tolerance to preemergence herbicides.

Methods. This study explored the relationship between preemergent herbicide applications and interseeding depth on the survival and growth of oats, barley, red clover, crimson clover, and common vetch. The sweet corn variety 'Captain' was planted on August 30 on 30 inch spacing. Preemergent herbicides were applied on August 5 (Table 1) to plots 10' by 35' using a 9 ft boom with 6 nozzles at a rate of 20 gal/acre, and the field was irrigated on August 7 (1.5" of water). A 5' herbicide-free area remained unsprayed at the end or beginning of each plot, for a combined check of 10' between treatments. On August 12 (7 days after PRE herbicide), cover crops were interseeded between the corn (Table 7). The interseeder planted 13 seedlines; 2 per row on the outside rows and 3 per row on the inside rows. Starting at the outside row, the depth was set to the shallowest setting for the clovers and the second shallowest for the cereals and vetch, then incrementally increased across the planter to the deepest depth setting possible, skipping the wheel rows. This resulted in 7 different depths. For the wheel rows, we did the same incremental increases resulting in 6 depth setting.

Results.

- For the clovers, there were no depth by herbicide interactions. Deeper planting depths did not allow clover to avoid the herbicide. The clovers were very sensitive to all herbicides except Reflex, and in some cases the herbicides killed the crop. The clovers were very sensitive to planting depth and should be planted 0.25" or shallower to maximize emergence.
- Common vetch emergence and growth was unaffected by all herbicides, and was very tolerant of shallow and deep planting, though the ideal planting depth was 0.75" in this study.
- Oats were most sensitive to Outlook, but a planting depth ≥0.5" significantly reduced or even eliminated phytotoxicity. Oats also showed reduced growth from Dual, but was less than Outlook. When oats were very shallowly planted (<1/8"), they showed phytotoxicity to Atrazine, but the plants were able to outgrow these effects.
- Barley behaved similarly to oats, but was less sensitive to Outlook and Dual. Growth of Barley was unaffected by Atrazine and Reflex.
- Emergence of cereals were relatively insensitive to planting depth and good stands were observed even for planting depths where there was visible seed on soil surface (this assumes timely and adequate irrigations).

Table 6. Herbicide treatments and rates.

Treatments	Timing	Product rate per acre
Dual Magnum	Pre	12 oz
Outlook	Pre	8 oz
Atrazine	Pre	0.5 pt
Reflex	Pre	0.25 pt

Table 7. Cover crops and seeding rates.

Cover crop	Interseeding rate (lb/A)
Cayuse Oat	100
Spring barley	100
Common vetch	40
Crimson clover	15
Red clover	15