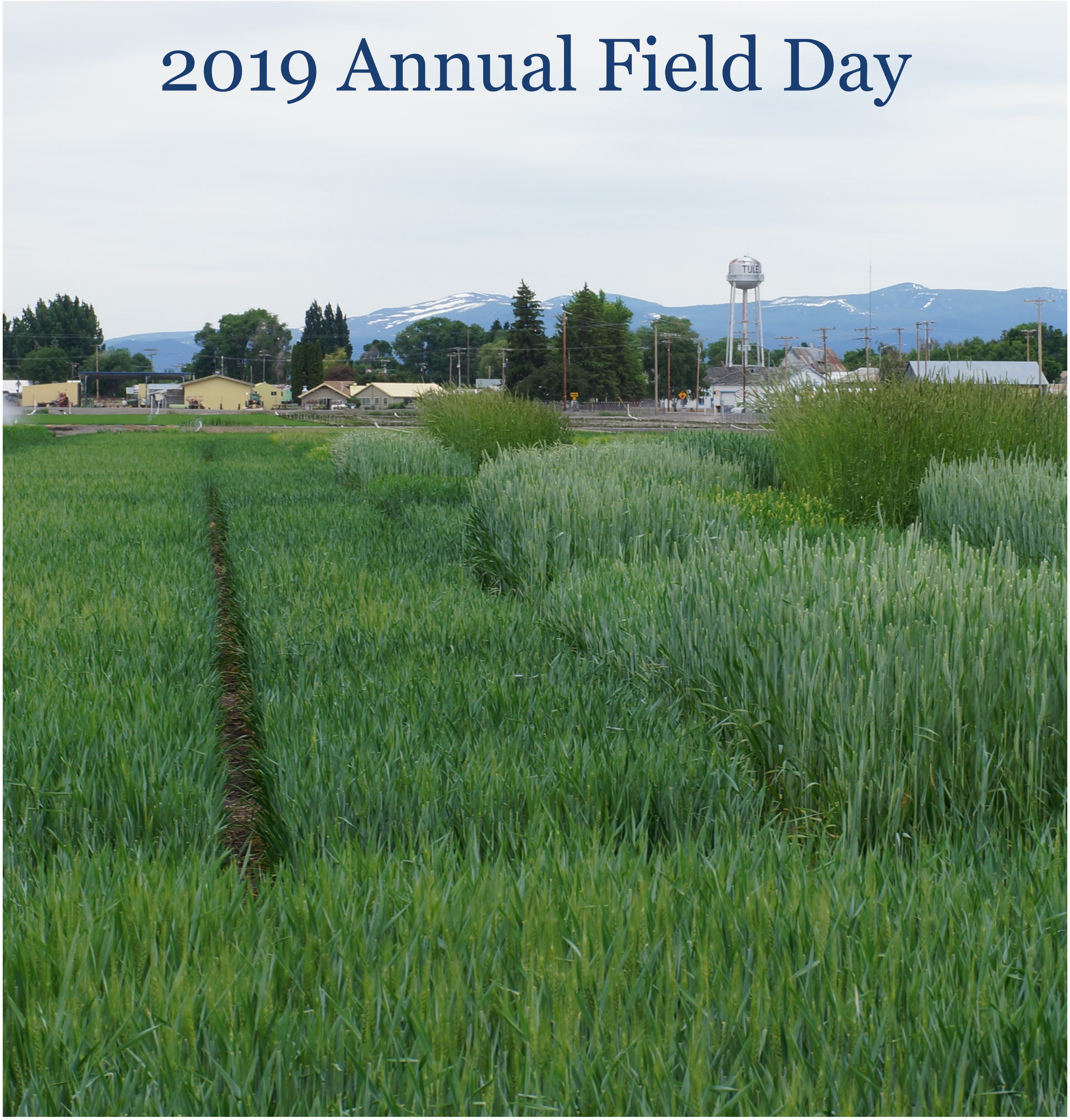
2019 Annual Field Day



Intermountain Research and Extension Center

RECS | University *of* California
Agriculture and Natural Resources

Welcome to our Annual Field Day

This Field Day event is a collaborative effort involving all of the Center Staff, visiting researchers and many growers and grower groups in the region. The general purpose of the tour is to allow participants a chance to see the research our Center is conducting and interact with Center researchers.

We sincerely appreciate the opportunity to share our research programs with members of the community, many of whom have helped sponsor the research and this event.

During the tour, please ask questions freely. If you would like additional information on any project, please seek out a side conversation with the researcher during breaks or over lunch. Additional information on all our research projects is available at the office.

Please enjoy the tour, the lunch and the conversation.

Thanks for coming!

Sincerely,

The IREC Staff

Table of Contents

Intermountain Research & Extension Center Current Staff 3

Guide to IREC's Website 4

List of Current Research Projects at IREC 5

Seed Treatment Options for Onion Smut and Maggots in Onions 12

UC Triticale Breeding: Enhancing Baking Performance 14

Developing Barley Varieties for the Klamath Basin... 15

Investigation of Cover Crops and Compost to Improve Soil Health in Conventional and Organic Crop Rotations 17

Managing Clover Root Curculio in Alfalfa 22

Frost Injury on Roundup Ready Alfalfa – 2019 NE California Research 26

Nitrogen Management in Small Grains 32

Thank You, Sponsors 35

Agenda 37

Intermountain Research & Extension Center
Current Staff

Rob Wilson	Center Director / Farm Advisor
Darrin Culp	Superintendent of Agriculture
Laurie Askew	Business Officer
Myra Chavoya-Perez	Cooperative Extension Coordinator
Kevin Nicholson	Staff Research Associate II
Seferino Salazar	Senior Agricultural Technician
Robert Carver	Agricultural Technician
Skyler Peterson	Senior Farm Machinery Mechanic
Tom Tappan	Farm Machinery Mechanic
Josefina Vallejo	Seasonal Farm Worker
Paul Greenwood	Seasonal Farm Worker

http://irec.ucanr.edu

Visit our website! Below is a list of some information available. Thanks for bookmarking!

Home:

Welcome to IREC and Tulelake

Stay current with upcoming IREC events

Subscribe to and read our blog

About Us:

Learn about the history of IREC

Get to know the IREC staff

Check out our facilities

Get directions to IREC

Research:

Learn how to submit a proposal

Keep up on current research

Read results of past research

Extension, Outreach & Education:

Read about the Center activities

Peruse our newsletters and Field Day booklets

Watch IREC videos

Study our cost studies

Weather, Physical & Biological Data:

Check out Tulelake weather and CIMIS

Use the Crop Water Use Table

IREC Alfalfa Projects

340-Alfalfa Variety Evaluation in Mountain Valleys of Northern California

Principal Investigator: Dan Putnam, Extension Agronomist, Dept. of Plant Science, UC Davis; Craig Giannini, UC SRA, UC Davis

- Evaluate certified cultivar differences in alfalfa forage yield, quality, and persistence, and to communicate these results to clientele
- Develop and provide forage yield and performance data on alfalfa experimental germplasm to public and private alfalfa scientists

342-Improved Management of Alfalfa Weevil in California to Facilitate Water Quality Protection and Crop Sustainability

Principal Investigator: Ian Grettenberger, UC Davis Field and Vegetable Entomologist Specialist

345-Cutting Schedule Effects on Reduced Lignin & Conventional Alfalfa

Principal Investigator: Dan Putnam, Extension Agronomist, Department of Plant Sciences, UC Davis

- Determine the effect of a 3-cut versus 4-cut harvest schedule on rate of forage quality change of genetically engineered low lignin alfalfa compared to the null that does not carry the trait and compared with a commercial standard
- Determine the appropriate cutting management schedule for low-lignin alfalfa compared with conventional non-genetically engineered alfalfa

360-Resiliance of Alfalfa Cultivars to Variable Environments

Principal Investigator: Charles Brummer, Director, Plant Breeding Center, UC Davis.

- The main goal of this project is to develop methods to measure and understand the resilience of alfalfa cultivars to abiotic stresses, to: a) identify cultivars with superior resilience, b) identify alfalfa plant traits associated with resilience, and c) study the relationship between productivity and resilience in alfalfa cultivars. To achieve these goals, a combined approach of a) long-term datasets analyses, b) field experiments and c) crop modeling will be used. Therefore, the project has the following objectives:

- To empirically measure resilience of alfalfa cultivars to water and cold stresses in controlled replicated field experiments across the USA, and identify plant traits associated with resilience.

366-Clover Root Cucurlio Management in Alfalfa Production

Principal Investigator: Rachael Long, Farm Advisor for Field Crops, Pest Management, UCCE-Capitol Corridor, Woodland, CA.

- Track the activity of CRC life stages during the season to improve our understanding of CRC biology and life history and of the conditions where CRC may be problematic, thus improving the timing and effectiveness of management decisions.
- Evaluate biological and chemical pesticides for CRC suppression given that there are no registered soil active products.
- Evaluate alfalfa varieties/lines that show resistance toward insect pests on CRC feeding and oviposition.
- Collaboratively conduct multistate Extension programs that help alfalfa growers understand CRC activity and adopt CRC management strategies.

386-Evaluation of New Herbicide for Between Cutting Weed Control in Alfalfa

Principal Investigator: Thom Getts, UCCE-Lassen, Susanville, CA.

- Evaluate the crop safety of various herbicides applied to alfalfa between cuttings, including multiple rates of herbicide CNV2243.

- Evaluate weed control efficacy of various herbicides applied to alfalfa between cuttings, including multiple rates of herbicide CNV2243.

387-Frost Injury on Roundup Ready Alfalfa - What's Happening?

Principal Investigators: Tom Getts, Lassen Weed Ecology and Cropping Systems Advisor; Rob Wilson, IREC Center Director/Farm Advisor; Giuliano Galdi, Siskiyou Agronomy and Crops Advisor

- Collaborate with Debby Samac with USDA-ARS to analyze alfalfa samples from several study sites to determine levels of *syringae* bacteria in alfalfa samples after frost events and following glyphosate applications at different application timings to relate how glyphosate affects P. syringae levels at different growth stages.
- Better document the injury and yield reductions associated with glyphosate at different growth stages to determine Roundup application times that cause the most and least crop injury.
- Determine if suppressing P. syringae populations on alfalfa plant tissue with copper bactericides and mancozeb influence crop injury following glyphosate applications and frost.

397-Alfalfa Germplasm Evaluation-Fall Dormancy

Principal Investigator: Charles Brummer, Director, Plant Breeding Center, UC Davis; Dan Putnam, Extension Agronomist, Department of Plant Science, UC Davis.

- To develop a measurement method to assess dormancy in swards.
- To evaluate fall dormancy of the standard check cultivars and selected other modern cultivars in both swards using the new protocol and in spaced plants using the current protocol.

IREC Forage Projects

731-Investigation of Indaziflam for Invasive Annual Grass Control and Perennial Grass Establishment

Principal Investigator: Tom Getts, Weed Ecology & Cropping Systems Advisor, Lassen County, Susanville.

- To determine effectiveness of invasive annual grass control after indaziflam and aminocyclopyrachlor application.
- To assess secondary weed invasion after annual grass herbicide applications.
- To determine perennial species herbicide tolerance, and establishment potential.

762-Tall Fescue Isogenic Population Evaluation

Principal Investigator: Charles Brummer; Co-PI's: Tami Leathers, Leslie Roche, Daniel Putnam, Josh Davy.

- The objective of this project is to determine the adaptation of tall fescue ecotypes with and without endophytes across California.

914-Kura Clover Project

Principal Investigator: Dan Putnam, Extension Agronomist, Dept. of Plant Science, UC Davis; Steve Orloff, UCCE, Siskiyou Co.; Charlie Brummer, UC Davis; N. Ehlke, C. Sheaffer, Univ. Minnesota; Oli Bacchi, UCCE, El Centro; Chris DeBen, UC Davis; Khaled Bali, UCCE El Centro.

- To determine preliminary seed and forage yield possibilities at 3 different locations in California.

IREC Peppermint Projects

511-Mint Variety Development

Principal Investigator: Isabelle Henry, UC Davis.

- Characterize Plant Morphology
- Characterize the Oil Profile of Diverse Materials
- Characterize Oil Yield

569-Weed Control in Peppermint

Principal Investigator: Rob Wilson, Center Director/Farm Advisor, UC Intermountain Research & Extension Center

- Investigate the fit of saflufenacil (Sharpen) and pyroxasulfone for control of winter annual and summer annual weeds in peppermint.
- Evaluate the performance of saflufenacil tank-mixed with dormant preemergence herbicides in peppermint

IREC Onion Projects

451-Management of White Rot of Onions with Fungicides

Principal Investigator: Rob Wilson, Center Director/Farm Advisor, UC Intermountain Research & Extension Center

- Evaluate the performance of new fungicides and fungicide tank-mixes for white rot suppression in processing onions

458-Management of Maggots and Smut in Processing Onions

Principal Investigator: Rob Wilson, Center Director/Farm Advisor, UC Intermountain Research & Extension Center; Kevin Nicholson, Staff Research Assistant, UC Intermountain Research & Extension Center.

- Compare different seed treatments and in-furrow pesticides for control of maggots and onion smut.

IREC Other Research

796-Reduction of Large Predator-Livestock Interactions through Livestock Mortality Composting and Predator Monitoring

Principal Investigator Laura Snell, UCCE- Modoc. Project Cooperators: Kasey DeAtley, CSU, Chico; David Lile, UCCE-Lassen; Dan Macon, UCCE-Placer; Tracy Schohr, UCCE-Plumas.

- Determine the feasibility of composting of livestock carcasses (natural mortalities) and bone while integrating whether compost piles are an attractant to wildlife or other pest species. Compare frequency of visitation by scavengers and predators between compost piles with traditional bone piles and develop and outline for the process, capacity, time-frame and nutrient profile of livestock carcass composting.
- Establish an economic model for composting procedures and benefits (for use upon legalization of composting in California).
- Use research findings to develop policy guidelines for the appropriate use of carcass composting and extend results to livestock producers, UC Cooperative Extension Advisors, regulatory agencies and others.

IREC Potato Projects

132-Potato Variety Selection Evaluation & Development

Principal Investigator: Rob Wilson, Center Director/Farm Advisor, UC Intermountain Research & Extension Center; David Holm, Professor of Horticulture, Colorado State University; Julian Creighton Miller, Professor of Horticulture, Texas A & M University; Brian Charlton, Cropping Systems Specialist, Oregon State University, Klamath Basin Research and Experiment Center

- Evaluate new russet, specialty, and chip cultivars developed by public and private breeding programs for adaptation and suitability to Tulelake's unique soil, climate and marketing conditions.

151- Investigation of Cover Crops and Compost to Improve Soil Health in Conventional and Organic Crop Rotations in Tulelake

Principal Investigator: Rob Wilson, Center Director/Farm Advisor, Intermountain Research and Extension Center; Daniel Geisseler, UC Davis Nutrient Management Specialist; Sonja Brodt, Academic Coordinator UCSAREP

- Estimate soil practices' environmental and agronomic benefits and pitfalls
- Increase land manager knowledge and adoption of cover crops and compost
- Compare the use of cover crops and compost in conventional and organic cropping systems

IREC Small Grains Projects

213-California Small Grain Variety Selection Trial

Principal Investigator: Mark Lundy, UC Specialist, Dept. of Plant Sciences, Davis.

- To determine productivity, phenological information and disease incidence for smallgrains relevant to the intermountain region.

239-Spring Barley Breeding Trials

Principal Investigator: Allison Krill, Dept. of Plant Sciences, UC Davis. Project Coordinators: Dr. Jorge Dubcovsky, Assistant Professor, Dept. of Plant Sciences, UC Davis; Charles Brummer, Director, Plant Breeding Center, UC Davis.

- Evaluate advanced experimental two-row malting barley lines from the UCD barley breeding program that have been selected over the previous two years.
- Evaluate and increase three six-row forage barley lines that wer of interest to growers in 2018.

260-Development of Wheat Varieties for California

Principal Investigator: Dr. Jorge Dubcovsky, Assistant Professor, Department of Plant Sciences, UC Davis; Oswaldo Chicaiza, Research Assistant, Department of Plant Sciences, UC Davis; John Heaton, Department of Plant Sciences, UC Davis.

To produce new varieties & improved germplasm and distribute them to growers, breeders and other researchers. A multi-objective project will be conducted which:

- Introduces new germplasm for evaluation and breeding
- Develops breeding populations through hybridization, selection and evaluation
- Develops information on the inheritance of characters important to quality and yield in California production environments and finds molecular markers to assist the introgression of these characters into adapted breeding lines, and finally
- Produces Breeders Seed for multiplication as new varieties and germplasm for distribution to breeders and researchers. Specific goals are to introduce and maintain disease resistance, maintain or increase grain yield potential and improve end-use characteristics

274-Use of Plant Growth Regulators (PGR) to Prevent Winter Wheat and Barley Lodging in Tulelake

Principal Investigator: Rob Wilson, Center Director/Farm Advisor, UC Intermountain Research & Extension Center

- Test different rates and timings of PGRs to determine the PGR's influence on lodging, wheat yield, and wheat grain quality.

2019 Onion Pest Management Updates

By Rob Wilson, IREC Center Director/Farm Advisor, Darrin Culp, IREC Principal Superintendent of Agriculture & Kevin Nicholson IREC Staff Research Associate

The major focus of 2019 onion pest management studies are control of maggots and onion smut. Maggots (the larval stage of flies) including onion maggot, *Delia antiqua*, and seed corn maggot, *Delia platura*, are widespread onion pests in Tulelake. Onion stand loss from maggots is routine each year, and the most common insecticide for maggot control, chlorpyrifos, is being phased out. With the loss of chlorpyrifos, growers have turned to insecticide seed treatment for preventing stand loss from maggots. 2019 studies compared different seed treatment active ingredients and coatings.

Onion smut, *Urocystis colchici* or *U. cepulae,* is a common disease throughout the US especially in areas where onions are grown in short rotation for many years. The fungus survives in the soil and spores may persist for over 15 years. Spores are triggered to germinate by onion exudates like white rot. Onions are susceptible to infection from planting until the cotyledon is fully mature approximately 12-24 days after planting. Once plants are infected the fungus can spread to new leaves resulting in stunted plants, stand loss, and severe yield loss. Current management options include transplanting healthy sets, fungicide seed treatment, and fungicide application in-furrow. 2019 studies compared fungicide treatments for smut control.

Early season onion stand and vigor evaluations are presented in Tables 1 & 2. Seed treatments with Regard or Sepresto provided the highest onion stands (ie best suppression of maggots) in the insecticide comparison study (Table 1). There were no differences in onion stand when comparing seed coatings (filmcoat vs. pelleted) (Table 1). Onions treated with Pro-Gro applied as a filmcoat had lower vigor compared to the pellet agreeing with company reports that Pro-Gro should be applied as a pellet. Fungicide treatments with peneflufen and Pro-Gro provided the best suppression of onion smut (Table 2).

Table 1. Influence of 2019 Maggot Treatments on Early Season Onion Stand & Vigor

Insecticide Comparison for Maggot Control in Onion

Trt #	Treatment	2-leaf vigor	2-leaf onion stand	7-leaf vigor
		1-10; 10= best	# of onions/plot	1-10; 10= best
1	Penflufen + thiram (control)	6.4 b	403 b	6.4 b
2	Penflufen + thiram + Regard	7.4 a	597 a	7.4 ab
3	Penflufen + thiram + Regard + Cruiser	7.4 a	586 a	7.8 ab
4	Penflufen + thiram + Sepresto	7.4 a	572 a	7.6 ab
5	Penflufen + thiram + Trigard	7 ab	454 b	7.6 ab
6	Penflufen + thiram + Agri-Mek in-furrow	6.8 ab	407 b	7.2 ab

Pellet Vs. Film Coat for Maggot Control in Onion

Trt #	Treatment	2-leaf vigor	2-leaf onion stand	7-leaf vigor
		1-10; 10= best	# of onions/plot	1-10; 10= best
7	Sepresto + Thiram + Penflufen (pelleted)	7.8 a	593 a	7.6 ab
8	Sepresto + Thiram + Penflufen (film-coat)	7.4 ab	605 a	8 a
9	Sepresto + Pro-Gro + F300 (pelleted)	7.2 ab	589 a	7.8 a
10	Sepresto + Pro-Gro + F300 (filmcoat)	6.4 b	568 a	7 b
11	Regard + Thiram (pelleted)	7.8 a	599 a	7.8 a
12	Regard + Thiram (film coat)	7.8 a	594 a	7.8 a

Regard Vs. Trigard for Maggot Control in Onion

Trt #	Treatment	2-leaf vigor	2-leaf onion stand	7-leaf vigor
		1-10; 10= best	# of onions/plot	1-10; 10= best
13	FarMore 300 (control)	7.8 a	543 a	6.8 a
14	FarMore F300 + Cruiser	8 a	590 a	7.8 a
15	FarMore F300 + Cruiser + Regard (FI500)	8 a	634 a	7.8 a
16	FarMore 300 + Cruiser + Trigard	8 a	612 a	7.8 a

Table 2. Influence of 2019 Onion Smut Treatments on Early Season Onion Stand, Onion Vigor, and Smut Supression

Trt #	Treatment	2-leaf vigor	2-leaf onion stand	5-leaf smut severity
		1-10; 10= best	# of onions/plot	1-10; 10=most severe
1	Sepresto + Thiram	5.2 d	536 b	7 a
2	Sepresto + Thiram + Penflufen	8.5 a	592 a	3 c
3	Sepresto + Thiram + Rancona	7.5 c	591 a	4.5 b
4	Sepresto + Pro-Gro	7.7 bc	587 a	3.7 bc
5	#4 + chlorpyrifos liquid in-furrow	8 abc	593 a	3.7 bc
6	#4 + manzate max + fontelis in-furrow	8.3 ab	588 a	3 c

UC Triticale Breeding: Enhancing Baking Performance

Josh Hegarty, Postdoctoral Researcher, UC Davis

Known as triticale for its combination of wheat species from the genus *Triticum* and rye from the genus *Secale*, it was created to combine the agronomic and end-use quality of wheat with the drought resilience of rye. Through decades of breeding efforts, new triticale cultivars have higher yield potential for both grain and forage than wheat and other small grains. The final challenge preventing triticale from achieving its full potential as a grain crop is the lack of sufficient end use quality required for the production of bread and other human food products.

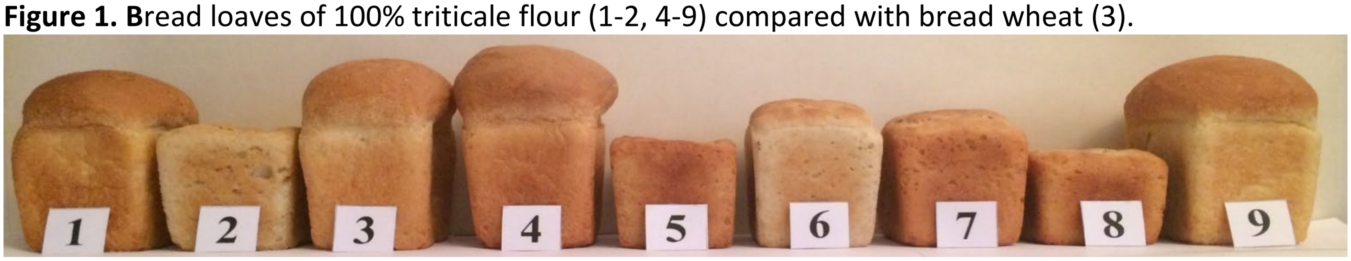
The primary goal of the UC triticale research and breeding program is to develop cultivars with improved grain quality. We are utilizing modern breeding techniques to leverage the knowledge gained on the genetic basis of wheat grain quality. This effort began with the acquisition of over 500 triticale lines from around the world that are adapted to a range of environments from autumn planting in Poland to spring planting in Mexico. We then evaluated these lines for grain yield and with rapid tests for grain quality, including protein, hardness, and SDS sedimentation. We then selected three lines with a high yield potential into which we are bringing genes from wheat known to improve milling and baking performance. In some preliminary test, without only three of our six targeted genes, we have observed a 5 fold increase in mixing tolerance and loaf volumes as high as 80% of bread wheat. As this research progresses, we are confident that we will produce triticale with a milling and baking performance that is competitive to wheat.

In addition to baking performance, we are making selections for more traditional forage and feed uses of triticale. While the research and breeding are primarily based in Davis, CA and focused on spring material, we have initiated a collaboration between multiple public wheat breeding programs to facilitate the selection and evaluation of winter adapted triticale. This nascent collaboration includes two locations in eastern Colorado, two in Washington in addition to Tulelake, CA. The development of triticale for human consumption will be a paradigm shift for triticale and through this collaboration, our germplasm will be adapted to the upper Great Planes, the Pacific Northwest and California with both spring and winter growth habits.

	Yield kg/ha			
Line	2017		2018	
UC3184	10302	A	10361	A
UC3185	9390	A	9148	B
UC3190	9022	A	9663	AB
NS-158EP	7040	B	8802	BC
NS-Camelot	6757	BC	8076	C
Patwin515HP	6472	C	7008	D

Table 1. Yield performance of three UC Davis triticale lines compared with two commercial available triticale varieties from the TriCal brand of Northern Seed (NS), NS-158EP and NS-Camelot and with the common wheat variety, Patwin515HP. Different letters indicate significant differences at $P < 0.05$. (LSD).

Figure 1. Bread loaves of 100% triticale flour (1-2, 4-9) compared with bread wheat (3).



Developing Barley Varieties for the Klamath Basin

Allison Krill-Brown, UC Davis Barley Breeder

Objectives: To develop spring planted 6-row feed barley and 2-row malt barley for the Klamath Basin
Main breeding goals: Yield, Disease Resistance, Lodging Resistance, Malting Quality (2 row)

Field layout. 6 row feed barley in strips. 2 row malt barley in replicated trial with checks (4 reps)

6 row feed barley				2 row malt barley							
UC 1337 6R	UC 1341 6R	UC 1278 6R	10	UC1390	B9K62	OP424	I409	I220	I344	I221	
			9	I341	UC1322	**Francine**	OP328	I217C	I219	I459	
			8	**Copeland**	**Butta12**	OP91	I291	B9K62	**Francine**	OP91	
			7	UC1322	I217C	I218	OP327	I343	I458	OP424	
			6	I219	**Copeland**	I290	**Butta12**	I340	I220	I409	N
			5	I289	**Butta12**	I217	OP326	I217C	B9K62	UC1390	
			4	**Copeland**	I457	I409	I339	I218	I342	I218MQ	
			3	**Francine**	**Copeland**	B9K62	**Francine**	OP424	OP91	UC1322	
			2	**Butta12**	I217	I288	I218	I217C	I216	OP325	
			1	OP91	OP424	I409	I341	I338	UC1322	I456	
				1	2	3	4	5	6	7	

Planted: 5-2-19 | 100 g/plot, 96lb/acre | ***check variety**

2017-2018 data from 2 row malt lines selected for the 2019 trial. Malt Quality data on 2018 in progress.

	2018					2017				Malt Quality (2017)			
Name	Ht (cm)	Lodging (%)	**Yield (lb/A)**	Heading Date	Maturity Date	**Yield (lb/A)**	Ht (cm)	Heading Date	Maturity Date	Kernel weight (mg)	Malt extract (%)	Protein (%)	BG (ppm)
OP91	115	5	7595	5-Jul	16-Aug	6563	86	1-Jul	3-Aug	46.9	81.9	**9.8**	132
OP424	108	35	7875	5-Jul	15-Aug	6691	80	3-Jul	3-Aug	46.4	81.7	**10.1**	**85**
I409	109	26	7835	6-Jul	15-Aug	5600	38	9-Jul	7-Aug	**53.3**	80.1	12.4	370
I341	110	5	**9100**	7-Jul	16-Aug								
I338	108	**0**	**8060**	28-Jun	16-Aug	6367	90	5-Jul	3-Aug	44.8	83.5	**10.2**	295
UC1322	103	15	7890	4-Jul	13-Aug								
I456	**85**	**0**	7800	28-Jun	**10-Aug**								
OP325	110	**0**	7440	28-Jun	16-Aug								
I216	117	**0**	7400	6-Jul	13-Aug								
I217C	117	**0**	7370	28-Jun	**6-Aug**								
I218	113	**0**	7290	6-Jul	16-Aug								
I288	**87**	**0**	7150	28-Jun	**10-Aug**								
I217	113	**0**	7130	28-Jun	13-Aug								
Butta12*	98	15	7890	23-Jun	**9-Aug**	**6768**	75	**28-Jun**	**1-Aug**	47.7	79.8	12.9	337
Francine*	110	**0**	**9875**	4-Jul	15-Aug								
Copeland*	120	44	**8320**	5-Jul	7-Aug								

*check variety

Agronomic data on 6 row feed barley varieties.

6 row feed barley													
	2018					2016	2015			2014		2013	
	IREC					IREC	LASSEN	SISKIYOU	IREC	LASSEN	IREC	LASSEN	IREC
Name	Ht (cm)	Lodging (%)	**Yield (lb/A)**	Heading Date	Maturity Date	**Yield (lb/A)**							
UC1278	107	0	**8405**	6-Jul	24-Aug	6404*							
UC1341	107	0	**8270**	10-Jul	30-Aug	7532*	5210	3080	5040	3790	4600	3510	7290
UC1337	88	0	4460	10-Jul	30-Aug	7477*							
STEPTOE						4989	4430	3510		3720	4430	3720	6195

*top 3 for yield in regional trials

Investigation of Cover Crops and Compost to Improve Soil Health in Conventional and Organic Crop Rotations in Tulelake

By Rob Wilson, IREC Center Director/Farm Advisor & Dr. Daniel Geisseler, UC Davis Nutrient Management Specialist

This project is investigating the influence of cover crops and compost on soil health in Tulelake. Objectives include: 1.) estimating soil practices' environmental and agronomic benefits specific to the region and 2.) increasing land manager's knowledge and adoption of the practices. Data include several soil health and agronomic production criteria. The study is being conducted at IREC using a barley, potato, and wheat rotation grown both conventional and organic. The inclusion of both methods is needed to accurately estimate changes in soil and crop yield in both systems and it provides the unique opportunity to compare soils, pests, and crop development in both systems. Table 1 shows a list of treatments in the study.

Table 1. Soil Management Treatment List and Cropping Plan

Treatment	Year 1 (2018)	Year 2 (2019)	Year 3 (2020)
1a. Untreated Control-Conventional Rotation	Spring 2-row malt barley grown for grain	Spring planted potatoes	Winter wheat grown for grain
1b. Untreated Control-Organic Rotation	Spring 2-row malt barley & spring application of composted chicken manure	Spring planted potatoes	Winter wheat grown for grain
2a. Compost Application-Conventional Rotation	Spring 2-row malt barley grown & spring compost application	Spring planted potatoes & fall compost application	Winter wheat grown for grain
2b. Compost Application- Organic Rotation	Spring 2-row malt barley & spring application of compost & composted chicken manure	Spring planted potatoes & fall compost application	Winter wheat grown for grain
3a. Cover Crop-Conventional Rotation	Spring mustard & field pea green manure and fall woollypod vetch cover crop	Spring planted potatoes	Winter wheat grown for grain
3b. Cover Crop - Organic Rotation	Spring mustard & field pea green manure and fall woollypod vetch cover crop	Spring planted potatoes	Winter wheat grown for grain

Conventional Rotation- Crops are grown using synthetic fertilizers and pesticides to match UC recommendations. Solid-set sprinklers are used for irrigation.

Organic Rotation- Crops are grown without synthetic fertilizers and pesticides and instead use organically approved practices according to UC recommendations. Nutrient deficiencies are corrected with organic amendments and pests are controlled with organically approved controls. Composted chicken manure was applied in spring 2018 to fertilize the barley crop. Feathermeal was applied in spring 2019 to fertilize the potato crop. Organic amendments were applied at the same nitrogen rate per acre compared to synthetic fertilizer. Solid-set sprinklers are used for irrigation.

Compost- The compost used in treatments 2a and 2b was a green waste compost that contained a high carbon content (C:N ratio 14) applied at 5 ton/acre.

Preliminary Results- Baseline soil properties before treatments were applied are shown in Table 2. Barley biomass in the untreated and compost treatments was measured on July 11, 2018 when barley was in the flowering stage. Pea/ mustard cover crop biomass was also measured on July 11, 2018 shortly before chopping and incorporation. Biomass yield and nutrient content for all treatments are presented in Table 3. Barley produced more biomass than the pea and mustard cover crop (Table 3), but all biomass contained similar lbs of nitrogen per acre as the pea and mustard cover had higher % nitrogen. Biomass from the organic untreated barley had more phosphorus compared the conventional untreated barley likely from added phosphorus in the chicken manure. The cover crop biomass had more sulfur compared to all barley treatments. Barley grain yield and bushel weights were similar for both treatments suggesting compost had no impact on barley yield. (Table 3).

Soil samples were collected in spring 2019 shortly before potato planting. Mineralized nitrogen available at potato planting for three soil depths is shown in figure 1. Both cover crop treatments had significantly higher mineralized nitrogen at all sampling depths compared to the control and compost treatments. Mineralized nitrogen did not differ between conventional and organic production systems. The deepest (16 to 24 inch) sampling depth had higher nitrogen compared to the shallower depths likely due to nitrate leaching from precipitation in late winter and spring. Ninety pounds of nitrogen as urea (conventional) or feathermeal (organic) were applied to the untreated and compost treatments to augment soil nitrogen for potato production. The cover crop treatment did not require additional fertilizer at potato planting.

Along with soil health, the economic benefit of compost and cover crops is an important consideration for growers. Conventional barley returned $486 per acre last year while organic barley returned roughly double that of conventional. To date, compost did not provide an economic benefit compared to the untreated control. Compost barley yields were similar to the untreated, and soil in the compost treatments required similar fertilization for barley and potatoes compared to the untreated. Conventional and organic fertilizer costs up until this point (barley and potato crop) differ significantly. The conventional fertilizer cost is $90 per acre and organic fertilizer cost is $766 per acre. The economic benefit of growing the cover crop could pay for itself in an organic system. For example, an organic producer would need to make at least $766 per acre on a barley crop to cover the additional organic fertilizer input cost compared to cover crops.

Table 2. Baseline soil characteristics determined in samples collected on May 1st, 2018. Values are means with standard deviation (n = 4).

			Treatment					
Soil Property	**Units**	**Depth**	**Untreated Conventional Production**	**Untreated Organic Production**	**Compost Conventional Production**	**Compost Organic Production**	**Cover Crop Conventional Production**	**Cover Crop Organic Production**
Soil organic matter	(%)	0-8 in.	6.08 (0.34)	6.02 (0.37)	6.01 (0.16)	6.06 (0.14)	6.08 (0.34)	6.07 (0.25)
Total C [1)]	(g kg^{-1})	0-8 in.	35.29 (1.96)	34.92 (2.15)	34.88 (0.90)	35.13 (0.82)	35.25 (2.00)	35.21 (1.44)
Total N [1)]	(g kg^{-1})	0-8 in.	3.38 (0.16)	3.38 (0.22)	3.52 (0.02)	3.53 (0.11)	3.52 (0.23)	3.65 (0.21)
POXC [2)]	(mg kg^{-1})	0-8 in.	879 (61.8)	867 (25.2)	914 (47.4)	975 (45.2)	999 (79.6)	998 (42.1)
Residual mineral N [3)]	(mg kg^{-1})	0-8 in.	19.39 (1.06)	20.71 (3.78)	18.32 (2.10)	20.31 (3.44)	19.16 (2.48)	18.59 (1.06)
		8-16 in.	36.41 (2.38)	36.51 (3.89)	31.5 (2.78)	34.73 (5.90)	30.94 (2.50)	32.62 (2.71)
		16-24 in.	36.19 (7.58)	37.94 (3.90)	28.47 (3.78)	32.22 (7.47)	30.77 (9.33)	34.04 (7.07)
Water holding capacity	(g g^{-1})	0-8 in.	0.84 (0.02)	0.83 (0.05)	0.84 (0.02)	0.84 (0.05)	0.85 (0.04)	0.8 (0.05)
pH		0-8 in.	6.35 (0.03)	6.39 (0.02)	6.44 (0.04)	6.38 (0.02)	6.4 (0.02)	6.41 (0.02)
EC [4)]	(dS/m)	0-8 in.	0.17 (0.01)	0.17 (0.01)	0.15 (0.01)	0.16 (0.01)	0.15 (0.01)	0.15 (0.01)
Microbial biomass C [5)]	(mg kg^{-1})	0-8 in.	292 (44.0)	277 (6.7)	261 (101.6)	286 (28.0)	267 (65.2)	266 (48.5)
Olsen P	(mg kg^{-1})	0-8 in.	31.81 (3.60)	30.04 (4.13)	29.56 (2.12)	29.97 (2.49)	28.84 (3.03)	30.16 (0.40)
Extractable K [6)]	(mg kg^{-1})	0-8 in.	267 (51)	236 (78)	232 (28)	210 (27)	222 (40)	214 (23)
Extractable Ca [6)]	(mg kg^{-1})	0-8 in.	4958 (260)	4962 (403)	5204 (384)	4581 (205)	4888 (563)	5021 (397)
Extractable Mg [6)]	(mg kg^{-1})	0-8 in.	1471 (92)	1465 (110)	1547 (109)	1367 (52)	1444 (160)	1480 (137)
Extractable Na [6)]	(mg kg^{-1})	0-8 in.	292 (44)	286 (47)	314 (26)	266 (28)	273 (35)	292 (34)

[1)] by dry combustion; [2)] Permanganate oxidizable carbon; [3)] Sum of ammonium-N and nitrate-N; [4)] Determined in a 1:5 soil: water slurry; [5)] by chloroform fumigation extraction method; [6)] in ammonium acetate extract

Table 3. Biomass and nutrient content for barley plants (untreated and compost treatments) and field pea/mustard cover crop (cover crop treatment) sampled on July 11, 2018. Barley grain yield and bushel weights collected on August 30, 2018 are shown for untreated and compost treatments. Values are means. Means with different letters within rows represent a significant difference (P< 0.05).

		Treatment				
Measurement	Units	Untreated Conventional Production	Untreated Organic Production	Compost Conventional Production	Compost Organic Production	Cover Crop Conventional & Organic Production
Biomass yield [1]	(lbs/acre)	7962a	8647a	8034a	8568a	6735b
Biomass % dry matter [2]	(%)	13.3a	14.1a	13.7a	14.0a	8.7b
Biomass % N [2]	(%)	3.33ab	2.96b	3.17ab	2.94b	3.58a
Biomass lbs N/A [3]	(lbs/acre)	264a	254a	254a	248a	241a
Biomass % P [2]	(%)	.36b	.38b	.36b	.38b	.43a
Biomass lbs P/A [3]	(lbs/acre)	28b	33a	29ab	33ab	29ab
Biomass % K [2]	(%)	2.95a	3.09a	2.81a	2.86a	2.82a
Biomass lbs K/A [3]	(lbs/acre)	238ab	271a	226ab	246ab	189b
Biomass % S [2]	(%)	.24b	.23b	.24b	.22b	.64a
Biomass lbs S/A [3]	(lbs/acre)	19b	20b	20b	19b	44a
Barley Grain Yield	(lbs/A)	5156a	5777a	5261a	5449a	n/a
Barley Bushel Wt.	(lbs)	45.2a	45.3a	42.9a	43.2a	

[1] 100% dry matter; [2] % of sub-sample [3] Calculated lbs of nutrient per acre in biomass

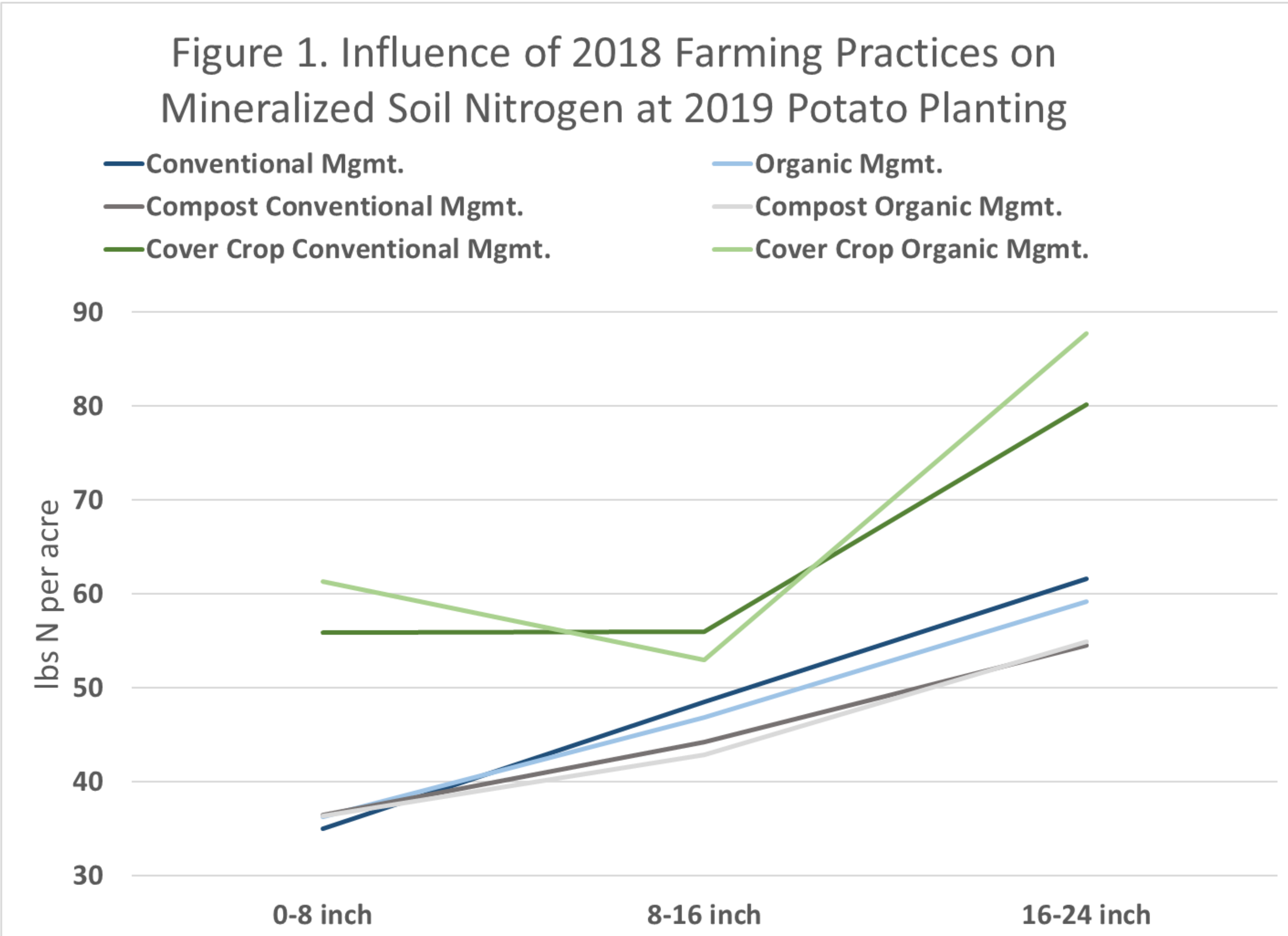


Figure 1. Influence of 2018 Farming Practices on Mineralized Soil Nitrogen at 2019 Potato Planting

Managing clover root curculio in alfalfa hay

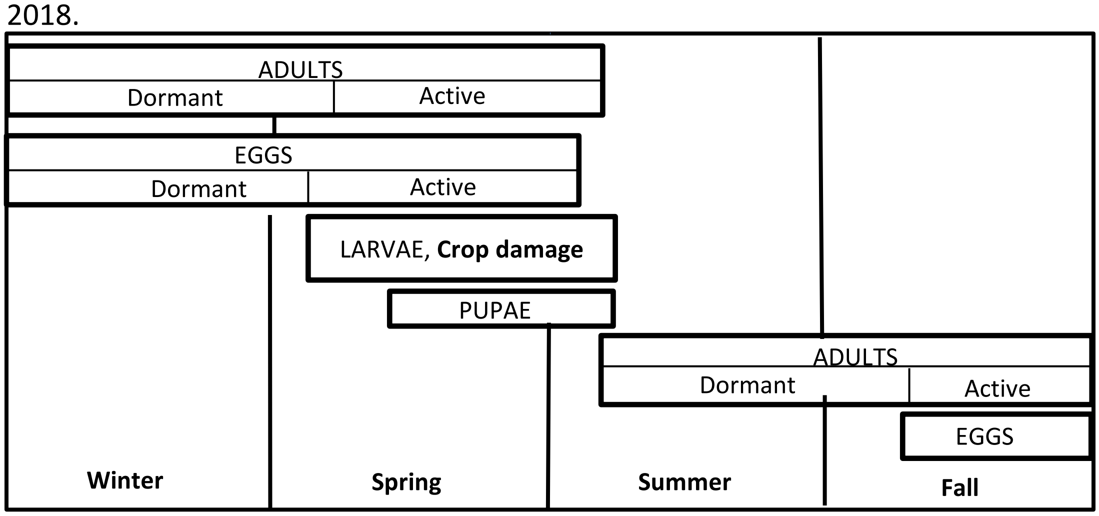
Rachael Long[1], Jasmin Ramirez Bonilla[2], Rob Wilson[3], Ian Grettenberger[3]

Introduction. The clover root curculio (CRC) is a weevil (beetle) that feeds on alfalfa roots in the larval stage, resulting in yield and stand losses. Adults feed on alfalfa foliage, but are generally not economically damaging, except occasionally for very young seedling stands in fall plantings where they can cause stand losses. Adult CRC are similar in appearance to alfalfa weevils, but tend to be smaller and have a shorter and broader snout. CRC larvae are whitish and found in the soil while alfalfa weevil larvae are greenish and feed on the foliage.

Clover root curculio is an introduced pest from Eurasia with few natural enemies to help control them. The primary host is alfalfa; however, CRC will also feed on most clovers in the *Trifolium* group (red, white, berseem) as well as soybeans and cowpeas. Clover root curculio is primarily a pest in cooler regions, including the Intermountain Region, but occasionally can be found in the Sacramento Valley.

Lifecycle and damage. Clover root curculio has one generation per year (Fig. 1). CRC overwinters in alfalfa fields in egg and adult stages. In the Klamath Basin, CA, adults begin to emerge mid-spring, when temperatures begin to warm (around 50^{o}F); they lay eggs at the base of alfalfa crowns, in soil or duff. When eggs hatch, larvae feed on roots and nitrogen fixing nodules during the growing season mostly in the top 8-inches of soil. Feeding damage weakens plants and creates entry wounds for secondary pathogens, such as *Fusarium* and *Phytophthora,* further injuring them. Most adults leave the field during the summertime and come back in the fall to lay eggs that stay dormant until the following spring.

Figure 1. Clover root curculio life history based monitoring this pest in the Klamath Basin, CA, during 2018.



Monitoring and Control

The easiest way to determine if you have clover root curculio in your field is to look for patches of alfalfa plants that are not growing or wilted and then dig up plants to look for feeding damage on roots. Larvae furrow and girdle plant roots, often leaving large gouges. The larvae are difficult to spot because they are small and cryptic. Unfortunately, there are no insecticides registered to control CRC larvae in alfalfa. With host specificity for alfalfa, crop rotation to non-host plants for at least two years is the key management practice for controlling CRC. Adult weevils can live for a year, so rotating fields out for one year is not enough time.

---

[1] RF Long, UCCE Farm Advisor, Yolo County, rflong@ucdavis.edu; [2]J Ramirez Bonilla, Junior Specialist, Dept. Entomology, UC Davis; [3]R Wilson, IREC Director and Farm Advisor, Tulelake, [8]I Grettenberger, Extension Entomologist, UC Davis.

Spring 2018 Insecticide Trial

A trial was conducted in 2018 to look at the efficacy of insecticides for CRC control in springtime. There were no significant differences eggs, larvae, or yield between treatments at harvest for spring treatments (Figs 2, 3, and 4). This timing is not effective because adults lay eggs for a long time (spring to summer), escaping pesticide treatment and overwintering eggs in the soil cannot be controlled with available alfalfa pesticides. Besiege was applied twice (4 weeks after first application). Agri-Mek* is not registered for use in alfalfa production.

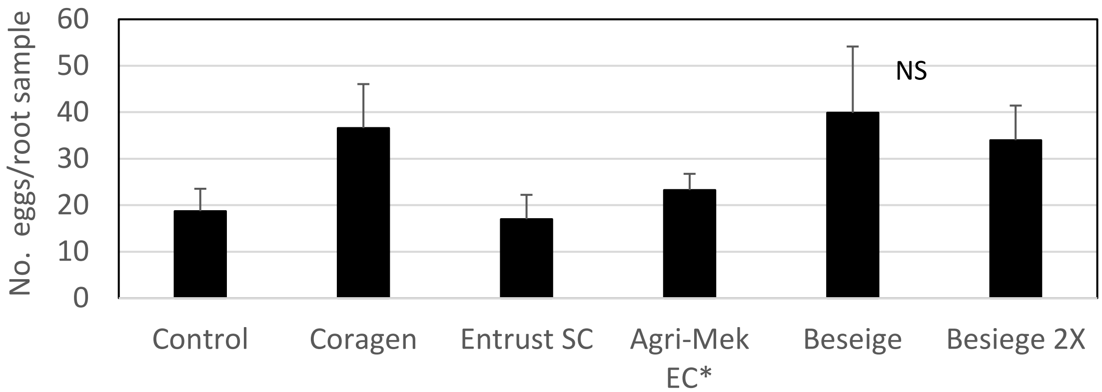


Figure 2. Number clover root curculio eggs/root sample vs. treatment, Tulelake, CA. Insecticides applied May 10, 2018, highest labelled rate. 1-ft deep root samples taken 2, 4, 6 weeks post treatment. Agri-Mek experimental (not registered for use on alfalfa). Besiege applied twice, second time 4 weeks after 1st application.

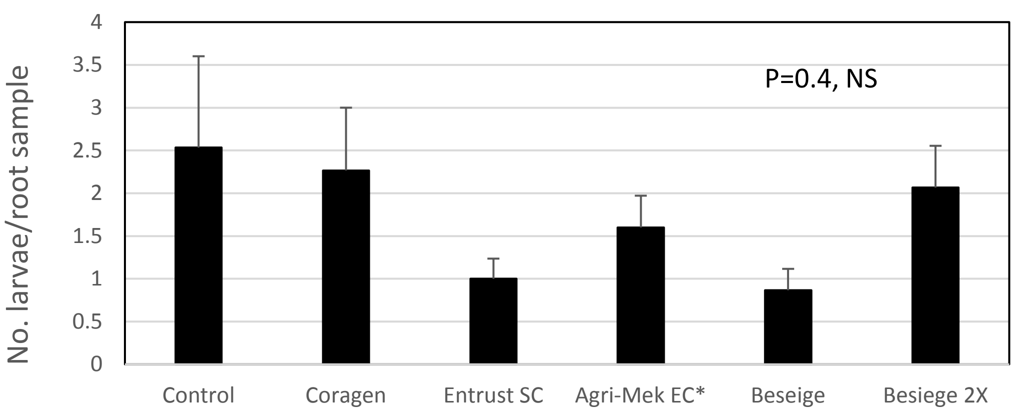


Figure 3. Number of clover root curculio larvae/root sample vs. treatment, Tulelake, CA. Insecticides applied May 10, 2018, highest labelled rate. 1-ft deep root samples taken 2, 4, 6 weeks post treatment. Agri-Mek experimental (not registered for use on alfalfa). Besiege applied twice, second time 4 weeks after 1st application.

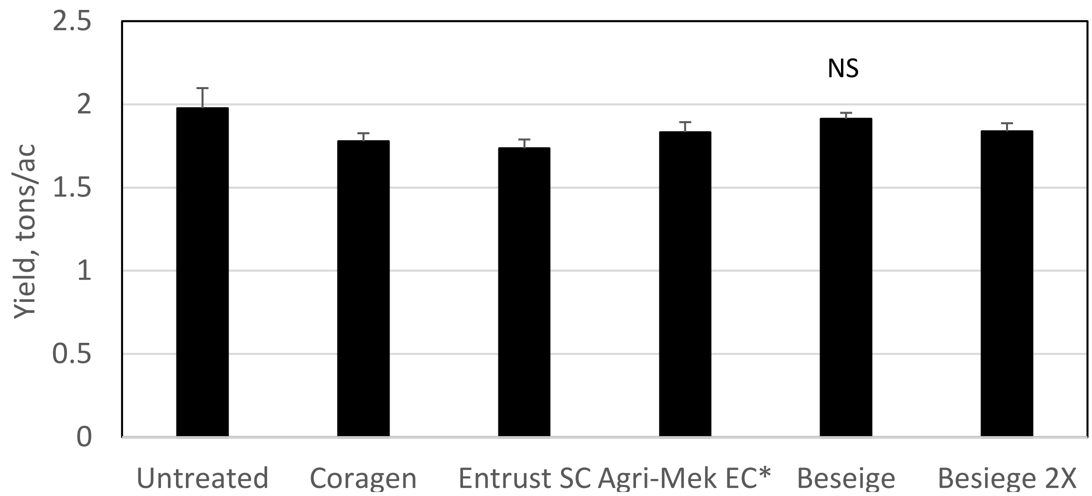


Figure 4. Yield versus treatment for clover root curculio control, Tulelake, CA (first cut, June 21, 2018). Insecticides applied at highest labelled rate on May 10, 2018. Agri-Mek EC* is not registered for use in alfalfa. There were no differences in yield between treatments.

Fall Insecticide Trial

We also evaluated a fall spray for adult control at the end of the season, when adults migrate back into alfalfa fields. Our data show that adult numbers were reduced by fall treatments (Fig. 5), along with marginally reduced overwintering eggs the following spring (Fig. 6). Very few larvae (2 total in all plots) were found in June 2019, so we do not know the impact on larval control. However, we will take yields this summer to see if there are any difference in yield by insecticide treatment.

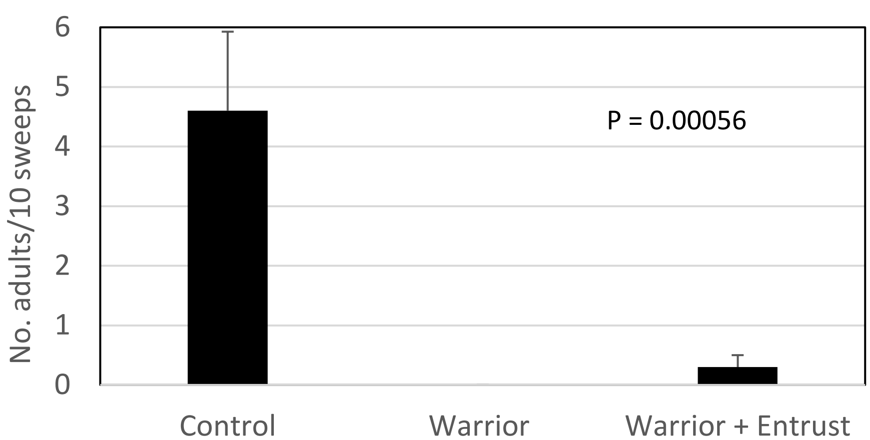


Figure 5. Number of adults per 10 sweeps versus treatment for clover root curculio control, Tulelake, CA. Insecticides applied at highest labelled rate on September 10, 2018.

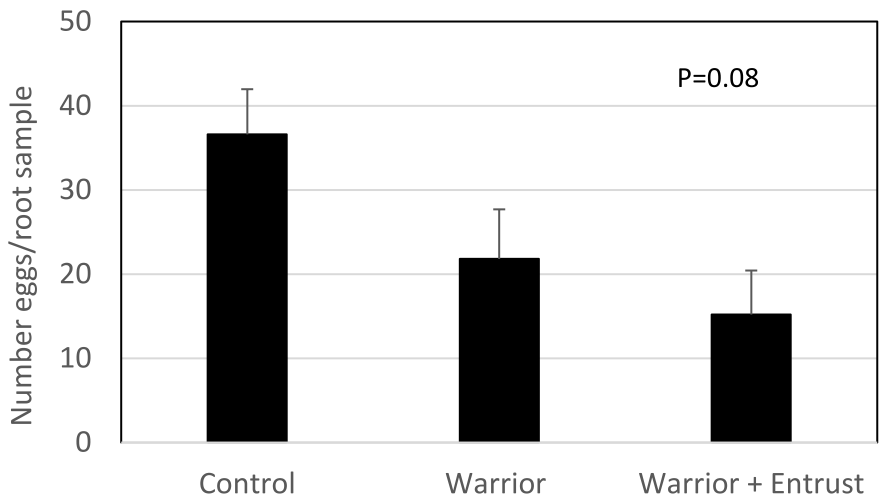


Figure 6. Number clover root curculio eggs/root sample in Spring 2019, for insecticide treatments applied in the Fall 2018. Root samples, 1-ft deep taken on April 17, 2019, Tulelake, CA.

Conclusion. Current management recommendations for clover root curculio control include rotating infested fields to a non-host crop (something other than alfalfa and legumes, including clovers, soybeans, or cowpeas), avoiding planting new alfalfa fields next to infested fields, and proper irrigation and nutrient management, to ensure a heathy alfalfa stand that is better able to withstand larval damage (especially accompanying secondary diseases). In addition, equipment should be cleaned after visiting infested fields to prevent spreading the pest to new fields. Fall insecticide treatments might help control CRC by controlling adults and potential egg-laying when they migrate back into alfalfa fields. This could help control the overwintering egg population and potentially reduce larval infestations the following spring. Possible treatment timing would be when adults are consistently found with a sweep net in alfalfa fields the fall and numbers are increasing.

This research is supported by a grant from USDA-NIFA; lead PI, Dr. Ricardo Ramirez, Utah State University. A special thanks to field and lab staff at UC Davis and Tulelake IREC for help in collecting and processing alfalfa samples.

Frost Injury on Roundup Ready Alfalfa

Tom Getts, Lassen Weed Ecology and Cropping Systems Advisor; Giuliano Galdi, Siskiyou Agronomy and Crop Advisor; and Rob Wilson, IREC Director and Farm Advisor

** This research is a continuation of work initially conducted by Steve Orloff. Steve's terrific scientific insight and constant wise cracks are surely missed.

Background:

Roundup Ready Alfalfa has been a tremendous weed control tool since it's second release in 2011. It has provided a useful strategy for controlling difficult weeds in alfalfa, particularly perennial species. Initial screening of the technology throughout the 2000's found excellent crop safety at a variety of growth stages.

In 2014, Steve Orloff and growers in Scott Valley observed injury to Roundup Ready Alfalfa, after applications of Roundup (glyphosate) were followed by frost. At the time, it was unclear what conditions, or agronomic practices, resulted in the injury occurring, and it was not known what role Roundup played.

During the field season of 2015, initial field trials were conducted, which replicated crop injury observed in 2014. The initial trials found significant yield differences between alfalfa treated with Roundup followed by a frost, compared to an untreated control plot. During the 2016 and 2017 growing seasons, research ramped up and numerous replicated field trials were conducted throughout the Intermountain Region of California. These trials focused on determining what agronomic practices could be taken in order to avoid injury to Roundup Ready Alfalfa after application of glyphosate.

In the 2016 and 2017 trials, applications of a low rate and high rate of Roundup were applied at various heights after the alfalfa broke dormancy. While some trial locations had variable crop injury, many locations found significant alfalfa yield reductions after applications of Roundup followed by frost. No visible injury occurred when applications were made to alfalfa shorter than 2 inches in height. However, applications to alfalfa 4 inches and taller resulted in visible injury occurring. Overall, the most injury occurred when higher rates of Roundup were applied to alfalfa plants between 6 and 8 inches. It is unclear how long after application a frost occurs that injury can still result.

The injury observed is not typically symptomology associated with a glyphosate treatment. Following frost after application, individual alfalfa stems would curl over and die, forming a shepherd's crook (Photo One and Two). Stems and plants would continue to show this symptomology develop for weeks after treatment. Additionally, some of the alfalfa plants developed chlorosis and stunting following the applications, resulting in yield loss. Injury is not always readily apparent at first glance, as stems in the understory often showed the worst symptoms.

The shepherd's crook symptomology on the affected alfalfa stems looked eerily similar to symptoms caused by bacterial stem blight. Pseudomonas syringe is a common bacterium found many places. It has a protein that mimics a crystalline structure and helps start the formation of ice. When water freezes, it needs a starting point for ice crystals to form, which the bacteria provides. After ice formation occurs, damage to the plant tissue allows a pathway for the bacteria to enter the tissue of the plant, causing infection. Pseudomonas syringe and frost damage have been studied extensively in a variety of annual crops. However, it has not been the focus of much research, until recently, within alfalfa. Initial trials in

2017 began to investigate the possibility of pseudomonas syringe playing an increased role in crop injury of applications of glyphosate, but trials were inconclusive.

While the 2015-2017 field trials found treating alfalfa early would minimize the risk of injury, it was still unknown exactly what combination of factors was resulting in the injury. Trials resumed in 2019 to replicate previous trials, to test new agronomic practices, and to continue to investigate the role of pseudomonas syringe in injury observed.

Three trial locations were selected in the Intermountain Region of California: Tulelake, Scott Valley and the Honey Lake Valley. Two sets of trials were put out at each location. The first trial made applications of Roundup to alfalfa at various growth stages, to replicate previous studies. Additional treatments at taller crop growth stage were added, to potentially avoid crop interaction with frost. The second trial focused on weekly applications of a bactericide to eliminate the pseudomonas syringe populations with and without glyphosate application.

Methods: Trials consisted of four replications of 10*20 ft. plots laid out in a randomized complete block design. Applications were made with a CO2 pressured backpack sprayer delivering 20 gal/acre. Temperature loggers were included at all trial locations to capture frost events. Visual injury, and the number of injured stems, crop height, and yield were measured for the first cutting.

Results:

Height Application Trial: Results can be observed in tables 1-4

Bactericide Trial: Results can be observed in tables 5-8.

Discussion:

Results from the trial locations in 2019 replicated results found in previous years' trials. There is potential for crop injury to occur after applications of glyphosate followed by frost. However, like previous years' experiments, injury was variable across sites. In some instances, significant yield reduction occurred, but not in all locations. At this time, it is still recommended to make Roundup applications to alfalfa at growth stages under 4 inches to minimize the risk of injury. If applications are made to small plants, glyphosate does not have soil residual activity and including a product with pre-emergent activity could be beneficial to control weeds that have not germinated. Further, when applications are made to alfalfa greater than 4 inches tall, if targeted species will be controlled with the 22 oz. rate, there is evidence to suggest there is less risk of crop injury than with the 44 oz. rate.

Results from the bactericide trial were promising at the Tulelake location, but inconclusive at the Honey Lake location. Continued work will need to take place next growing season to confirm what role pseudomonas syringe plays in the crop injury observed. Based on the visual symptoms observed in the plots, our working hypothesis still involves an interaction with pseudomonas syringe, glyphosate, and frost.

Height Trial: Visual Injury Assessment - First Cutting						
	Scott Valley		Honey Lake Valley		Tulelake	
Treatment	Mean	Letter Report	Mean	Letter Report	Mean	Letter Report
Control	13	AB	3	E	10	D
Tricor 75% DF + Gramoxone SL 2.0	15	AB	3	D E	13	C D
Glyphosate 22 oz./A 2"	10	B	8	B C D E	20	B C D
Glyphosate 44 oz./A 2"	11	AB	13	A B C D E	20	B C D
Glyphosate 22 oz./A 4"	13	AB	6	C D E	21	B C D
Glyphosate 44 oz./A 4"	13	AB	13	A B C D E	25	A B C
Glyphosate 22 oz./A 6"	14	AB	9	B C D E	24	A B C
Glyphosate 44 oz./A 6"	15	AB	24	A B C	35	A
Glyphosate 22 oz./A 8"	16	AB	24	A B C	31	A B
Glyphosate 44 oz./A 8"	15	AB	31	A	35	A
Glyphosate 22 oz./A 12"	18	A	28	A B	30	A B
Glyphosate 44 oz./A 12"	16	AB	31	A	30	A B
Glyphosate 22 oz./A 16"	18	AB	21	A B C D	19	B C D
Glyphosate 44 oz./A 16"	16	A	30	A	21	B C D

Table One: Visual injury assessment of crop damage in the first cutting (*color coded by site for visualization)

Height Trial: Average Crop Height in Inches - First Cutting						
	Scott Valley		Honey Lake Valley		Tulelake	
Treatment	Mean	Letter Report	Mean	Letter Report	Mean	Letter Report
Control	25	A	25	A	19	A
Tricor 75% DF +Gramoxone SL 2.0	25	A	24	A B	17	B C
Glyphosate 22 oz./A 2"	26	A	24	A B C	19	A B
Glyphosate 44 oz./A 2"	25	A	23	A B C	18	A B C
Glyphosate 22 oz./A 4"	26	A	23	A B C	17	B C
Glyphosate 44 oz./A 4"	24	A	22	B C	18	A B C
Glyphosate 22 oz./A 6"	25	A	23	A B C	17	C
Glyphosate 44 oz./A 6"	26	A	21	B C	18	A B C
Glyphosate 22 oz./A 8"	27	A	21	C	17	B C
Glyphosate 44 oz./A 8"	27	A	21	C	17	C
Glyphosate 22 oz./A 12"	27	A	23	A B C	18	A B C
Glyphosate 44 oz./A 12"	28	A	21	C	18	A B C
Glyphosate 22 oz./A 16"	26	A	23	A B C	17	B C
Glyphosate 44 oz./A 16"	27	A	22	B C	18	A B C

Table Two: Average crop height before first cutting (*color coded by site for visualization of data)

Height Trial: Number of Injured Stems/Plot - First Cutting						
	Scott Valley		Honey Lake Valley		Tulelake	
Treatment	Mean	Letter Report	Mean	Letter Report	Mean	Letter Report
Control	1	A	0	D	19	A
Tricor 75% DF +Gramoxone SL 2.0	2	A	0	D	18	A
Glyphosate 22 oz./A 2"	1	A	1	D	18	A
Glyphosate 44 oz./A 2"	3	A	1	C D	20	A
Glyphosate 22 oz./A 4"	1	A	1	D	18	A
Glyphosate 44 oz./A 4"	2	A	2	C D	22	A
Glyphosate 22 oz./A 6"	2	A	2	C D	22	A
Glyphosate 44 oz./A 6"	3	A	6	B C D	18	A
Glyphosate 22 oz./A 8"	2	A	4	C D	22	A
Glyphosate 44 oz./A 8"	2	A	11	A B	23	A
Glyphosate 22 oz./A 12"	2	A	5	B C D	19	A
Glyphosate 44 oz./A 12"	5	A	17	A	19	A
Glyphosate 22 oz./A 16"	2	A	5	B C D	20	A
Glyphosate 44 oz./A 16"	4	A	8	B C	16	A

Table Three: Average number of injured stems (*color coded across site for visualization of data)

Height Trial: Yield in Tons/Acre - First Cutting						
	Scott Valley		Honey Lake Valley		Tulelake	
Treatment	Mean	Letter Report	Mean	Letter Report	Mean	Letter Report
Control	2.37	A	2.51	A B	1.95	A
Tricor 75% DF +Gramoxone SL 2.0	2.31	A	2.58	A	2.02	A
Glyphosate 22 oz./A 2"	2.60	A	2.38	A B C	2.02	A
Glyphosate 44 oz./A 2"	2.41	A	2.42	A B C	1.88	A
Glyphosate 22 oz./A 4"	2.63	A	2.31	A B C	1.88	A
Glyphosate 44 oz./A 4"	2.24	A	2.16	A B C	1.90	A
Glyphosate 22 oz./A 6"	2.29	A	2.33	A B C	1.76	A
Glyphosate 44 oz./A 6"	2.19	A	2.09	C	1.72	A
Glyphosate 22 oz./A 8"	2.19	A	2.10	C	1.73	A
Glyphosate 44 oz./A 8"	2.28	A	2.05	C	1.67	A
Glyphosate 22 oz./A 12"	1.99	A	2.34	A B C	1.91	A
Glyphosate 44 oz./A 12"	1.99	A	2.13	B C	1.87	A
Glyphosate 22 oz./A 16"	2.28	A	2.29	A B C	1.96	A
Glyphosate 44 oz./A 16"	2.39	A	2.32	A B C	1.82	A

Table Four: Average yield in tons/acre (*color coded by site for visualization of data)

Because of complications at the Scott Valley location, only data for Tulelake and the Honey Lake Valley are shown.

Bactericide Trial: Visual Assessment of Injury - First Cutting				
	Honey Lake Valley		Tulelake	
Treatment	Mean	Letter Report	Mean	Letter Report
Control	0	B	15	B
Kocide DF+Manzate Max	3	B	14	B
Kocide DF+Manzate Max+Glyphosate 44oz	29	A	31	A
Glyphosate 44oz	33	A	39	A

Table 5: Visual injury assessment of crop damage in the first cutting (*color coded by site for visualization)

Bactericide Trial: Average Alfalfa Height Inches - First Cutting				
	Honey Lake Valley		Tulelake	
Treatment	Mean	Letter Report	Mean	Letter Report
Control	24	A	19	AB
Kocide DF+Manzate Max	24	A	20	A
Kocide DF+Manzate Max+Glyphosate 44oz	20	B	18	B
Glyphosate 44oz	20	B	17	C

Table 6: Average number of injured stems (*color coded by site for visualization of data)

Bactericide Trial: Number of Injured Stems - First Cutting				
	Honey Lake Valley		Tulelake	
Treatment	Mean	Letter Report	Mean	Letter Report
Control	0	B	13	AB
Kocide DF+Manzate Max	1	B	13	AB
Kocide DF+Manzate Max+Glyphosate 44oz	12	A	12	B
Glyphosate 44oz	16	A	21	A

Table 7: Average number of injured stems (*color coded across site for visualization of data)

Bactericide Trial: Yield in Tons/Acre - First Cutting				
	Honey Lake Valley		Tulelake	
Treatment	Mean	Letter Report	Mean	Letter Report
Control	2.59	A	2.13	A
Kocide DF+Manzate Max	2.53	A	2.39	A
Kocide DF+Manzate Max+Glyphosate 44oz	2.00	B	2.11	A
Glyphosate 44oz	1.97	B	1.71	B

Table 8: Yield in tons/acre (*color coded by site for visualization of data)

***** Color was added to the charts in order to better visualize trends in the numerical data and are a non-exact measure of those numerical differences. Color does not indicate statistical differences, which are indicated by the letter reports for each site.

Green colors generally represent a positive value for the associated variable, where red colors indicate a "negative" value for the associated variable. Yellows and oranges fall somewhere in the middle. The table below is an example of values for each variable visualized. High numerical values for yield and alfalfa stem height were considered positive/good, and are highlighted in green. Conversely, large numbers of injured stems and high values of visual ratings were considered negative/bad and are colored in red.

Example of Generalized Color Code: (Green="good" value Red="bad" value)			
Yield tons/acre	Height inches	# Injured Stems	% Visual Injury
1.7	14	0	0
1.8	15	2	2
1.9	17	4	4
2	19	6	5
2.1	21	8	8
2.2	22	10	12
2.3	23	12	15
2.4	24	14	20
2.5	25	16	22
2.6	26	18	27
2.7	28	20	32

Photo One: Shepherd's Crook symptomology as the stems die in a glyphosate treated plot

Photo Two: General chlorosis and injured stems in a glyphosate treated plot

Photo Three: Untreated plot with no apparent symptoms

Managing and Measuring Nitrogen to Optimize Efficiency in California Small Grains

Mark Lundy, UC Cooperative Extension Specialist, Grain Cropping Systems (melundy@ucdavis.edu)

Key Points:

1) Crop response to nitrogen (N) fertilization is difficult to predict from year-to-year and field-to-field.
2) Relative to other crops, small grains have a very plastic (flexible) growth habit, which is useful for adaptive N management strategies.
3) Due to the timing of crop N demand and the plasticity of small grain crops, N fertilizer is used most efficiently when the majority is applied at early vegetative growth stages versus pre-plant.
4) Relatively simple and widely available measurements of the plant-soil system taken prior to N fertilizer applications can greatly improve the predictability of crop response to N fertilization.

Timing affects grain yield and grain protein content

From 2013-2017, University of California researchers have conducted N fertility research on hard spring wheat and spring malting barley under a wide range of field conditions, including trials at the Intermountain Research and Extension Center (IREC) in Tulelake. All trials have included a range of N fertilizer rates applied at different times throughout the cropping season. A consistent conclusion from the wide range of trial results is that N applications made in the early vegetative growth period are more efficiently used by the crop than applications made pre-plant. In hard spring wheat trials, where yields ranged from 2000 to 8000 lb/acre (average ≈ 6000 lb/acre), protein concentrations ranged from 7% - 15% (average ≈ 12.5%), and overall crop responses to fertilizer N were strong, absent, and somewhere in between, N fertilizer applied at tillering resulted in a 10% increase in grain yield and an increase in grain protein concentration of 0.5% points compared to a pre-plant application (Figure 1). An important point to mention is that the seeding rates on these trials were all relatively high (≈1.3 million seeds/acre).

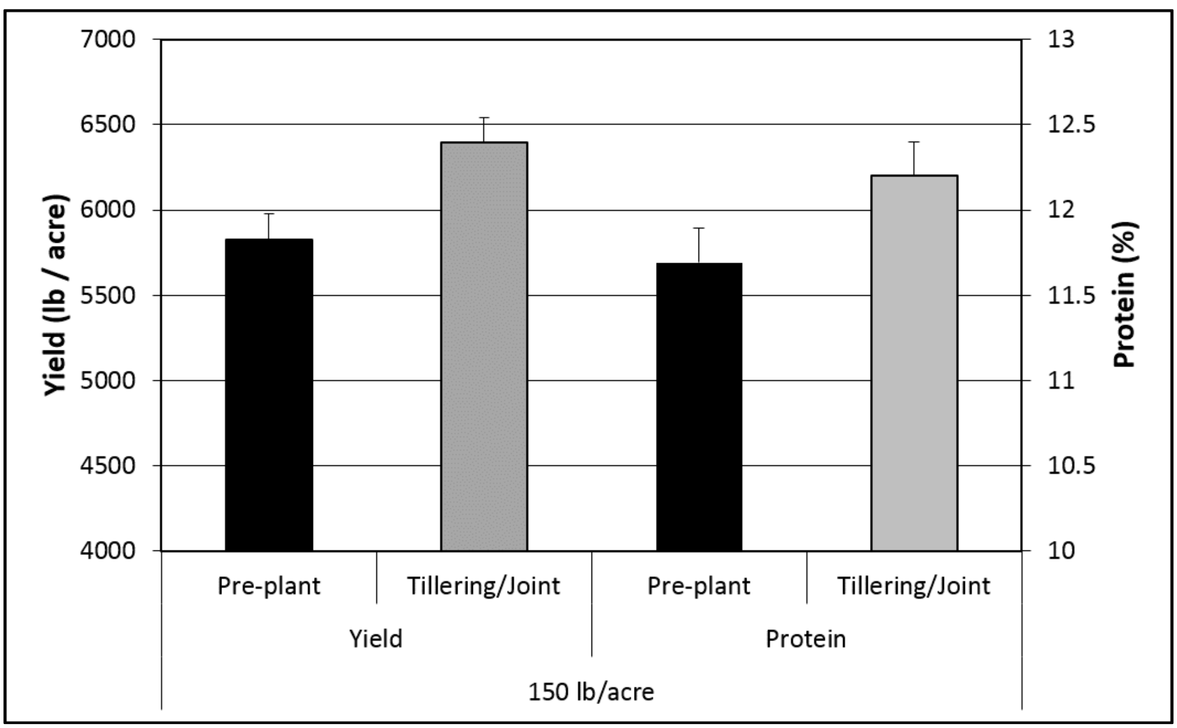


Figure 1. Effect of 150 lb/acre fertilizer N applied either pre-plant or at the tillering-to-jointing stages of growth on hard spring wheat grain yield and protein concentration. Figure is based on 9 site-years at 3 locations in the Sacramento Valley, the San Joaquin Valley and the Intermountain Region of California.

Soil Nitrate Quick Test is a simple way to determine if the soil is high in available N

Nitrate-N is the most available form of soil N, and the majority of N uptake by small grain crops is in the nitrate-N form. Nitrate moves with water and is thereby highly mobile in the soil. So, the soil nitrate-N concentration in the root zone of the crop is a good indicator of the current soil N available to the crop (but not always a great predictor of future crop N availability). Soil nitrate quick tests are an inexpensive method for determining if there is sufficient available soil N to meet immediate crop demand (Figure 2).

Figure 2. Illustrates several of the steps and materials involved in the soil nitrate quick test method.

This test can be conducted on moist or dry soil, with or without the use of calcium chloride in the mixing solution. Interpretations of test values vary a little based on how the test is conducted and the bulk density and moisture content of the soil being tested. More information on how to conduct and interpret these tests is available here: http://blogs.cdfa.ca.gov/FREP/index.php/nitrate-quick-test/ and http://smallgrains.ucanr.edu/Nutrient_Management/.

In general, it is difficult to get a "false positive" from these tests. So, the big picture about this tool for informing N fertilization decisions: it is good at indicating when available soil N is high. In work conducted in California small grains and in many other cropping systems, when soil nitrate-N values are ≥ 20ppm in the top foot of soil, additional application of N fertilizer at that time is unlikely to benefit crop growth. So, whether measured pre-plant or at the early vegetative growth stage, high values resulting from this test are an indication that fertilization is not currently necessary. Medium and low values from this test can be harder to interpret. Therefore, for in-season fertilization decisions, combining the soil nitrate quick test with measurements of the plants themselves is the best way to determine whether applications of N fertilizer are likely to benefit crop growth.

Nitrogen Rich Reference Strips to determine crop N sufficiency/deficiency and management action

N-rich reference strips are a tool for determining whether in-season applications of N fertilizer are needed. They require three steps: 1) establishing a N rich zone in a location that is representative of the broader field conditions, 2) measuring the plant vigor in both the N-rich reference zone and the broader field and interpreting whether the plants in the two zones are different, and 3) determining whether/how much N to apply as a result of this information.

Step 1: The objective for the use of N-rich zones is to create a point of reference in a representative subset of the field where N does not limit crop growth. Many factors aside from soil N availability can cause differences in crop vigor in a field. By creating a specific area in the field where soil N is not limiting, any differences in crop vigor measured in the reference region and compared to the larger field can be more easily attributed to differences in soil N availability specifically.

Step 2: When a decision is being made about whether and how much N fertilizer to add during the season, the crop vigor measured in the N-rich zone and compared to the broader field can indicate whether the broader field is likely to respond to a topdress of N fertilizer. Based on work conducted in California hard spring wheat and malting barley, when canopy reflectance values (eg. NDVI, GNDVI, GRVI) measured in the broader field at the tillering-to-jointing stage of growth is ≤ 90% of the N-rich reference area (Figure 3), there is more than a 70% likelihood that the crop will respond to subsequent N fertilizer applications.

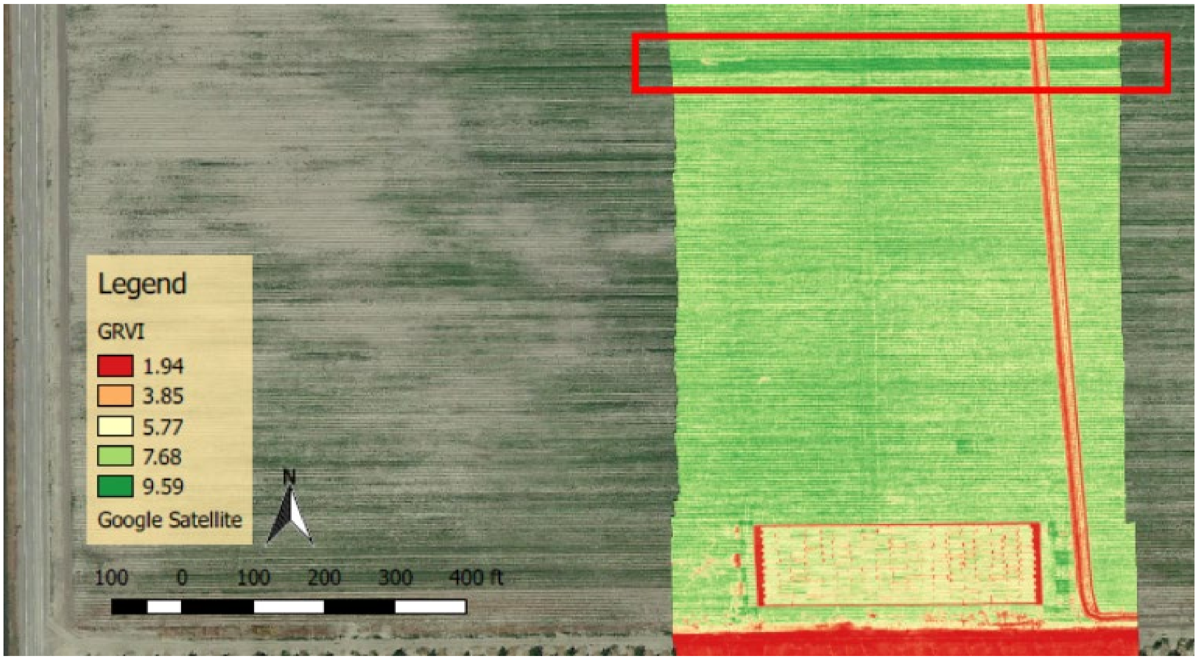


Figure 3. GRVI measured via UAV and a Parrot Sequoia camera in a Sacramento Valley hard spring wheat field where a N-rich reference strip had been implemented prior to planting.

Step 3: Once the relative measurements between the N-rich reference zone and the broader field establish that a crop response to N fertilizer application is likely, the next task is to decide whether and how much N fertilizer to apply. This will depend on a number of factors including: the yield potential of the field, the current stage of crop growth, the inherent N supplying capacity of the soil, the likelihood that water supplies will match crop demand during the remainder of the season, and the expected cost/benefit of the application to crop value. Since many of these factors are site- and crop-specific, it is difficult to make general conclusions about what rates would be appropriate for a given location and crop. Nevertheless, for the average irrigated hard spring wheat crop in UC trials, when canopy reflectance was ≤ 90% of the N-rich reference at tillering, crops responded linearly to between 70 and 110 lb acre^{-1} N fertilizer applied after measurement (this was assuming that sufficient water for crop demand also followed the application).

Summary

For equivalent amounts of N fertilizer, the relative benefit of applications made in-season is greater than applications made pre-plant in California small grains. Therefore, shifting the majority of N fertilizer applications to early vegetative growth stages will improve N fertilizer use efficiency. N use efficiency can be increased even further by employing tools such as the soil nitrate quick test and implementing N-rich reference strips alongside real-time measurements of crop vigor. These methods will help to reduce uncertainty about whether a crop will respond to N fertilizer prior to making fertilizer applications, thereby improving the precision of N fertilizer management in California small grains.

2019 IREC Field Day Sponsors

We would like to take this opportunity to sincerely thank the following sponsors. The support they provide allows us to offer the morning refreshments, the informational publication, and the excellent catered lunch and dessert.

- Alsco, Inc.
- The Annex by Ardent Mills
- Basin Fertilizer & Chemical Co.
- California Garlic & Onion Research Advisory Board
- California Potato Research Advisory Board
- JW Kerns Irrigation
- Macy's Flying Service
- Northwest Farm Credit Service
- Sensient
- Syngenta
- Winema Elevators, LLC

2019 IREC Field Day
Thursday, August 8
Tulelake, CA

8:00 am		*Registration Opens*
8:30 am		*Introductions and Opening Remarks* Rob Wilson, IREC Center Director/Farm Advisor, Tulelake, CA
8:40 am	**Stop 1**	*Seed Treatment Options for Onion Smut and Maggots in Onions* Rob Wilson, IREC Center Director/Farm Advisor, Tulelake, CA
9:00 am	**Stop 2**	*UC Triticale Breeding: Enhancing Baking Performance* Dr. Josh Hegarty, Postdoctoral Researcher, UC Davis
9:20 am	**Stop 3**	*Developing Barley Varieties for the Klamath Basin* Dr. Allison Krill-Brown, UC Davis Barley Breeder
9:40 am	**Stop 4**	*Investigation of Cover Crops and Compost to Improve Soil Health in Conventional and Organic Crop Rotations* Rob Wilson, IREC Director/Farm Advisor, Tulelake, CA
10:00 am	**Stop 5**	*Alfalfa and Tall Fescue Breeding and Evaluation* Dr. Charlie Brummer, Director and Professor for Plant Breeding, UC Davis
10:20 am		*Break and Refreshments*
10:40 am	**Indoor**	*Managing Weevils and Aphids in Alfalfa* Dr. Ian Grettenberger, UC Davis Field and Vegetable Extension Specialist
11:00 am	**Indoor**	*Managing Clover Root Curculio in Alfalfa* Rachael Long, UC Farm Advisor, Woodland, CA
11:20 am	**Indoor**	*Frost Injury on Roundup Ready Alfalfa- 2019 NE California Research* Tom Getts, Weed Ecology and Cropping Systems Advisor, Susanville, CA
11:40 am	**Indoor**	*Nitrogen Management in Small Grains* Dr. Mark Lundy, UC Davis Grain Cropping Systems Specialist
Noon		Lunch