UC Cooperative Extension

UC Davis Alfalfa/Forage/Biofuels Field Day

Tuesday, May 17, 2022, Davis, CA

Sponsored by: UC Cooperative Extension, Division of Agriculture and Natural Resources, and UC Davis Department of Plant Sciences, California Crop Improvement Association

For further information on alfalfa see:

https://alfalfa.ucdavis.edu

University *of* California
Agriculture and Natural Resources

2022 UC Davis Small Grains and Alfalfa/Forages Field Day
May 17th, 2022

(with tours of Small Grains Breeding plots to follow in the afternoon)

Department of Plant Sciences Field Facility, UC Davis

(2400 Hutchison Dr, Davis CA 38.5390, -121.7800)

CCA CE Credits Offered

REGISTER HERE (no charge for event)

7:30 **Sign-in** (*refreshments available*)
8:00 **Welcome and Introductions** (John Palmer and Lauren Port, CCIA)
8:05 **Travel** on Wagons to Field

Alfalfa/Forage/Biofuel Field Tour

8:20 **Breeding Alfalfa Varieties for Drought Tolerance and other Traits**—*Charlie Brummer and Matt Francis, UC Davis*

8:30 **Strategies for Coping with Drought in Alfalfa**--*Dan Putnam, UC Davis*

8:40 **Breeding Cool Season Grasses for Various Markets**—*Charlie Brummer, UC Davis*

8:50 **Switchgrass & Sorghum Field Trials**—*Bob Hutmacher, UC Davis and UC West Side Research and Extension Center, Five Points, CA*

9:00 **Novel Applications for Biofuels**—*Corinne Scown and Henrick Scheller, Joint Bioenergy Institute, Emeryville, CA*

9:10 **Producing Sorghum under Limited Water**—*Bob Hutmacher, UC Davis*

9:20 **Choosing Alfalfa Varieties for Pest Resistance and Yield.** *Dan Putnam, UC Davis*

9:30 ***'Lightning Talks' on UC Forage Projects***

- **Utilizing Pre-Plant Treatments for Weed Management for Alfalfa Stand Establishment.** *Sarah Light, UCCE, Yuba City*
- **Options for Alfalfa Weevil and the Importance of Controlling Resistance.** *Ian Grettenberger, UC Davis*
- **Using Drones for Pest Management in Alfalfa**—*Rachael Long, UCCE, Woodland, CA*
- **Technologies for Improving Water Use Efficiency with Overhead Irrigation**—*Isaya Kisekka, UC Davis*
- **Using Compost on Alfalfa for Healthy Soils**—*Rad Schmidt, UC Davis*
- **Soil Quality Considerations During Drought**—*Michelle Leinfelder-Miles, UCCE, Stockton, CA*

10:00 **Depart for Grain Plots**

10:15-12:15 Small Grains Tour (see Separate Agenda)

12:00 **CCIA Sponsored LUNCH. Welcome and Introductions** (Gail Taylor, Chair, UC Davis Department of Plant Sciences; Claudia Carter, Executive Director, California Wheat Commission; Acknowledgement of Retirees)

MANY THANKS TO CCIA FOR THEIR SPONSORSHIP OF LUNCH!!

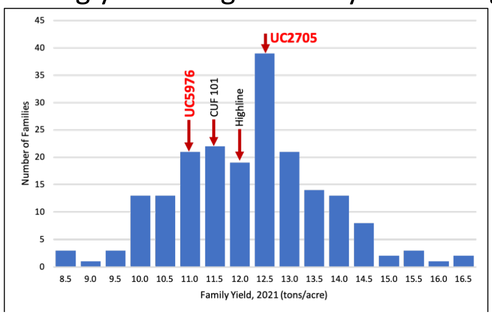
1:30 -3:30 Small Grains Breeding Field Tour (see Separate Agenda)

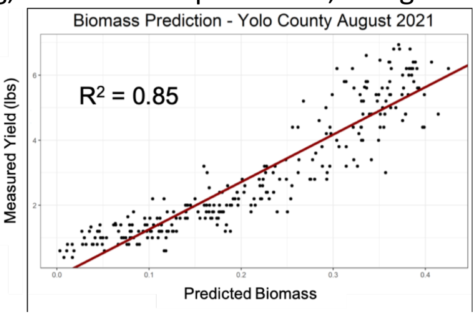
Breeding & Evaluating Alfalfa and Grass for Yield and Drought Tolerance

Charlie Brummer and Matt Francis, UC Davis
ecbrummer@ucdavis.edu

A. Alfalfa Breeding

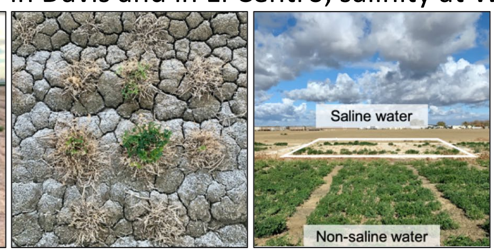
1. Improving yield using half-sib yield testing, drone-based prediction, and genomics





2. Selecting under full and deficit irrigation in Davis and in El Centro, salinity at Westside.

With (L) and without (R) summer water cut-off for four months at DREC in El Centro



Saline tolerant plants selected from WSREC

3. Dryland range – selecting alfalfa from rangeland in Paskenta and Rio Vista (right)

B. Grass Evaluation and Breeding

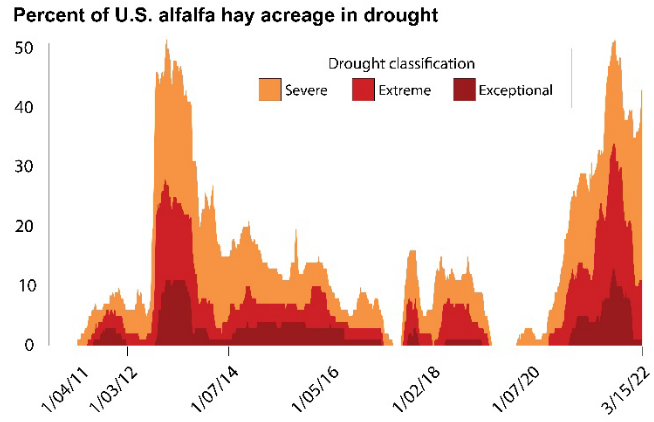
1. Evaluating yield, persistence, and other traits of tall fescue, orchardgrass, timothy, meadow fescue, and assorted other grasses. Tall fescue includes novel endophyte varieties; summer dormant varieties. Sites: Tulelake (IREC, hay); Susanville (on-ranch, beef grazing); Davis (hay; sheep grazing)

2. Breeding nurseries of these species to select new varieties (Davis)

STRATEGIES FOR COPING WITH DROUGHT IN ALFALFA

Dan Putnam, University of California Davis (Field Day, May 17, 2022)

Most parts of the West are currently under **'severe, extreme, or exceptional'** drought. This affects all of agriculture, but USDA-NOAA estimates that 40% of western alfalfa is currently under severe to exceptional drought. We have seen record high alfalfa hay prices in 2022 (see Table), with premium hay ~$150/ton more than last year.



Source: National Drought Mitigation Center and the U.S. Drought Monitor.

WHAT ARE THE OPTIONS?

There are few good answers when surface waters are cut off and well waters are restricted. However, alfalfa is a highly resilient crop, and can survive short-term (3 month) droughts, and can recover after these dry-down periods. Options?

1. TRIAGE-Move water to only those best fields. Many growers move water to only the highest return crops. However, alfalfa is an excellent economic option with such high prices, and production of good stands of alfalfa even with expensive water, is likely to be profitable,

2. STARVATION DIET--Water the crop less at each cutting than normal. A 'deficit irrigation strategy' in this case would apply (for example) 50-60% of this amount per week or month.

3. SUMMER DRY-DOWNS--This would require FULL irrigation during the first several growth periods in the spring: fully watered early to meet ET, followed by summer sudden cut off of irrigation water when necessary.

RECOMMNEDATIONS

Choose only the best fields to water, and water them fully during the early part of the year. We do NOT recommend 'starvation diet' strategies (#2). Make sure that the soil profile is as well-supplied with water as much as possible early in the season (full profile). Then, if necessary, cut down on irrigation in the late part of the season. Why?

1.**Early Yields are high & high quality.** 60-70% of alfalfa yields are achieved by early- mid-July.
2. **Can Obtain 60-90% full yields.** (Davis Data)
3. **Alfalfa enters a 'summer dormancy'**, foregoing harvests, saving money.
4. **Crop generally recovers** in the winter/spring.
5. **Extend cutting schedules** during the early growth periods to maximize yields.

Alfalfa Hay Price (Hanford/Tulare-Hoyt Report)

Quality Category	April 2022	April 2021
Supreme Quality	$435-455	$285-310
Premium Quality	$410-425	$270-285
Good Quality	$395-410	$255-260
Fair Quality	$380	$235

6. **Test for Nutrient Limitations.** Drought stressed roots are less able to obtain nutrients from the soil. Test to make sure that P, K, S, and some micronutrients (e.g. Mo) are not limiting for maximum early yields.

Growers face unhappy choices when it comes to coping with drought. However, alfalfa is a highly resilient crop that can be partially irrigated to produce from 50% to 90% of full yields under drought, depending upon how it's done. See: https://ucanr.edu/blogs/Alfalfa/

FIELD TRIALS ON SWITCHGRASS – LINKS TO BIOFUELS

Dan Putnam, Bob Hutmacher, Chris DeBen, UC Davis

Background: Over the past number of years, UC has been conducting field trials on switchgrass and sorghum. These have important applications for biofuels and for forage crops. In the past 4 years, we've worked with JBEI (Joint Bioenergy Institute) on applications for bioenergy. For bioenergy crops, it's important to minimize inputs while maintaining high yields. Several regulated unique genetically-engineered constructs were examined for their performance under stress and fully irrigation (non-stressed) conditions at Davis and Kearney.

Switchgrass Evaluations under different agronomic conditions – Trials Conducted at UC Davis and Kearney Agricultural Research and Extension Center (Parlier, CA).

(1) **High Input / Full Input Treatment:** Irrigation amounts applied to meet full estimated crop evapotranspiration (ETc) based on an estimated crop coefficient and potential evapotranspiration (ETo) data from a nearby CIMIS weather station using a modified Penman ET calculation. Total applied nitrogen (N) fertilizer was 240 lbs N/acre (Davis site) and 270 lbs N/acre (Kearney REC site) applied in 1/3 increments at three different times (early season at start of growth and first irrigations, then following harvest #1 and harvest #2).

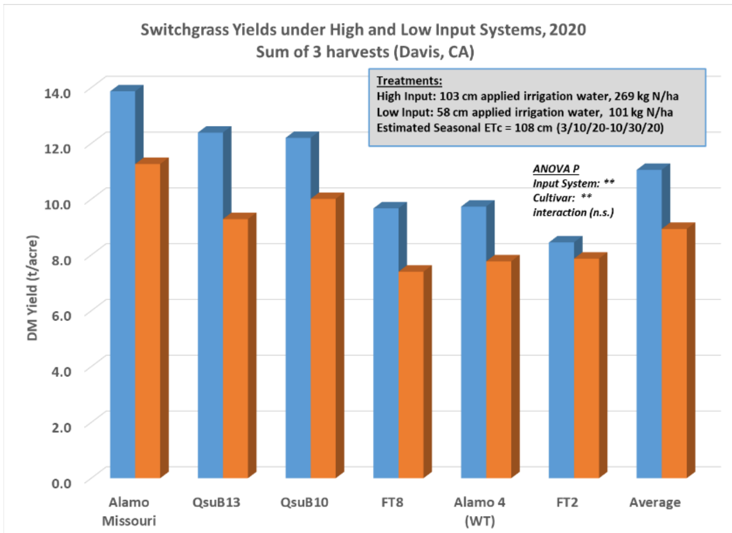
(2) **Low Input / Deficit Input Treatment:** Irrigation amounts were applied to meet full estimated crop ETc from the initiation of irrigation in the spring up until the first irrigation after the first harvest of the year, after which irrigation application amounts were reduced by about ½ (see graph). Total applied N fertilizer was 90 lbs. N/acre applied in three 30 lb./acre increments at times described above for the High Input treatment.

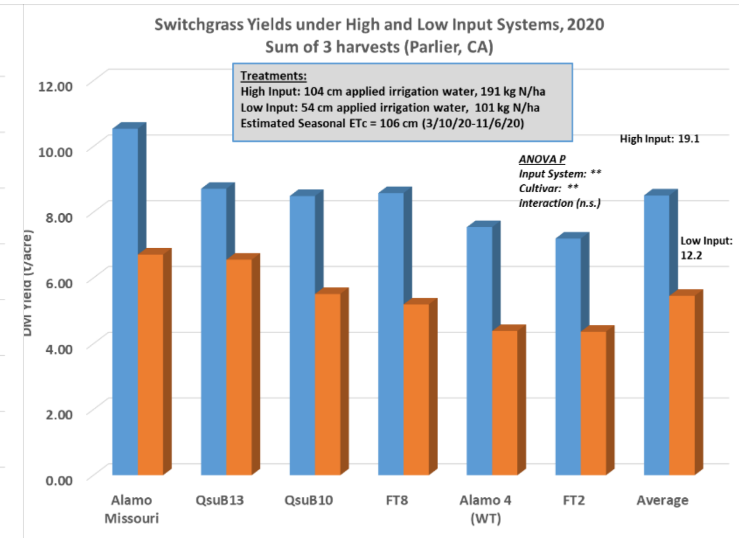
UC Davis Switchgrass Trial2 2021. Yields by cut for low and high input irrigation and fertilizer treatments

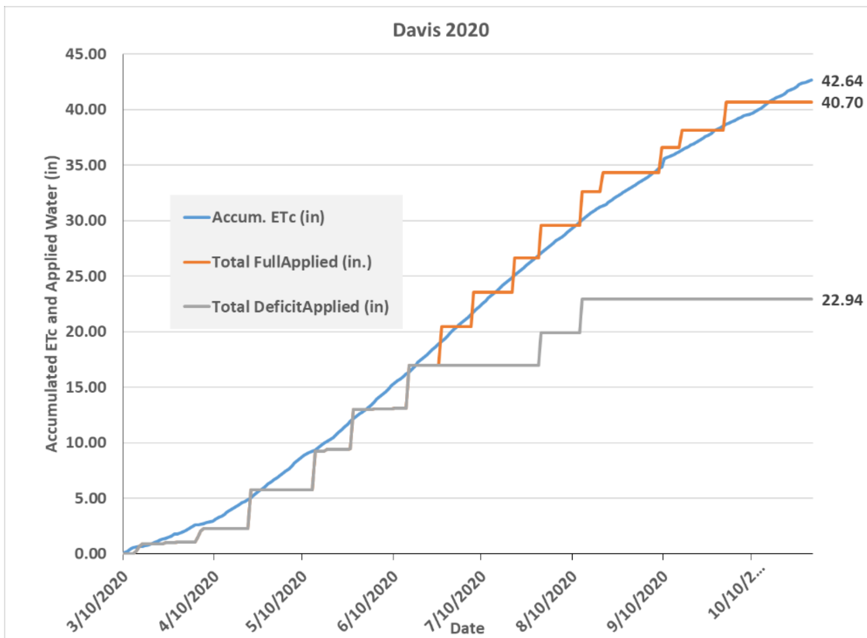
		yield t/A 6-Jun-21		yield t/A 10-Aug-21		yield t/A 10-Nov-21		Season Total yield t/A	Season Total yield t/A
Entry	Variety	high input	low input	high input	low input	high input	low input	high input	low input
6	Alamo Missouri	4.27	4.24	3.90	1.83	4.72	1.80	12.89	7.88
1	QsuB10	4.52	4.09	3.48	1.77	2.04	1.67	10.04	7.54
2	QsuB13	4.44	3.64	2.16	1.60	2.59	1.99	9.19	7.23
5	Alamo 4 (WT)	3.54	3.08	2.39	1.45	2.96	1.89	8.88	6.42
4	FT8	2.54	2.50	1.89	1.19	2.85	2.08	7.28	5.77
3	FT2	2.57	1.94	1.88	1.46	2.35	1.54	6.80	4.93
	Average	**3.65**	**3.25**	**2.62**	**1.55**	**2.92**	**1.83**	**9.18**	**6.63**
	Irrigation treatment	*		***		***		***	
	variety	***		***		***		***	
	Irr trt * var	ns		***		***		*	
	CV%	19.9		19.1		21.7		13.3	
	LSD (p=0.05)	0.40		0.24		0.30		0.62	

KAC Switchgrass Trial3 2021. Yields by cut for high and low input irrigation and fertilizer treatments

		yield t/A 17-Jun-21		yield t/A 8-Aug-21		yield t/A 11-Nov-21		Season Total yield t/A	
Entry	Variety	high	low	high	low	high	low	high	low
6	Alamo Missouri	7.84	4.98	4.00	1.51	1.20	1.26	13.04	7.74
2	QsuB13	5.93	5.65	3.70	1.42	0.91	0.99	10.55	8.07
1	QsuB10	6.31	5.22	3.07	1.31	0.71	0.74	10.09	7.27
4	FT8	5.85	3.26	3.84	1.23	1.29	1.07	10.98	5.56
5	Alamo 4 (WT)	5.10	4.69	3.18	0.83	1.14	0.83	9.41	6.35
3	FT2	4.17	3.50	2.20	0.76	0.84	0.64	7.21	4.90
	Average	**5.87**	**4.55**	**3.33**	**1.18**	**1.02**	**0.92**	**10.21**	**6.65**
	Irrigation treatment	**		***		ns		***	
	variety	*		***		**		**	
	Irr trt * var	ns		ns		ns		ns	
	CV%	31.3		21.5		32.0		21.5	
	LSD (p=0.05)	0.96		0.29		0.18		1.07	







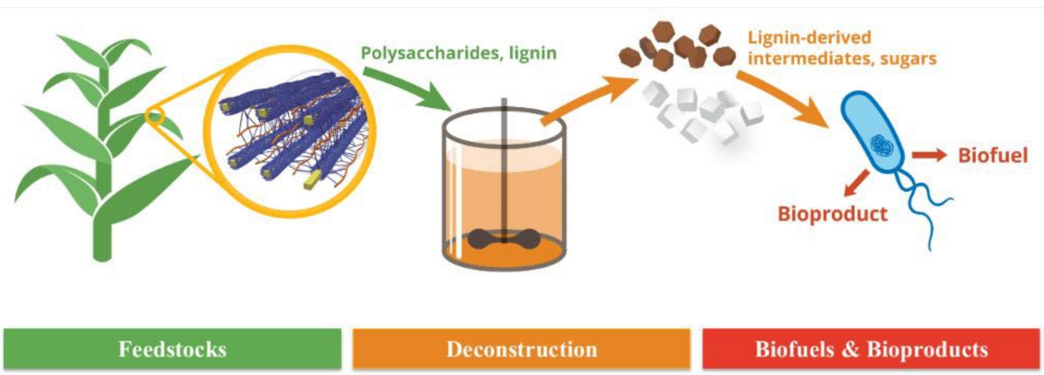
Comments: Switchgrass (*Panicum virgatum*) is a highly productive grass native to North America. These trials indicate the very high yield levels can be obtained with full irrigations in California's Central Valley, but also that 'reasonable' yields can be obtained with reduced watering and N fertilization regimes. 'Deficit irrigated' switchgrass yielded 64% and 85% of fully irrigated crops at Kearney and Davis, respectively. Previous work at UCD on switchgrass as a biofuel found that partial season irrigations to maximize yields during the most productive period (spring, early summer) utilizing deficit irrigation techniques is likely to be a better strategy when considering a biofuel (Pedroso et al., 2011). Like all grasses, it responds well to N fertilization, which is an important energy-balance factor. Switchgrass is a perennial crop with an expected life of 8-12 years, depending (likely) on management, region grown, and has the advantage of stabilizing soils over a long period of time. Switchgrass is also used as a medium- to low-quality forage crop, but would likely require dedicated biofuel acreage. Annuals (such as sorghum) and perennials (such as switchgrass) have advantages and disadvantages as biofuels.

RESEARCH PROJECTS FOR CONVERSION OF BIOENERGY CROPS

Corinne Scown, Jutta Dalton, Henrik Scheller, JBEI (Emeryville, CA)

The Joint BioEnergy Institute (JBEI) is a U.S. Department of Energy (DOE) Bioenergy Research Center dedicated to developing advanced biofuels—liquid fuels derived from the solar energy stored in plant biomass that can replace gasoline, diesel and jet fuels. It is challenging not only to produce fuels on an industrial scale, but also at a competitive market price with minimal agriculturally relevant land and water resources.

JBEI scientists are working on developing and testing sorghum, switchgrass, and poplar with improved traits, but also developing processes for chemically deconstructing these crops into a mixture of sugars and co-products, such as lignin-derived aromatics, making them more cost-and resource effective and thereby competitive with conventional fuels.




Feedstocks


Aviation fuels



Industrial plastics & other polymers

One effort specifically is aimed at producing renewable jet fuels that contain more energy per unit volume than conventional petroleum-derived jet fuels, thereby reducing greenhouse gas emissions by as much as 80%. Producing a domestic supply of energy-dense, renewable liquid fuels for sectors that are difficult to electrify, such as aviation, will be important for future energy security and climate change mitigation.

JBEI also is actively developing plants with aromatic co-products, which are expensive to produce chemically, yet essential as polymer building blocks for industrial plastics. Contacts: Henrik Scheller (hscheller@lbl.gov), Jutta Dalton (jdalton@lbl.gov), Corinne Scown (cdscown@lbl.gov)

SORGHUM PRODUCTION UNDER DEFICIT IRRIGATION

Bob Hutmacher, UCCE Specialist / Agronomist – UC West Side REC and UC Davis Plant Sci. Dept.

It is widely generalized that most sorghums have better tolerance of extremes of drought and high temperatures than commercial corn cultivars, and for the most part this is a reasonable generalization. Sorghum productivity in tons of total biomass per unit of applied irrigation water has been shown to be significantly higher than corn in multiple experiments done under rainfed conditions where irrigations are a supplement to rainfall. The biomass yields of many forage sorghums, even those producing some grain, also are more resilient than corn when exposed to water or high temperature stresses at any specific growth stage, such as during flowering and pollination stages. Sorghum germplasm has origins in regions including Africa in regions exposed to both drought and intense high temperature periods, and plant mechanisms for improved tolerance to drought and high temperatures have evolved or been selected for by breeders and farmers in response to these challenges.

<u>Management Under Drought</u> – In assessing likely sorghum responses to reduced water applications, consider the diversity across sorghum types in characteristics such as rooting density/depth, days to harvest, and growth habit (varying maturities, forages ranging from multi-cut sudangrass to one-cut tall photoperiod responsive types, multi-purpose types with significant grain heads, brachytic types, etc.). Particularly in forage types, these characteristics can impact duration of leaf development, water stress responses and total water use. Remember that if significant periods of plant water stress are imposed with deficit irrigations, yields/biomass production <u>will</u> be reduced, you are just trying to minimize negative impacts of stress through better choices of timing of stress periods. Generalizations regarding when to focus irrigations if you plan to deficit irrigate (not meet full plant water needs) can be broadly summarized as: **Grain sorghum**: (a) achieve good stand establishment and early root /shoot growth by avoiding moderate to severe stress during first 30-35 days after emergence during panicle differentiation; (b) If water available, irrigate again prior to boot growth stage; (c) avoid severe stress during grain fill period if possible. **Forage sorghums:** (a) Similar to grain sorghum, but can get away with delaying 1st or 2nd irrigations, particularly if planting longer-season photoperiod sensitive types – stress should not be so severe as to affect seedling survival and root establishment; (b) avoid severe stress during late panicle differentiation through flowering if growing a multi-purpose type forage where grain yields are an important part of yield/quality. Even if a deficit irrigation plan is a necessity during the growing season, a good pre-irrigation to provide stored soil water in upper 2-3 feet is almost always the best plan (if possible). When not possible, under <u>very dry conditions after planting</u>, you may need a 2 to 4 inch irrigation soon after planting to encourage emergence and early root development. Remember that what you can "get away with" in terms of growing season deficit irrigations is strongly influenced by depth of stored soil water and how that impacts the root system development and access to stored soil water.

<u>Other Considerations – High Temperature Sensitivity Under Drought Conditions</u>

High Temperatures: In sorghums producing grain, some exposure to high daily maximum temperatures can cause direct impacts on flowering and pollen viability, which can then impact both yields and forage quality. Despite this sensitivity, high temperature damage to grain production is generally less in sorghum than in many other grains due in part to: (a) perfect flowers in sorghum (male/female flower parts together; b) early AM timing of pollen "release"; and c) relative abundance of pollen. When high temperatures extend for many days, plant responses are not only due to exposure to peak/maximum daily temperatures, but also multiple indirect impacts, including high night-time temperatures and elevated respiration, combination stresses (such as water stress plus high temperatures, or high temperatures plus anoxia if you are irrigating in heavy soils). Since all these combination stresses can impact assimilation and growth, they can significantly affect yields of both forage and grain-producing types of sorghum. Achieving the best possible crop responses under any combination of these conditions (drought, high temperatures, salinity) depends on good timing in use of available resources, and a measure of good fortune in hoping that they don't all occur at the same time.

Sorghum Characteristics that can be important - *if you are deficit-irrigating*

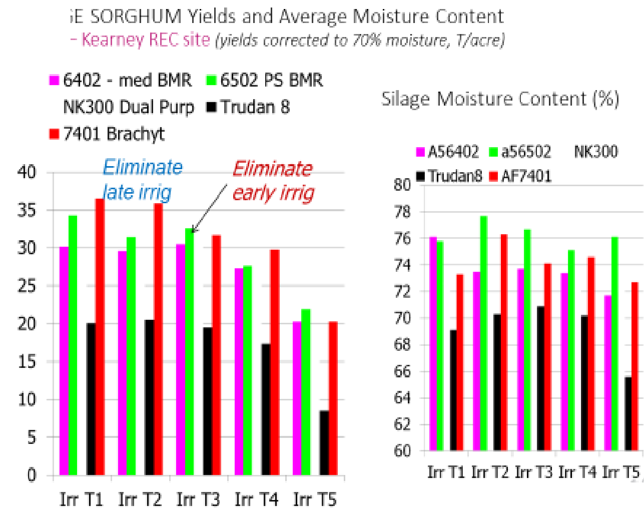
A characteristic of many sorghums is an ability to tolerate significant water stress & still be able to resume vegetative growth even after a water stress-induced dormancy or slowing of growth.

This is partly due to:

(1) water stress tolerance mechanisms (osmotic adjustment, stomatal response, leaf rolling, leaf waxiness); &

(2) root system depth, distribution, duration of growth

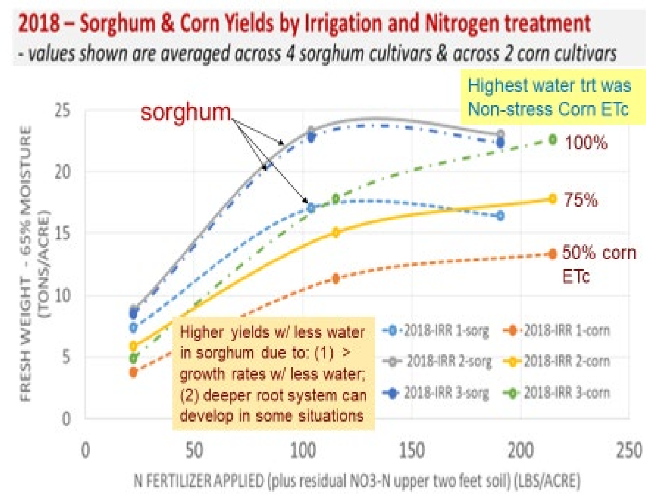
(both of which can vary across types & cultivars)

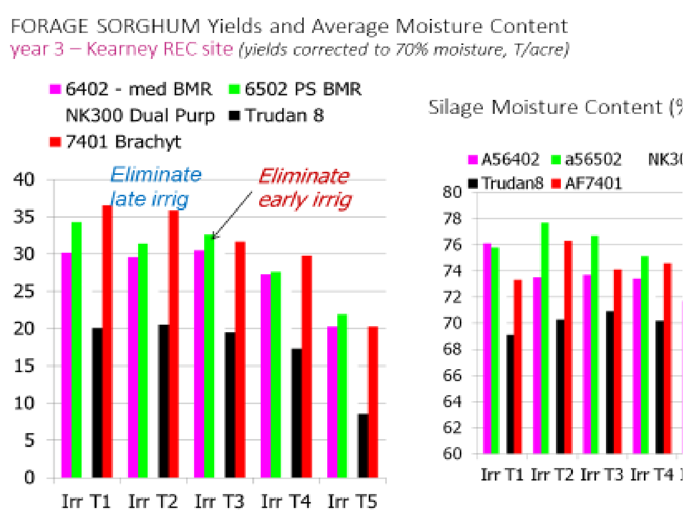


Generalizations Regarding When to Water Sorghum - *if you are cutting back on water*

- Grain sorghum
  - Don't impose severe stress on plants during first 30-35 days after emergence when panicle differentiation occurs
  - If limited water available, irrigate again prior to boot
  - Can improve yields if water available during grain fill
- Forage sorghums
  - Similar to grain sorghum, but can get away with delaying the first irrigation, particularly if planting a long-season photoperiod-sensitive type
  - Under very dry conditions after planting, may need 2-3 inch irrigation at planting to encourage emergence and root system development

  ** What you can get away with is strongly influenced by depth of stored soil water and how that can impact root system development*





CONCLUDING COMMENTS:

Most study sites where we compared sorghum cultivars response to irrigation had good stored soil moisture in upper 4 - 5+ feet of soil profile

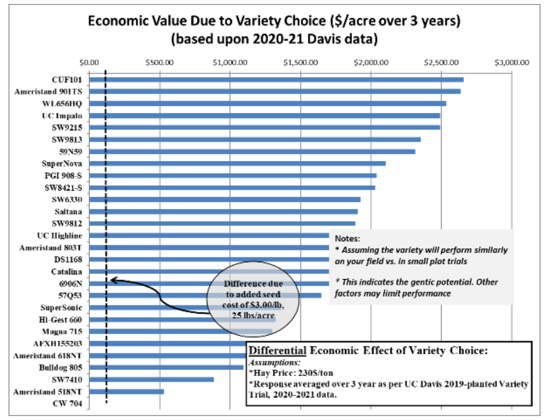
Forage sorghum entries had total water use (Etc) of 11-14" in lowest water treatments, a range of 19-24" in highest application treatments

Total crop water use for sorghum cultivars was strongly related to time to maturity for harvest (ie. longer season, more water)

Some evidence that eliminating or reducing early season irrigations reduced yields more than eliminating late season irrigations (useful for planning deficit irrigation timing when needed)

Understanding Alfalfa Varieties

Dan Putnam, UC Davis



Choosing a Variety: While alfalfa varieties may superficially look similar, there are important differences that can be detected over many cuttings and over years, and by studying the data.

Yield * Fall Dormancy * Pest Resistance * Quality * Persistence * Biotech (HarvXtra, RR) * Price of seed * Hats

2020-2021 YIELDS, UC Davis ALFALFA CULTIVAR TRIAL. TRIAL PLANTED 10/4/2019

	FD	2020 Yield		2021 Yield		Average			% of CUF101
				Dry t/a					
CUF101	9	12.59	(1)	10.63	(4)	11.61	(1)	A	100.0
Ameristand 901TS	9	12.20	(5)	10.94	(2)	11.57	(2)	A	99.7
WL656HQ	6	11.85	(6)	11.01	(1)	11.43	(3)	A	98.5
UC Impalo	9	12.26	(4)	10.48	(5)	11.37	(4)	A	97.9
SW9215	9	12.32	(3)	10.41	(6)	11.37	(5)	A	97.9
SW9813	9	11.56	(13)	10.77	(3)	11.16	(6)	A B	96.2
59N59	9	11.83	(7)	10.38	(7)	11.11	(7)	A B C	95.7
SuperNova	9	11.74	(9)	9.87	(10)	10.80	(8)	A B C D	93.1
PGI 908-S	9	12.35	(2)	9.07	(17)	10.71	(9)	A B C D	92.3
SW8421-S	8	11.40	(16)	9.99	(9)	10.69	(10)	A B C D	92.1
SW6330	6	11.66	(10)	9.43	(13)	10.54	(11)	A B C D E	90.8
Saltana	9	11.21	(17)	9.82	(11)	10.52	(12)	A B C D E	90.6
SW9812	9	10.74	(23)	10.25	(8)	10.49	(13)	A B C D E	90.4
UC Highline	9	11.79	(8)	9.10	(15)	10.45	(14)	A B C D E	90.0
Ameristand 803T	8	11.46	(14)	9.31	(14)	10.38	(15)	A B C D E	89.5
DS1168	6	11.64	(11)	9.09	(16)	10.37	(16)	A B C D E	89.3
Catalina	9	11.12	(19)	9.60	(12)	10.36	(17)	A B C D E	89.3
6906N	9	11.44	(15)	9.03	(18)	10.24	(18)	A B C D E	88.2
57Q53	7	11.60	(12)	8.69	(19)	10.14	(19)	A B C D E	87.4
SuperSonic	9	11.18	(18)	8.27	(24)	9.73	(20)	B C D E F	83.8
Hi-Gest 660	6	10.89	(21)	8.45	(21)	9.67	(21)	B C D E F	83.3
Magna 715	7	11.05	(20)	8.22	(25)	9.64	(22)	B C D E F	83.0
AFXH155203	6	10.82	(22)	8.34	(23)	9.58	(23)	C D E F	82.6
Ameristand 618NT	5	10.61	(24)	8.49	(20)	9.55	(24)	D E F	82.3
Bulldog 805	8	10.33	(25)	8.35	(22)	9.34	(25)	D E F	80.5
SW7410	7	10.31	(26)	7.77	(26)	9.04	(26)	E F G	77.9
Ameristand 518NT	7	10.12	(27)	6.92	(27)	8.52	(27)	F G	73.4
CW 704	7	9.57	(28)	5.93	(28)	7.75	(28)	G	66.8
MEAN		11.34		9.24		10.29			
CV		10.60		16.61		12.32			
LSD (0.1)		1.45		1.85		1.53			

Trial seeded at 25 lb/acre viable seed on Yolo clay loam soil at Univ.of California Agronomy Farm, Davis CA.
Entries followed by the same letter are not significantly different at the 10% probability level according to Fisher's (protected) LSI
FD = Fall Dormancy reported by seed companies.

Table 1. Fall Dormancy and Pest Resistance Ratings for Varieties in the UC Davis trials:

Released Varieties		Fall Dormancy Rating		Bacterial Wilt	Verticillium Wilt	Fusarium Wilt	Anthracnose	Phytophthora Root Rot	Spotted Alfalfa Aphid	Pea Aphid	Blue Alfalfa Aphid	Stem Nematode	Northern Root knot Nem	Salt Tolerance-Germination (G) or Forage (F)
Name	**Company**	**FD**	**Roundup Ready?**	**BW**	**VW**	**FW**	**ANT**	**PRR**	**SAA**	**PA**	**BAA**	**SN**	**NRKN**	**ST**
UC Impalo	UC	9	Conv.											
DG9212	Dyna-Gro	9	Conv.	LR	R	HR	HR	HR	HR	HR	HR	HR		
SW9215	S&W	9	Conv.	R		HR		R	HR	R	HR			F
AmeriStand 803T	America's Alfalfa	8	Conv.	MR		HR	HR	HR	R	HR	HR	HR	R	F
Desert Sun 8.10 RR	Croplan	8	RR			MR	R	HR	HR			MR		
RRAlf 8R100	Eureka	8	RR	HR		R	R	HR	HR			MR	HR	
AmeriStand 715NT RR	America's Alfalfa	7	RR	R	R	HR	HR	HR	HR	HR		HR	R	G/F
RR Alf 9R100	Eureka	9	RR	R	R	HR	R	HR	HR	HR	HR	HR		G
6R200	Eureka	6	RR	R	R	HR	HR	R	HR	HR	R	HR	HR	G
UC415	UC	9	Conv.											
Camas	LG Seeds	4	Conv.	HR	R	HR	HR	HR				HR	HR	
Integra 8800	Wilbur Ellis	8	Conv.			HR	R	HR	R	HR		HR	R	
Pacifico _	Eureka	8	Conv.	R	MR	HR	R	HR	HR	HR	HR	R	R	
Arriba II	America's Alfalfa	6	Conv.	HR		HR	HR	HR	HR	HR			R	G
SW8421 S	S&W	8	Conv.	HR		HR		R	HR	R	R		R	F
Integra 8420	Wilbur Ellis	4	Conv.	HR	HR	HR	HR	HR		HR	R	HR	R	
Cuf 101			Conv.											
Integra 8600	Wilbur Ellis	6	Conv.		MR	R	R	R	HR	HR	HR	R	HR	
Integra 8444 RR	Wilbur Ellis	4	RR	R	HR	HR	HR	HR		HR		HR	R	G/F
RRAlf 4R200	Eureka	4	RR	HR	HR	HR	HR	HR	MR			HR	R	

An alfalfa variety is a 'population' consisting of a range of plant types in a single variety. The 'mean' value creates superior or inferior varieties in terms of yield, stand, pest resistance, and quality. Varietal Pest Resistance through choice of variety is often the only way to combat specific diseases or insect pests.

Recommendations Sacramento/San Joaquin Valley:

Fall Dormancy:	4-9 Rating
Spotted Alfalfa Aphid (SAA):	R
Pea Aphid (PA)	HR
Blue Alfalfa Aphid (BAA):	HR
Pythopthora Root Rot (PRR).	HR
Bacterial Wilt (BW):	MR
Fusarium Wilt (FW):	HR
Stem Nematode:	HR
Root Not Nematode:	HR
Verticillium Wilt (VW)	R

Current Variety Leaflet: https://www.alfalfa.org/publications.php

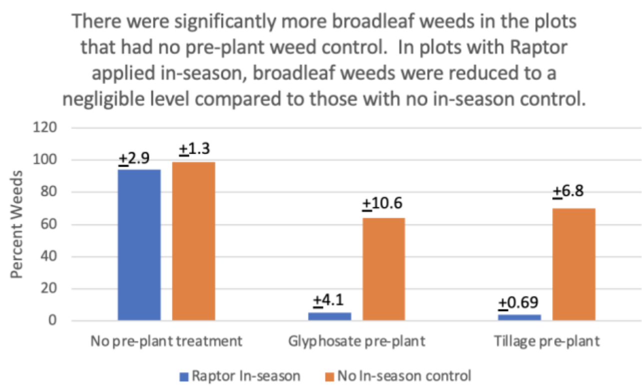
Variety Trial Data: *https://alfalfa.ucdavis.edu/+producing/variety/*

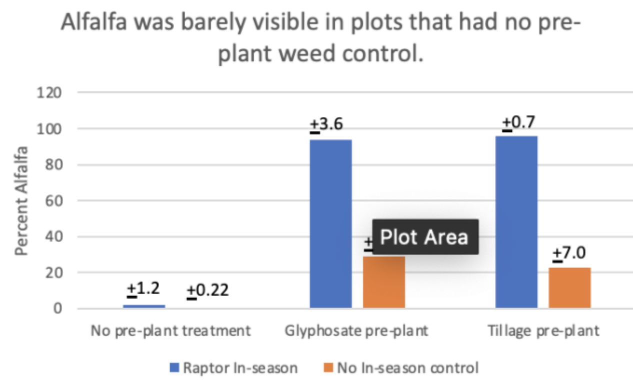
Utilizing Pre-Plant Treatments for Weed Management for Alfalfa Stand Establishment

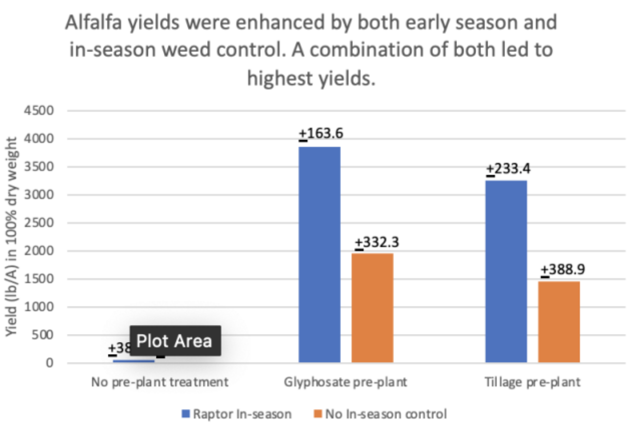
Sarah Light, Agronomy Advisor, UCCE Sutter-Yuba and Colusa. selight@ucanr.edu

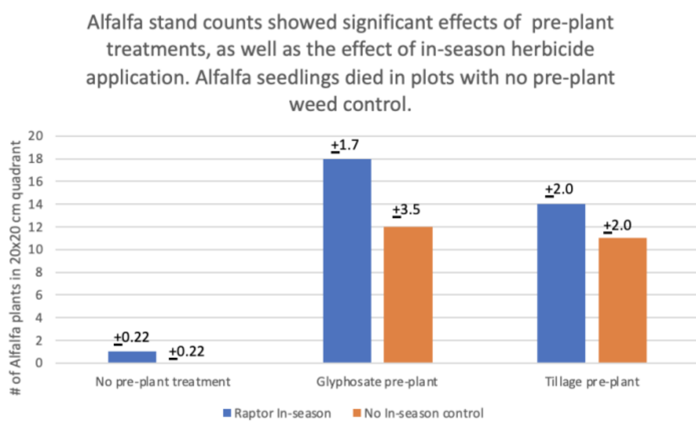
Project Overview: Weed competition during stand establishment may be irreversible because it can reduce alfalfa root growth, and lead to thinner alfalfa stands and lower forage quality. This project evaluated the efficacy of weed control options for conventional and organic growers. Weeds were germinated with winter rains and then *Glyphosate* was sprayed or pre-plant mechanical cultivation was implemented prior to alfalfa planting (field planted on 3/4/20). Additionally, half the plots received in-season Raptor application on 4/25/20 and half the plots received no in-season weed control. Percent cover of broad leaves and alfalfa, as well as first-cutting yield data, were collected on 6/8/20. Post-harvest stand counts were done on 6/23/20.

Results:









Project Summary and Conclusions: The data shows that controlling weeds prior to planting, either with shallow tillage or an herbicide spray (Glyphosate) will reduce weed pressure, increase yields, and lead to a stronger alfalfa stand after first cutting. There were also differences between plots that got an in-season herbicide and those that did not. Yields were highest in plots that had both pre-plant weed control and an in-season herbicide. The plots with the highest stand counts after first cutting were also the plots that had both pre-plant and in-season weed control. However, the stand in the pre-plant treatment plots that did not have in-season herbicide application still had relatively high alfalfa stand counts after first cutting. This means that with early effective weed control, the alfalfa stand may be more robust for future cuttings, even if weed pressure was high initially. By first cutting, many broad leaf weeds had gone to flower so likely would not return after first cutting. However, when included in the harvest weeds reduce quality and price of the hay, and contribute seed to the weed-seed population in the field.

Ideally, both pre-plant and in-season weed control would be implemented to get highest yields, quality, a vigorous stand, and ensure animal safety. However, growers (particularly organic) may be able to do a pre-plant tillage to control weeds and establish a good alfalfa stand, accept some yield reduction and additional weed pressure leading up to first cutting, and then have a strong alfalfa stand for subsequent cuttings.

Acknowledgments: Thank you to the California Alfalfa & Forage Association for funding this project. Thank you to River Garden Farms, Knights Landing, CA, for their collaboration.

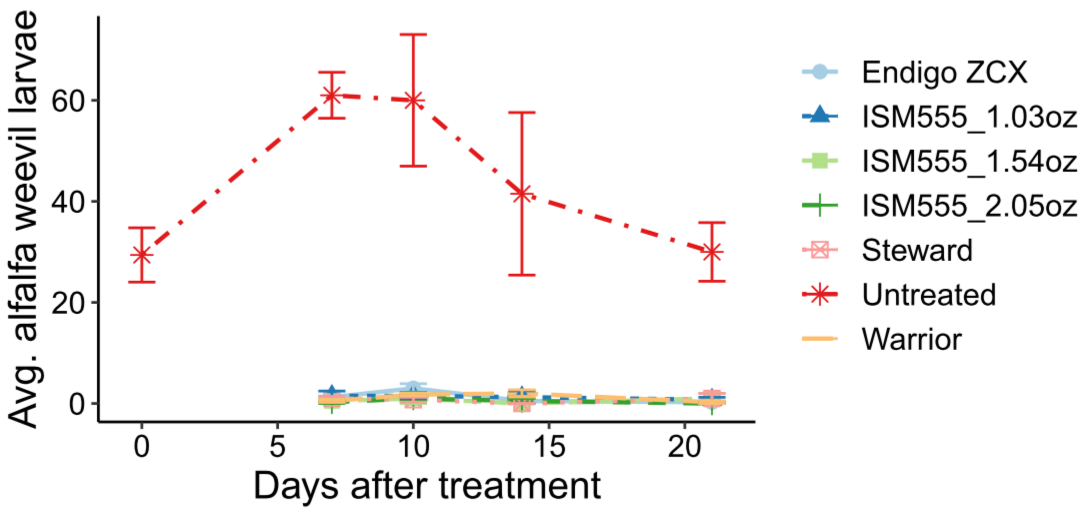
Evaluation of new materials for alfalfa weevil – 2021 trial

Ian Grettenberger, Asst. Cooperative Extension Specialist, UCD and
Rob Wilson, Farm Advisor and IREC director

- We conducted a trial evaluating a new insecticide. It could be a very good fit for alfalfa weevil given the efficacy we saw as well as the critical need for novel modes of action for alfalfa weevil management.
- The new material we focused on was *isocycloseram*, marketed as Plinazolin technology by Syngenta. This is a group 30 mode of action. We were working with an experimental formulation at multiple rates. We also evaluated Endigo ZCX (lambda-cyhalothrin + thiamethoxam). These were compared to the standards of Warrior II (lambda-cyhalothrin) and Steward (indoxacarb). Plinazolin registration in CA and alfalfa is TBD.

Trt #	Product*	Rate	Unit
1	Untreated	--	oz/ac
2	isocycloseram	1.03	oz/ac
3	isocycloseram	1.54	oz/ac
4	isocycloseram	2.05	oz/ac
5	Endigo ZCX	4.5	oz/ac
6	Warrior II	1.92	oz/ac
7	Steward EC	11.3	oz/ac

- Trial conducted at Intermountain Research and Extension Center in Tulelake, CA.



Effect of treatments on alfalfa weevil larvae populations (#/10 sweeps).

- All tested materials were equivalent, substantially reducing weevil populations relative to the untreated (the over-plotted lines). This effect extended through the end of the trial.
- Of note, all treatments had strong negative effects on lady beetle adults after application. This is notable given that aphids, which lady beetles can control, are also significant pests.
- The most promising result here is that there may be a weevil-active material in the pipeline. This is absolutely critical given our current recommendation of rotation for insecticide resistance management (across years; alfalfa weevils have one generation/year). Practically speaking, we are limited to pyrethroids (e.g., lambda-cyhalothrin) and indoxacarb/Steward. Pyrethroid resistance is a growing problem and areas with resistance do not have good rotation options. *Rotation options will still be limited even with a new registration.*
- **To manage resistance: 1) follow good agronomic practices produce a vigorous crop, 2) scout, use thresholds, avoid unnecessary applications, and 3) rotate modes of action.**

Interested in alfalfa weevil pyrethroid resistance? Contact Ian at imgrettenberger@ucdavis.edu

A technician checks over the spray drone to ensure it is ready for the next launch. Researchers at the University of California-Davis have been assessing the use of drones for controlling alfalfa summer worm pests.

Drones show utility in controlling alfalfa pests

by Rachael Long and Ken Giles

DRONES, or unmanned aerial vehicles (UAV), are more frequently being used for applying pesticides on farms for crop protection. This innovative technology for managing pests, weeds, and diseases is appealing for many reasons.

Drones are highly efficient, precise, help save time and energy, have a quick response time, and can cover vast areas tough-to-reach places that might need spot treatments. They also provide an additional tool for farmers to manage pests, especially in times of labor shortages. This is a growing reality as more agricultural pilots retire and there are fewer replacements to fill a need for crop dusters.

Although the use of drones for applying pesticides on farms is still limited in the U.S., UAVs are often commercially used in crop production elsewhere. For example, large drones are currently being used to spray fungicides on banana plantations in Central America and for applying insecticides on cereal grains and rice fields in Southeast Asia.

The future is now

The use of drones will continue to grow in the U.S. as laws restricting weight carrying capacity change and with research showcasing high levels of efficacy for pest control that are comparable to manned airplane applications. Pesticide registrants are also developing label language to facilitate and guide future use.

In California, that reality for controlling pests in alfalfa fields with drones is here. Researchers from the University of California (UC) Cooperative Extension service and UC-Davis, in collaboration with growers and registrants, found that drones work well for applying pesticides for summer worm control in alfalfa fields, including armyworms and alfalfa caterpillars. These insects are key pests of alfalfa as they feed on the foliage, resulting in yield and forage quality losses if left uncontrolled.

For the past two summers, the lead researchers evaluated the performance of a small six-rotor drone (PV35X, Leading Edge Associates) compared to traditional manned airplane and grower ground rig sprayer application methods for controlling summer worms in alfalfa.

In the trials, Prevathon and Vantacor insecticides (chlorantraniliprole) were applied to alfalfa fields at 0.054 pounds of active ingredient per acre. In 2020, Prevathon was applied by drone versus a manned airplane at 10 gallons per acre (gpa); a second alfalfa field compared both application methods at 5 gpa. In 2021, Vantacor was applied to a third alfalfa field by drone at 2 gpa and 5 gpa, compared to Prevathon at 10 gpa by a ground rig sprayer. The 2 gpa volume is the minimum labeled rate for aerial application of Vantacor.

Spray cards (water sensitive paper) were used to assess spray coverage, and plant samples were taken to compare insecticide residue concentrations after treatment for the different application methods. Summer worm counts were also taken to determine the effect of the different application methods on pest control, the best indicator of the success of the application technology. Natural enemy counts were taken to determine the impact of the pesticides on beneficial insect activity.

Positive first results

The results of multiple field trials revealed that the spray cards had similar coverage for the drone and airplane insecticide application methods for all three alfalfa field sites. Overall, the drone application had a bit more variability in terms of spray deposition uniformity than the airplane application methodology. This was not due to the inherent qualities of the drone, but instead that the drone-based spray technology may require more refinement.

Airplanes have been used for applying pesticides for decades, and that technology is refined. Drones are new and there is a bit more work that needs to be done to fine-tune them for optimum pest control in crops, such as exploring different nozzle types for maximum coverage and optimal ground speed and flight altitude.

Insecticide residue concentrations on the alfalfa plants were remarkably similar for the drone and airplane application methods at the 2, 5, and 10 gpa spray volumes (Figure 1). Likewise,

RACHAEL LONG

Long (pictured) is a University of California (UC) Cooperative Extension farm advisor in Woodland, Calif. Giles is an emeritus professor in the Department of Biological and Agricultural Engineering at the UC-Davis.

the drone, airplane, and ground sprayer rig all showed excellent summer worm control five to seven days after application (Figure 2). Prevathon and Vantacor insect control showed a true selectivity with no visible negative impacts to predators such as ladybird beetles or parasitoid wasps for any of the application methods. This is good news for an insecticide that controls the target pest well, without adverse impacts to natural enemies that help control secondary pests in alfalfa such as aphids.

Drone technology is a reality for pest control in alfalfa fields. While more research is underway, the results of this study show that effective drone spray applications can now be made with commercial UAV equipment. California currently has a specific UAV (unmanned) ag pilot license category, which means that for most commercial applications, the pilot of the drone is not required to have a commercial pilot certificate, only the Federal Aviation Administration (FAA) UAV certificate

Drones were shown to provide a similar spray coverage as airplanes. Different nozzle types along with speeds and altitudes are being evaluated to achieve maximum performance.

and the California Department of Pesticide Regulation license.

A current limitation for the use of drones for aerial spraying of crops in the U.S. is the 55-pound weight limit mandated by FAA regulations for the category of "small" UAVs. Some drone companies, such as Yamaha, have obtained certification for handling more than 55 pounds, and many others are in the process of requesting similar approval with research being conducted on larger aircrafts.

Further refinements and greater load limits will help to pave the way for more people to use drone technology on a larger scale in crop production in the U.S. Additionally, an industry-wide UAV Task Force is being formed to coordinate the development of labels and standards. Based on university and industry research, drones are a promising and viable option for aerial application of insecticides for pest control in alfalfa fields. ●

The authors wish to acknowledge Xuan Li with FMC Corporation and Bill Reynolds with Leading Edge Aerial Technologies in California for their expertise and contributions in completing this research.

Figure 1. Prevathon (Fields A and B) and Vantacor (Field C) insecticide residue concentrations on alfalfa plants

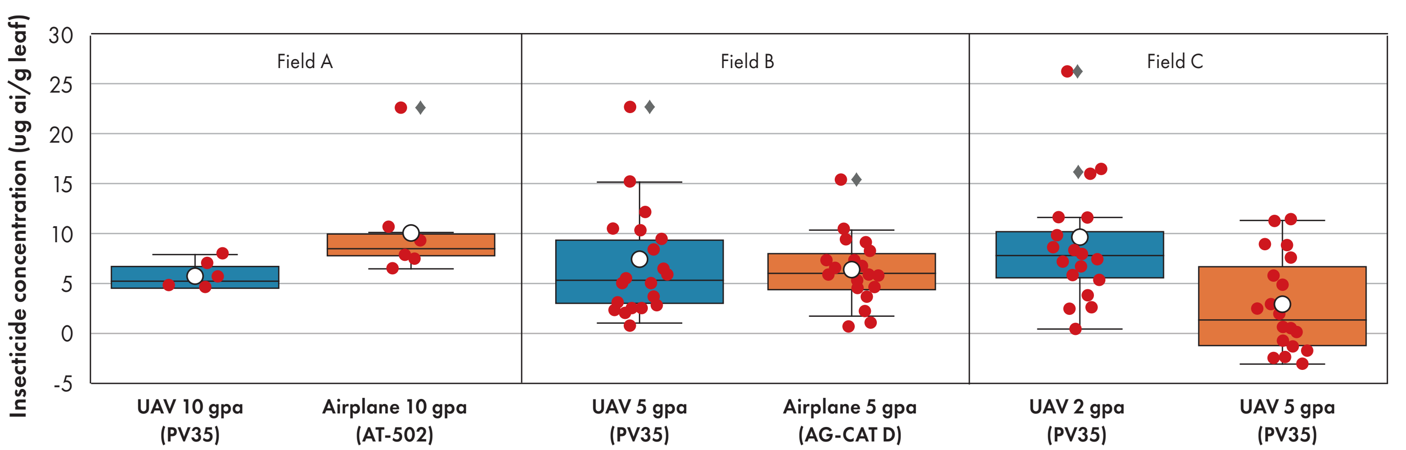
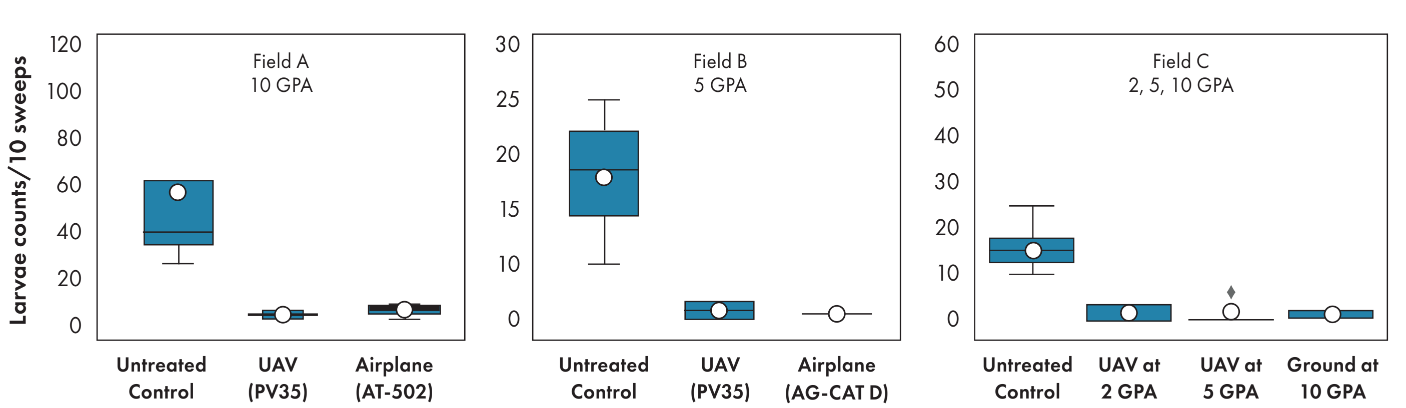


Figure 2. Prevathon and Vantacor alfalfa summer worm control by UAV, ground, or airplane application methods



TECHNOLOGIES FOR IMPROVING WATER USE EFFICIENCY IN ALFALFA WITH OVERHEAD IRRIGATION

Isaya Kisekka[1], Umair Gull[2] and Daniel H. Putnam[2]

Figure 1. Linear Move Overhead Irrigation System at University of California Davis operating in Alfalfa.

Prevailing droughts in the Western US have underscored the need for high efficiency irrigation systems. Recent advances in overhead irrigation systems has resulted in systems that water apply with more than 95% application efficiency coupled with automation. To evaluate the impact of utilizing improved overhead irrigation systems (e.g., Low Elevation Spray Application (LESA) and Mobile Drip Irrigation (MDI)), on alfalfa productivity a research study (2019-2020) was conducted at UC Davis under full and limited water (Gull, 2021). The experiment design was a randomized complete block with split plot arrangement, where irrigation system (LESA and MDI) was the main plot while irrigation amounts (100% ET_c, 60% ET_c-summer cutoff, 60% ET_c- gradual deficit and 40% ET_c- gradual deficit) were in the subplots. Crop evapotranspiration (ET_c) was calculated based on crop coefficients approach. Soil water was monitored weekly using a calibrated neutron probe to a depth of 8 feet. The study revealed significant differences among treatments in 2020 for dry matter yields (90% of full yields in MDI and 60% ET_c-summer cutoff), water productivity (21.2 kg ha^{-1} mm^{-1}) while during 2019 results were non-significant. LESA performed better in all the other treatments during 2020. With these results it was concluded that for cultivating alfalfa, LESA or MDI can successfully be utilized. But care should be taken during periods of droughts, where, MDI can perform better with limited supply of water. It appears that MDI was able store more water in the deep soil profile that may have sustained production during longer periods of drought (Oker et al. 2020, Kisekka et al. 2017). The two irrigation systems are quite comparable but MDI may help in improving water productivity during periods of severe droughts. MDI could also be a better alternative to the sub-surface drip irrigation systems where rodents are an issue. Overhead irrigation system applications can also be easily integrated into cutting schedules. Both of these systems are superior to older mid-elevation sprinkler designs and can improve yield and preserve water vs. wheel line systems.

Literature Cited:

Gull, U. 2021. Sustaining Alfalfa Forage Production with Limited Water Resources. PhD Dissertation. December, 2021. University of California, Davis.

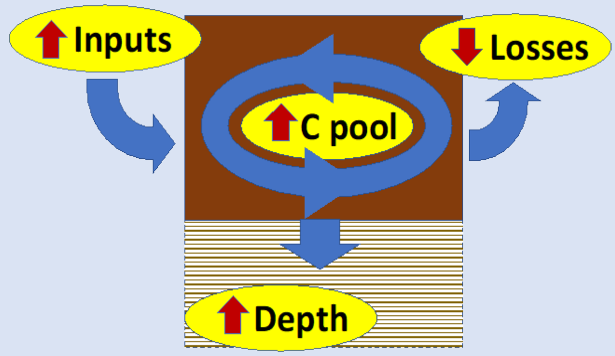
Kisekka, I., Oker, T., Nguyen, G., Aguilar, J., Rogers, D., 2017. Revisiting precision mobile drip irrigation under limited water. Irrig Sci 35, 483–500. https://doi.org/10.1007/s00271-017-0555-7

Compost for Soil Improvement in Alfalfa

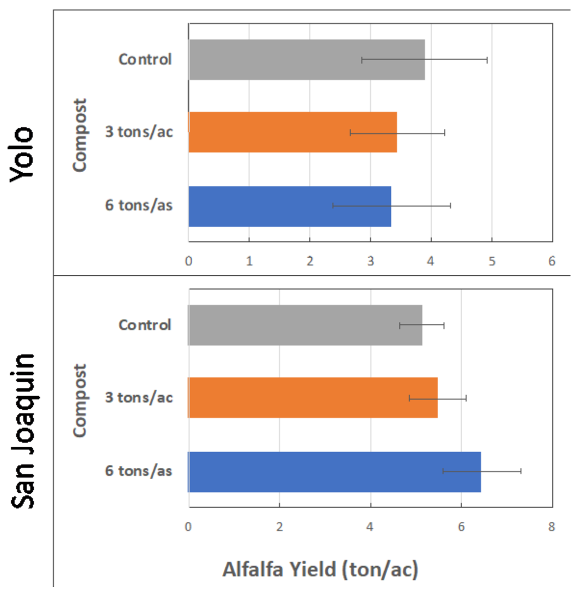
Radomir Schmidt UC Davis (radschmidt@ucdavis.edu)

Why study compost?

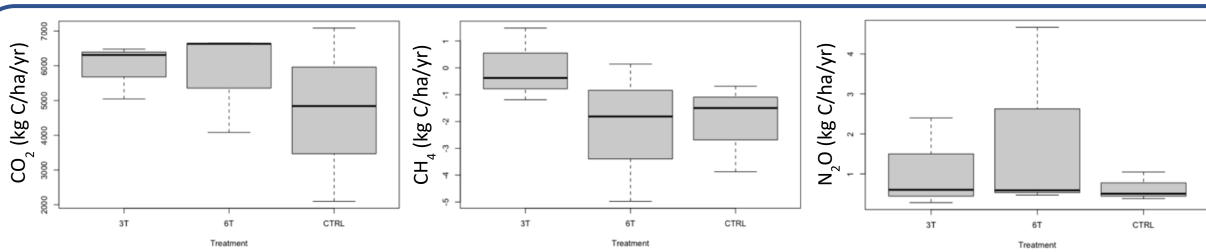
- Strategy for increasing soil carbon
    - Slow release of nutrients
        - steady food supply for microbes
    - Variety of organic compounds
        - promote metabolic diversity
        - feed range of soil cycles
- Mechanisms of action not well understood
    - Best compost x crop x soil combination?
    - Optimum application rate?
    - Soil microbe effects?



Increasing soil carbon



- Green waste compost application at two rates - 3 or 6 tons/acre
- Compost was applied in fall
- Alfalfa flood irrigated
- Compost treatments had similar yields to no compost control during first season
- Yield trends
    - lower in Yolo
        - limited water
    - higher in San Joaquin
        - sufficient water



Gas fluxes in alfalfa

- With compost - higher CO_2, mainly due to higher activity through winter
- Steady increase in activity in spring for all treatments, highest in July/August
- Overall negative methane (CH_4) flux - soils act as methane sink

Healthy Soils Program
CDFA OFFICE OF ENVIRONMENTAL FARMING & INNOVATION

Department of
LAND, AIR AND WATER RESOURCES
University of California, Davis
Climate Change • Sustainable Agriculture
Environmental Quality • Landscape Processes

Soil Quality Considerations during Drought

Michelle Leinfelder-Miles, Delta Farm Advisor
UC Davis Alfalfa Field Day
May 17, 2022

Over the last few years, I have been working on a project to characterize a suite of soil health properties in alfalfa receiving full and deficit irrigation. Soil health has been described as the ability of soil to function and is characterized by biological, chemical, and physical soil properties that are sensitive to changes in management. The idea for this project developed after the 2012-2015 drought when water shortages and regulatory curtailments meant that growers had to make tough decisions on how to apply scarce water resources. Some growers opted to cut irrigation to alfalfa since it is a deep-rooted crop that can scavenge water and nutrients from the soil profile. I had a hunch, however, that while alfalfa may be adapted to survive drought conditions, soil health properties might be negatively impacted because water is essential to life in the soil, facilitates nutrient movement and availability, and influences soil physical characteristics, among other things. Fortunate for me, there was a research trial at UC Davis where I could test this idea.

The UC Davis trial was initiated by Dan Putnam and Isaya Kisekka (UCD Associate Professor of Agricultural Water Management) and managed by graduate student Umair Gull. Their interest was in evaluating alfalfa yield and survival under different levels of deficit irrigation. The replicated treatments were: 1) full irrigation (100 percent of crop evapotranspiration, ETc), 2) full irrigation at the beginning of the season with a sudden cutoff toward the end of the season (60 percent ETc CT), 3) sustained deficit where each irrigation imposes restriction (60 percent ETc SD), and 4) more-severe sustained deficit (40 percent ETc SD). The treatments were applied using overhead irrigation – an 8000 series Valley 500-ft, four-span linear-move system (Figure 1). The primary soil classification at the site is a Yolo silt loam.

Soil sampling occurred twice each year – in the spring before irrigation began and in the fall after the last irrigation. We conducted a comprehensive nutrient analysis, as well as testing organic matter, total carbon and nitrogen, salinity, compaction, bulk density, N mineralization, and particulate organic carbon.

See this recent blog post by UC Alfalfa and Forage Specialist Dan Putnam, and Farm Advisor Rachael Long on the resiliency of alfalfa during drought: https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=51887.

Figure 1. UC Davis trial location with overhead irrigation system used to apply irrigation treatments.

Acknowledgements: In addition to Dan, Isaya, and Umair, I want to acknowledge Daniel Geisseler (UC Nutrient Management Specialist), Will Horwath (Professor of Soil Biogeochemistry), and graduate student Veronica Suarez Romero who have helped on soil nitrogen and carbon testing. I want to thank the South Delta Water Agency for financially supporting the project.

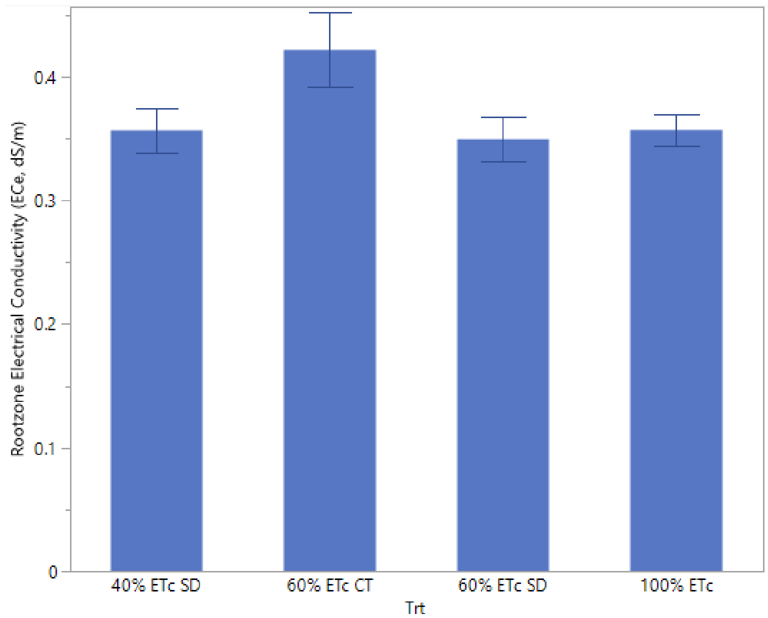


Figure 2. Rootzone salinity from the soil surface to 36-inch depth across three seasonal readings (Fall 2019, Spring 2020, Fall 2020). Of note, the statistical analysis from all three seasons, including Spring 2020, indicated that not even winter (2019-20) rainfall leaching was adequate to bring rootzone salinity down in the 60% ETc cut-off (CT) treatment.

Data analysis is ongoing, but preliminary results suggest that soil health may not be resilient under deficit irrigation or drought, even if alfalfa is. When the trial began in Spring 2019, there were no differences in rootzone salinity among treatments, which averaged 0.41 dS/m. After two cropping seasons where deficits were imposed, the 60 percent ETc treatment with the water cut-off toward the end of the season (CT) resulted in significantly higher rootzone salinity down to the 36-inch depth (Figure 2). The salinity in that treatment was higher than even the 40 percent ETc treatment that had the sustained deficit (SD) throughout the entire season (Figure 3). In other words, it appears that the timing of the deficit is more important than the amount of deficit, and applying water throughout the season – even if the amount is severely reduced – appears to mitigate salinity build-up in the rootzone. Of note, salinity is not high enough to be problematic at this site. The overall ECe of the soil is low, and water quality is generally good at this location. I would expect, however, that in locations where soil and/or water has higher salinity to begin with, then deficit irrigation that includes a water cut-off could be problematic. There will be a lot more information to come about this project in the near future, but the salinity information seemed timely to share given our current water year.

I view alfalfa as a model crop for studying soil health under restricted water conditions because practices like crop rotation and tillage do not occur over the four or more years of an alfalfa stand. Therefore, those practices would not confound our results. From this experiment, we are learning how imposing varying levels of deficit at different stages of the cropping season impact soil properties, which will help us optimize deficit irrigation strategies for alfalfa. Additionally, the deficit treatments serve as a proxy for drought and could potentially demonstrate how prioritization of water uses during drought may impact soil conservation outcomes.

Figure 3. Treatment 4 (40% ETc SD) with Treatment 2 (60% ETc CT) to left.