Subsurface Drip Irrigation, Deficit Irrigation Strategies, and Varieties to Improve Alfalfa Water Use Efficiency

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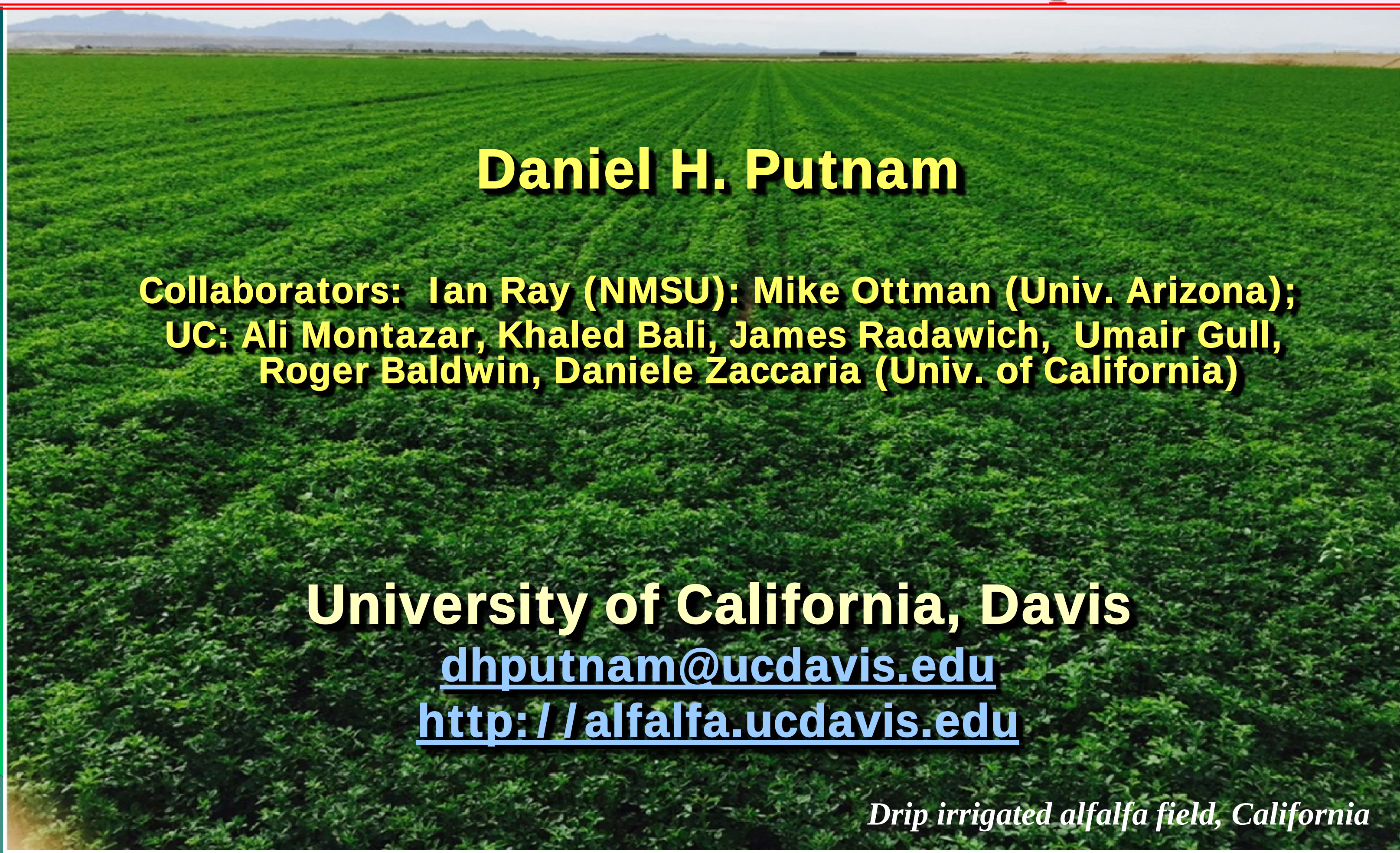

Drip irrigated alfalfa field, California

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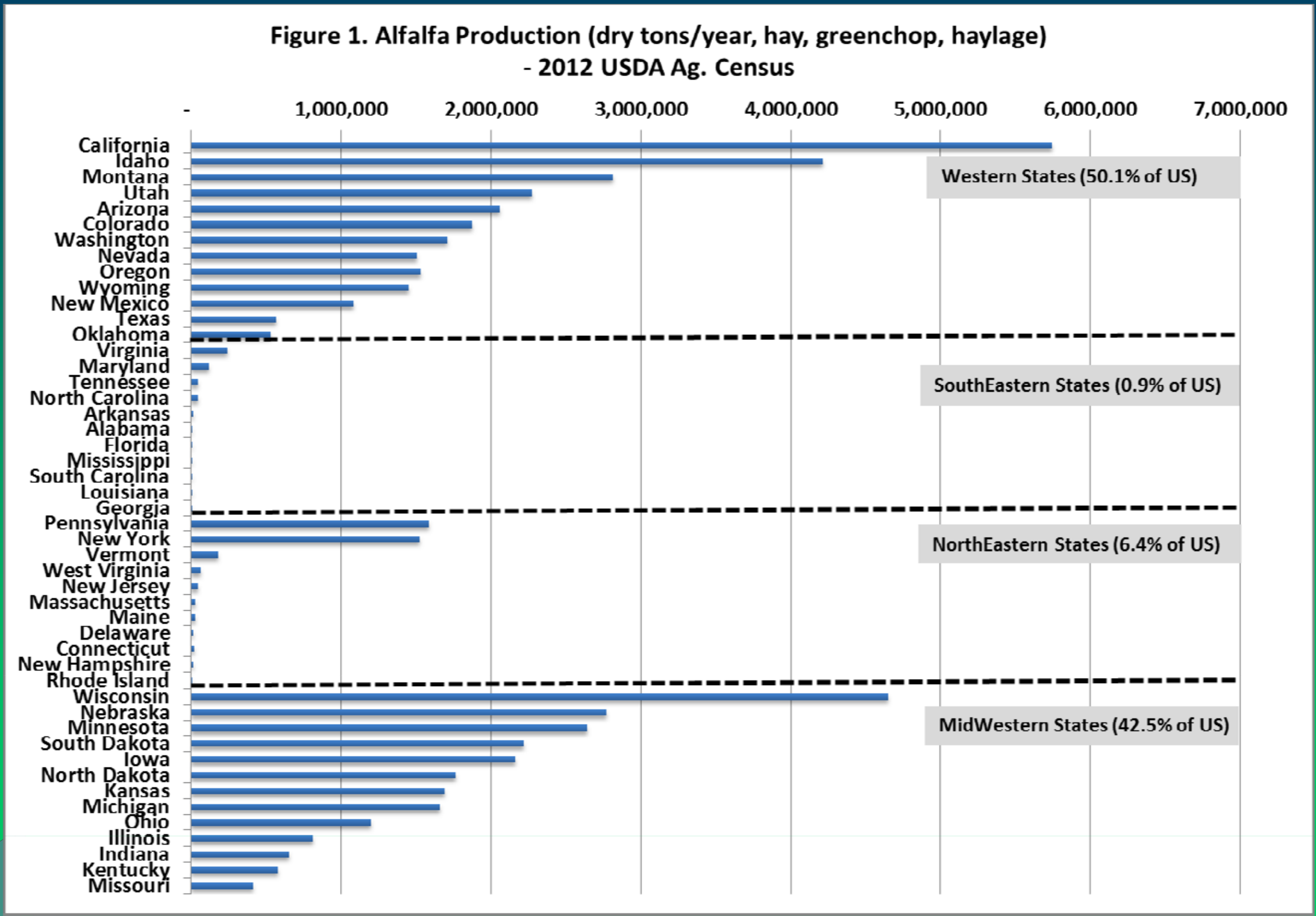
Alfalfa Production



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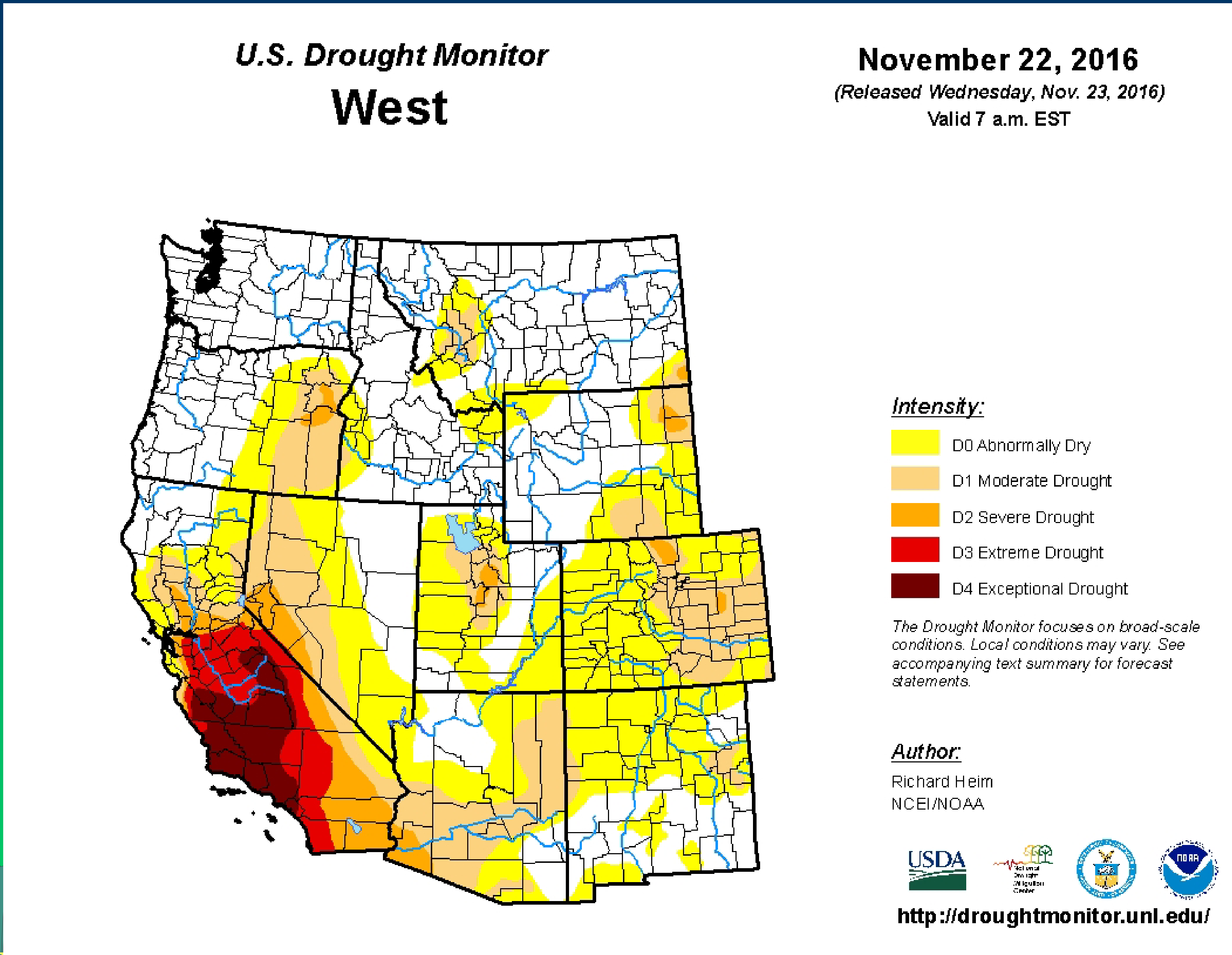
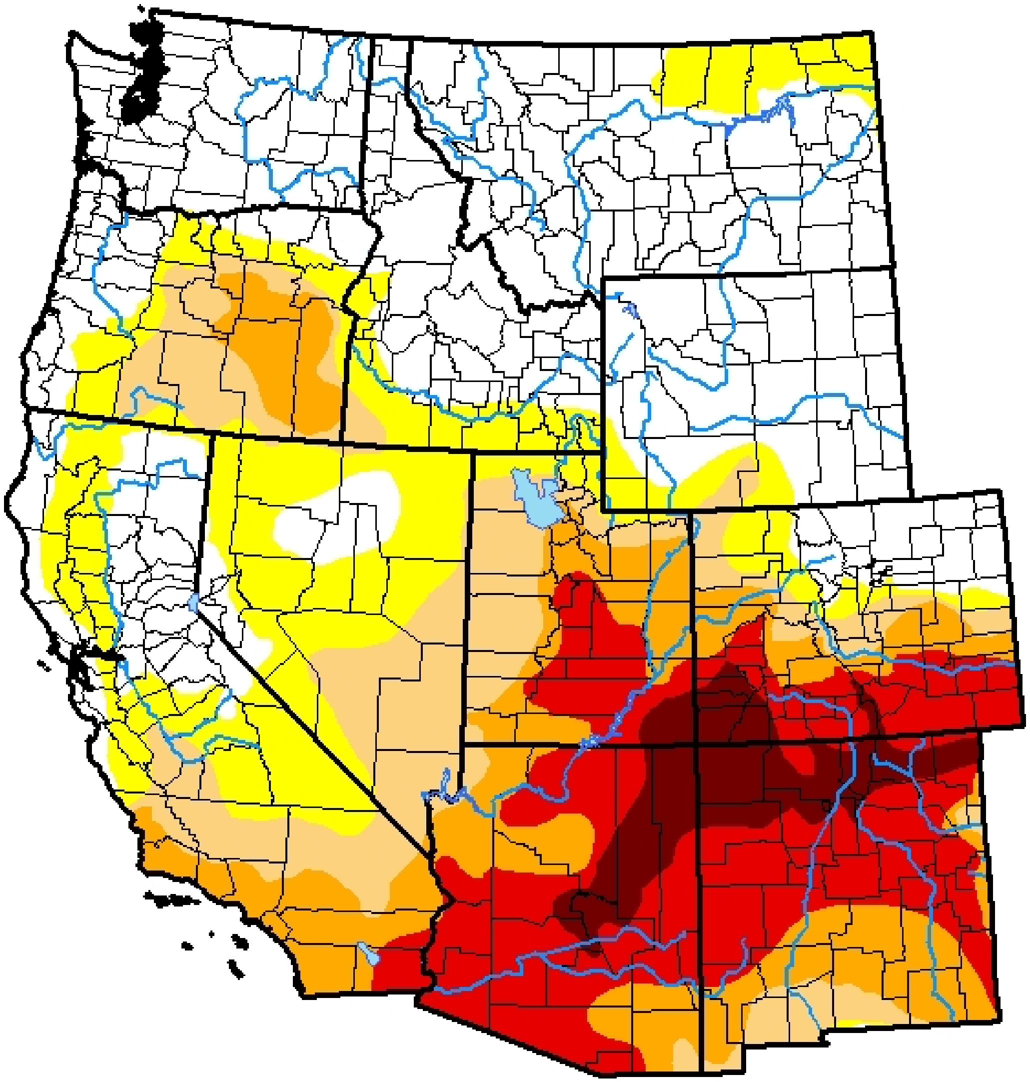

U.S. Drought Monitor
West
November 22, 2016
(Released Wednesday, Nov. 23, 2016)
Valid 7 a.m. EST
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.
Author:
Richard Heim
NCEI/NOAA
USDA
NOAA
http://droughtmonitor.unl.edu/

U.S. Drought Monitor
West

May 29, 2018
(Released Thursday, May. 31, 2018)
Valid 8 a.m. EDT



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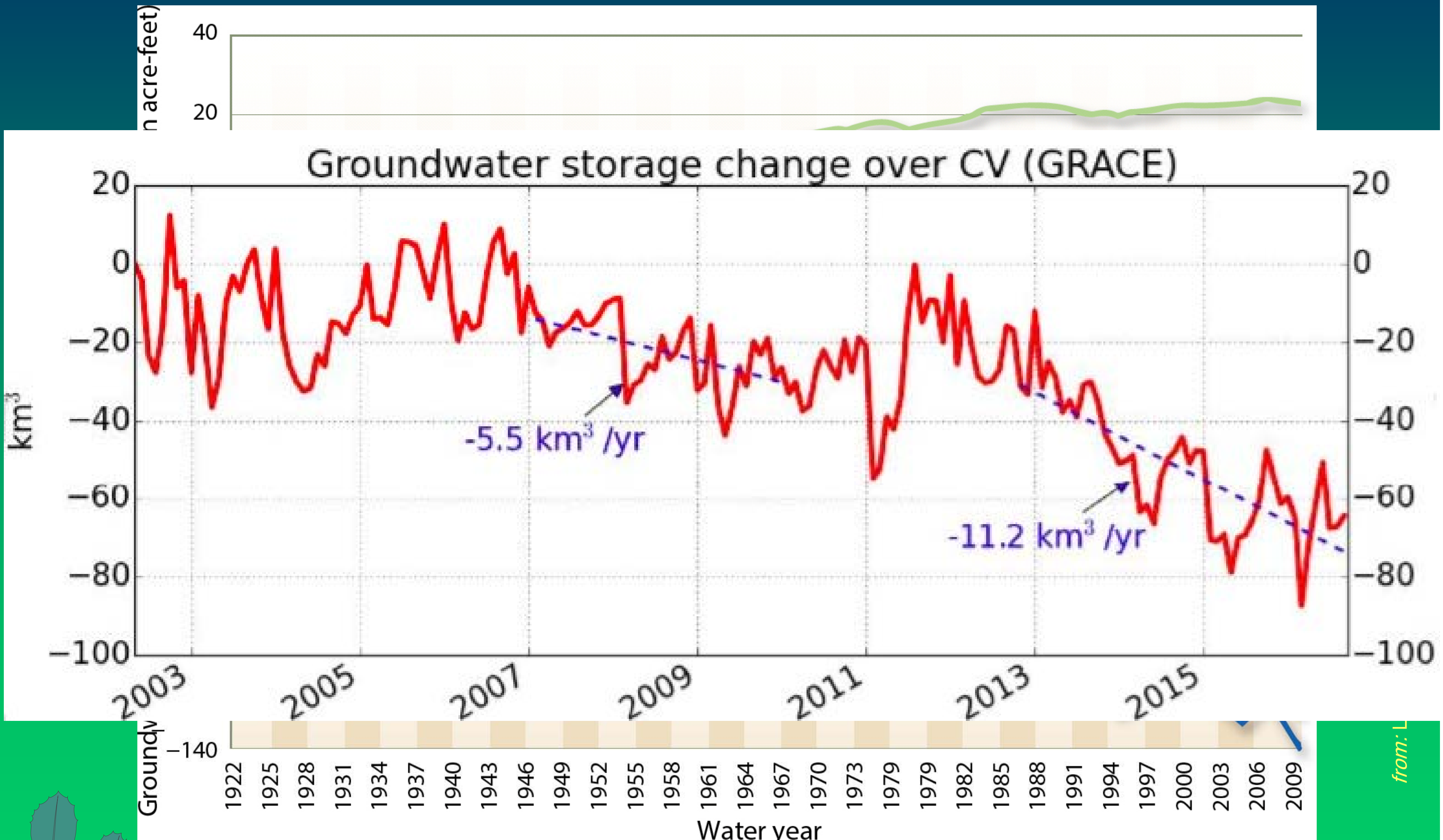
Author:

Anthony Artusa
NOAA/NWS/NCEP/CPC

http://droughtmonitor.unl.edu/

Groundwater Challenge in the Central Valley



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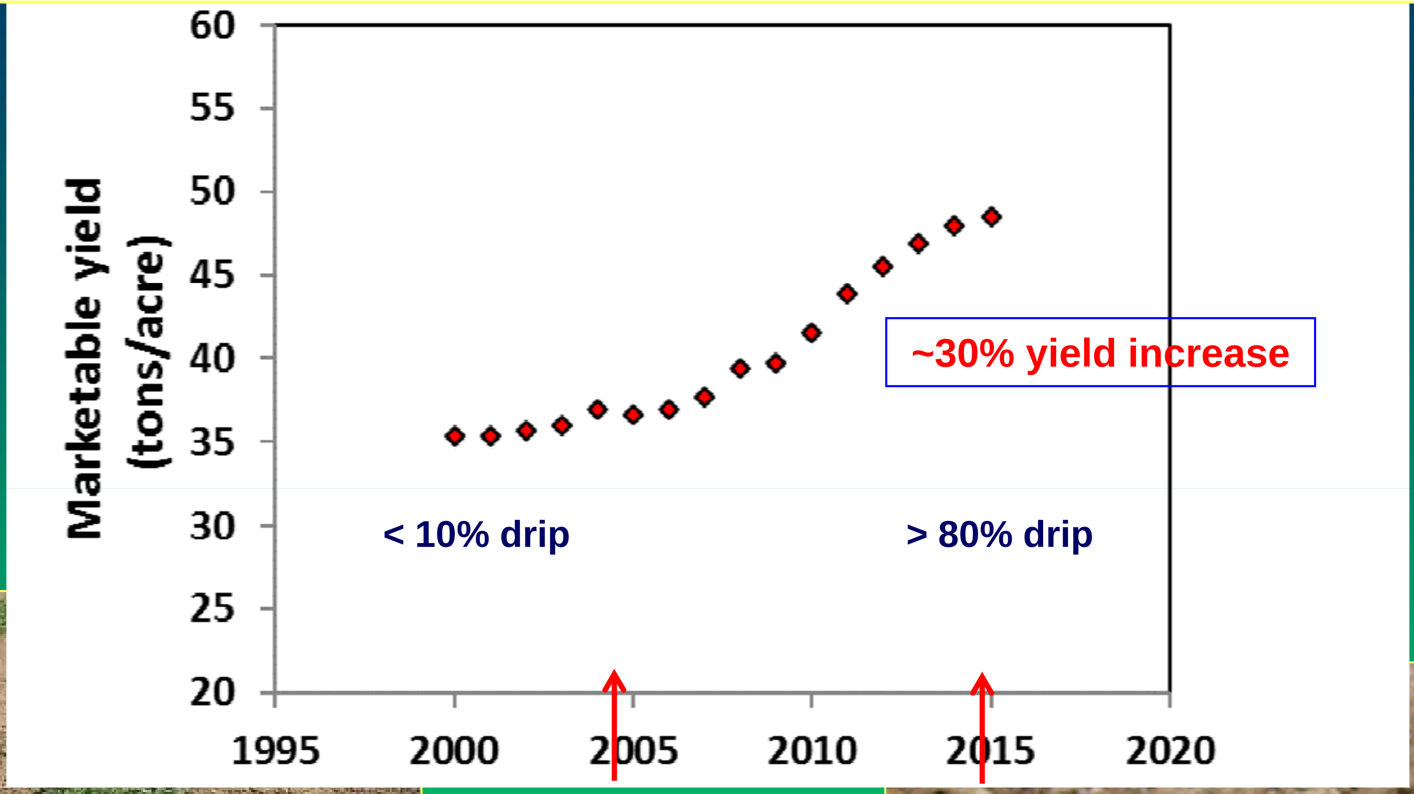
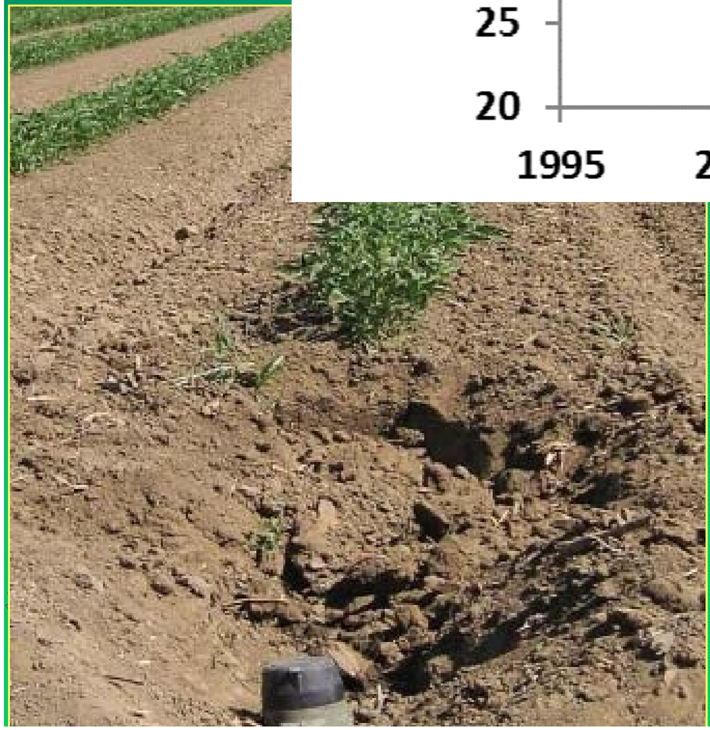
Xiao et al. Apr. 2017

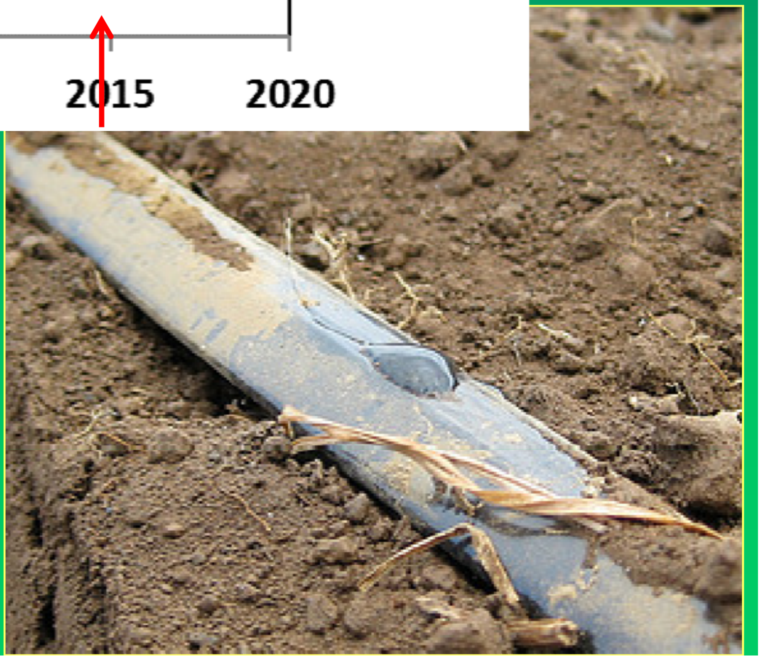
Impetus:

- **Periodic droughts – water supply limitations**
- **Water transfers to other uses**
  - **Competing crops**
  - **Cities**
  - **Environmental (regulatory)**
- **Irrigation management is a major limiting factor for yield**
  - **Distribution uniformity, timing**

Why Subsurface Drip (SDI)? (tomato story)







Overall Objectives

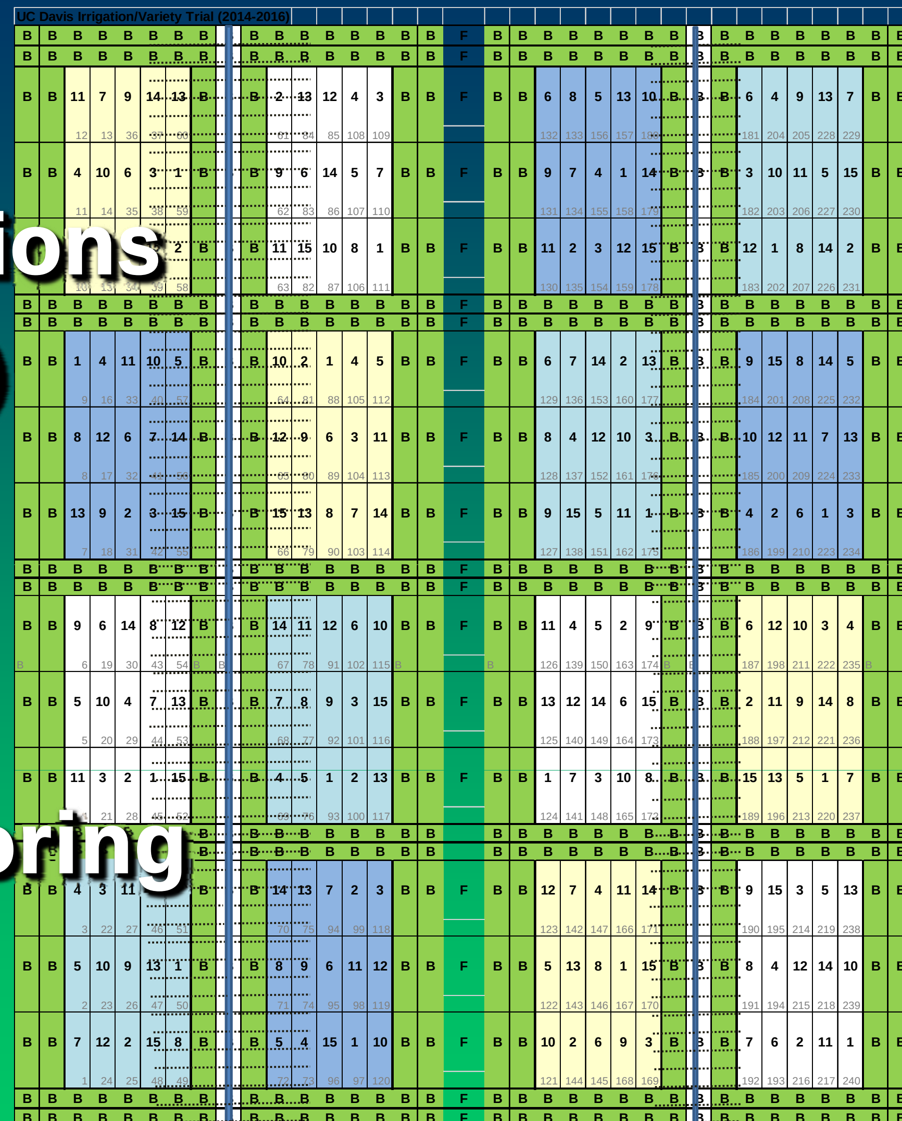
- Is Subsurface Drip Irrigation (SDI) a viable strategy for western alfalfa producers?
- Can Alfalfa be partially irrigated to achieve water savings and economically-viable yields?
- Are there specific varieties that are more suited to water deficits?
- Issues of technique (spacing, etc.)

Activities

- Breeding of Varieties under drought (NMSU)
- Variety X water deficits (UC Davis)
- SDI vs. Flood (UC, Fresno Co.)
- Working with farmers (~30 Farm visits) – SDI alfalfa (CA, AZ)
- Field Days, Farmer Training programs, Irrigation workshop (CA, AZ, NV)
- Grad Student training (CA, NMSU)

Davis Trial

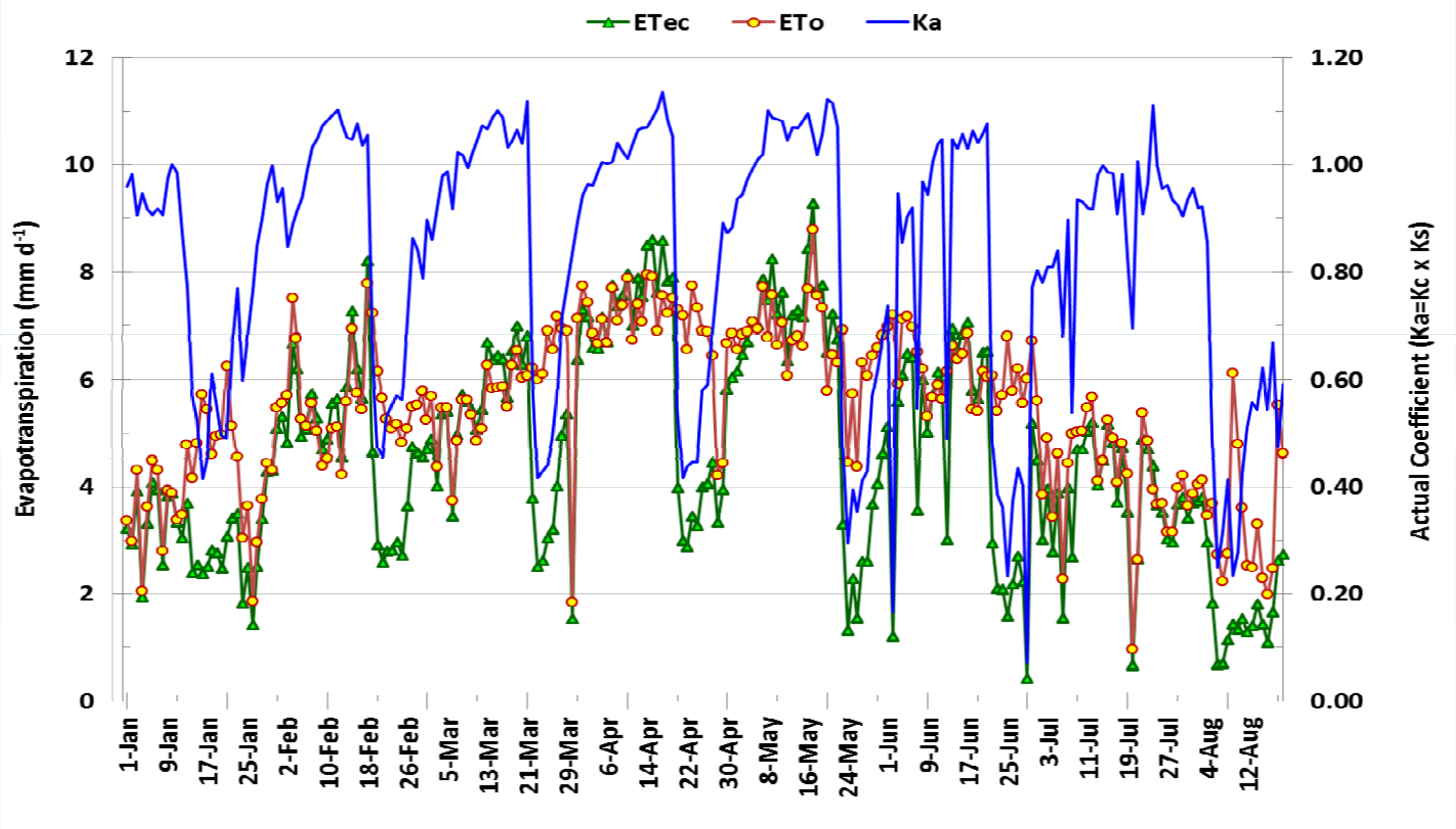
- Split Plot- 4 replications
- Deficit Irrigation (4)
- Variety (15)
  - FD 5-10
- 3 years
- Yields, water monitoring



Irrigation Treatments

- 100% of ET_c (guided by K_c) Applied
- 75% of ET_c (full, then sudden cutoff at 75% of seasonal ET_c) - July
- 75% of ET_c (fully irrigated to mid-season, then 50% of ET_c)
- 50% of ET_c (fully irrigated to mid-season, then cutoff) - June

ET – Davis, CA



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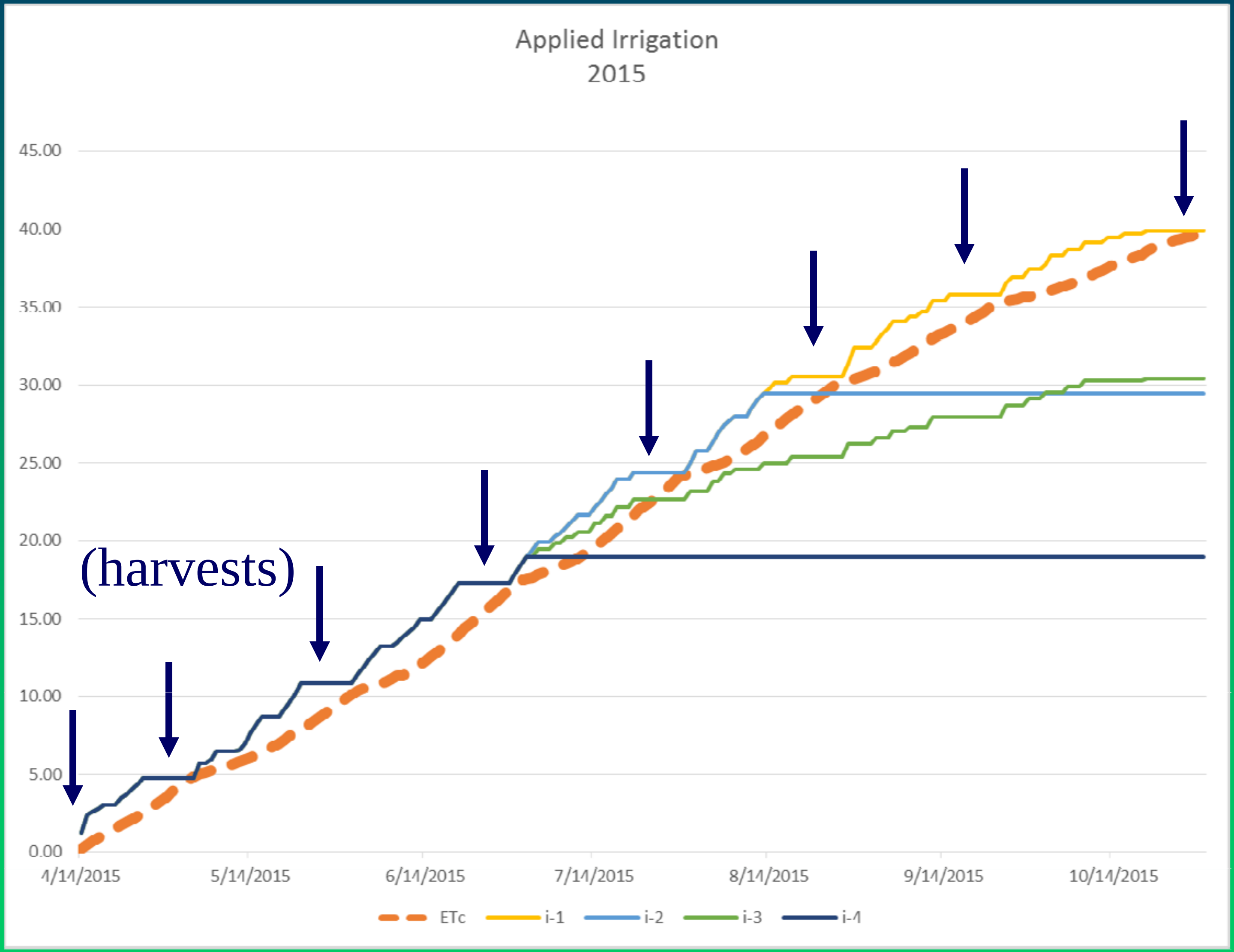
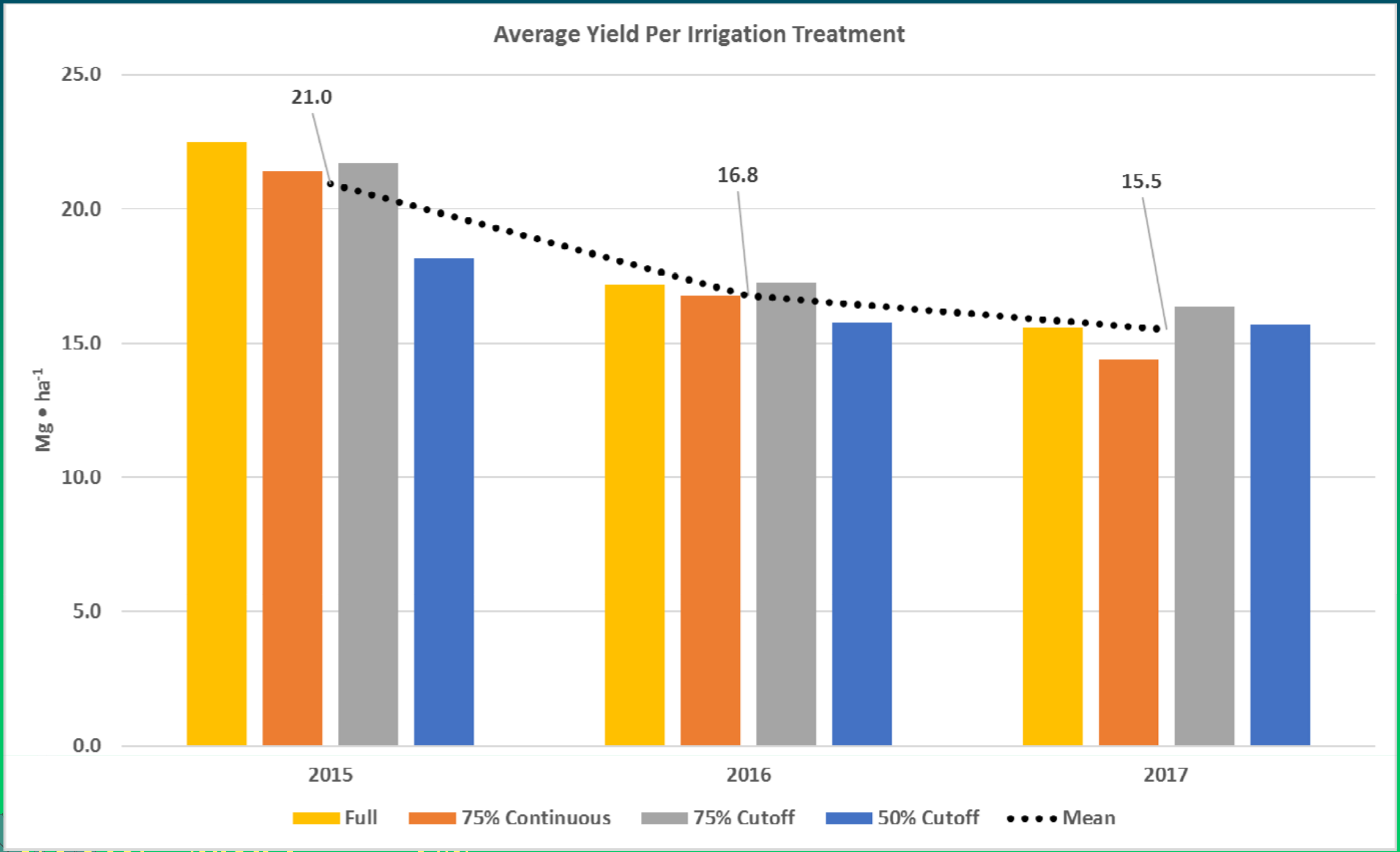
Irrigation Treatments



Results

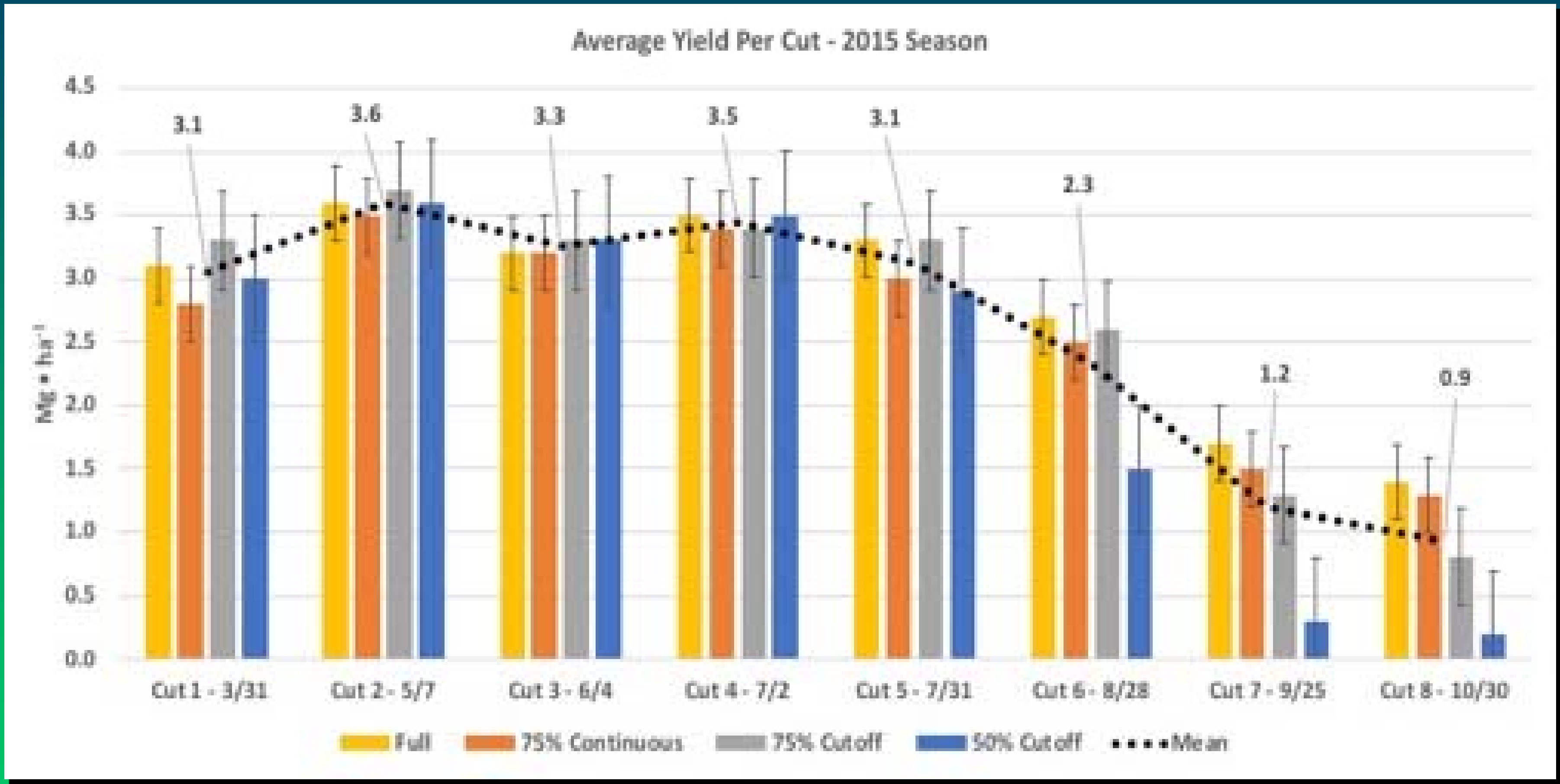


Average Yield Per Irrigation Treatment
25.0
20.0
15.0
10.0
5.0
0.0
Mg • ha-1
21.0
16.8
15.5
2015
2016
2017
Full
75% Continuous
75% Cutoff
50% Cutoff
Mean

Results (cum. t/a)

3 Season Totals - Response to Irrigation Treatments					
CUMULATIVE YIELD - UC DAVIS TRIAL (2015-2017) t/a					
Variety	Fall Dormancy	50% Cutoff	75% Continuous	75% Cutoff	Full
NM14GTAF	8	24.47	24.79	28.97	29.16
AFX149092	9	24.50	26.75	26.76	28.76
CUF 101	9	22.86	24.95	25.47	26.28
NM14ALWLHQ	7	23.48	25.41	27.01	26.09
NM14BM1008251	7	22.03	23.48	23.14	25.91
AFX148091	8	23.33	25.61	26.45	25.79
SW10	10	24.34	24.28	28.00	25.26
S8421S	8	24.09	25.09	26.19	25.20
Artesian Sunrise	7	20.31	23.38	22.21	24.30
NM14MLLS2	6	21.37	21.24	25.13	23.62
NM14MALHS3	6	20.95	22.70	22.09	23.24
HybriForce 2600	6	19.92	21.91	23.32	21.93
NuMex Bill Melton	7	22.25	22.55	22.82	21.70
NM14BMHS1	6	21.30	21.19	22.44	21.60
R510Hg812dt	5	17.45	18.73	20.78	21.04
Mean		22.18	23.47	24.72	24.66
Percentage of Full:		90%	95%	100%	100%
F test:		VAR (**), IRR (**); VAR X IRRIG (n.s.)			
		LSD 12.408			
		C.V. 7.7%			

38%



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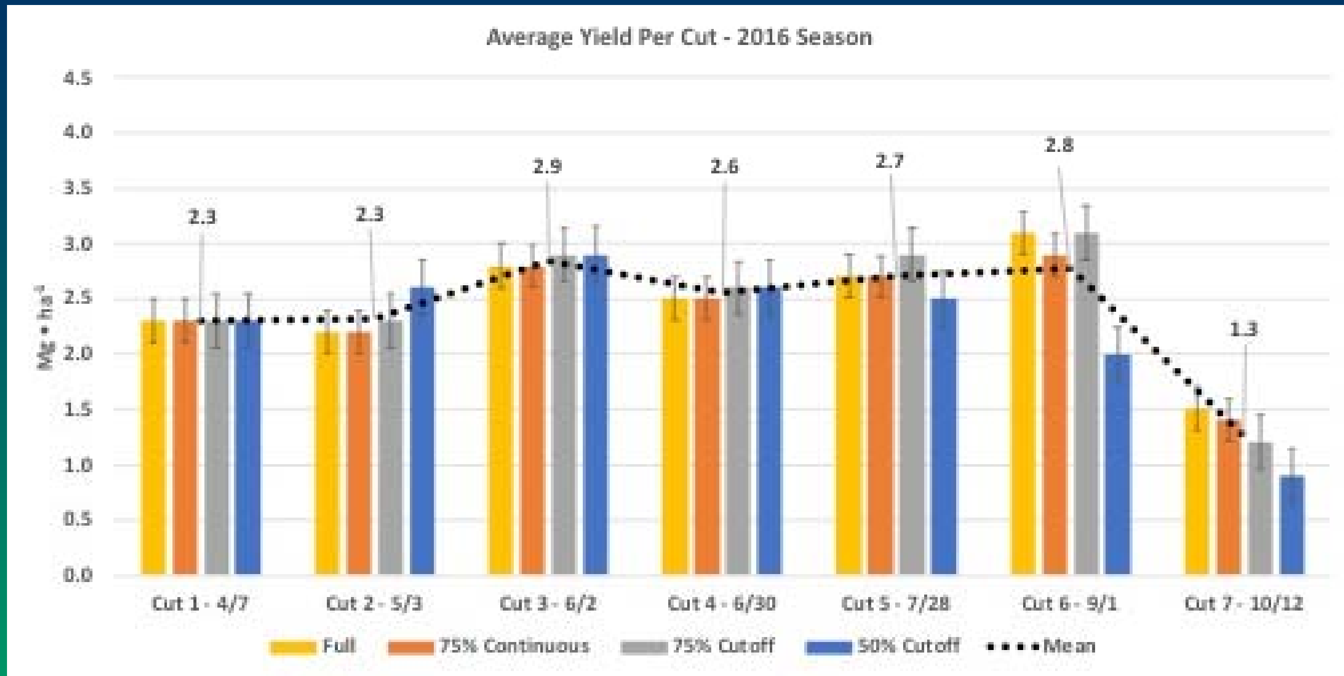
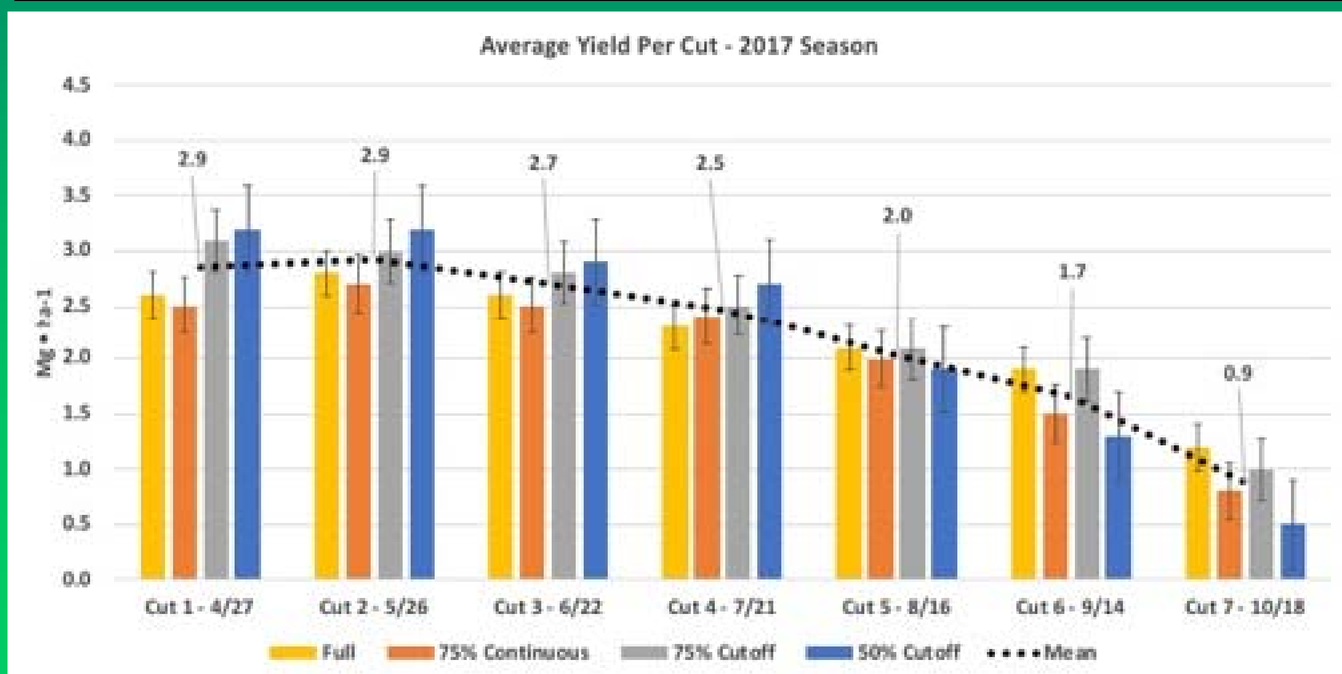

Average Yield Per Cut - 2016 Season
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Mg • ha-1
2.3
2.3
2.9
2.6
2.7
2.8
1.3
Cut 1 - 4/7
Cut 2 - 5/3
Cut 3 - 6/2
Cut 4 - 6/30
Cut 5 - 7/28
Cut 6 - 9/1
Cut 7 - 10/12
Full
75% Continuous
75% Cutoff
50% Cutoff
Mean


Average Yield Per Cut - 2017 Season
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Mg • ha-1
2.9
2.9
2.7
2.5
2.0
1.7
0.9
Cut 1 - 4/27
Cut 2 - 5/26
Cut 3 - 6/22
Cut 4 - 7/21
Cut 5 - 8/16
Cut 6 - 9/14
Cut 7 - 10/18
Full
75% Continuous
75% Cutoff
50% Cutoff
Mean

End of trial

Full Irrigation (100% Seasonal ET)

75% (Cutoff)

75% (Continuous Deficit)

50% (Cutoff)

(Oct. 16, 2017 Davis, CA)

What traits may be important?

- High overall yields under full irrigation
- Early season yields
- Stand Survival under drought
- Deep roots to access deep moisture
- ‘Shutting down’ during drought (even with moisture)

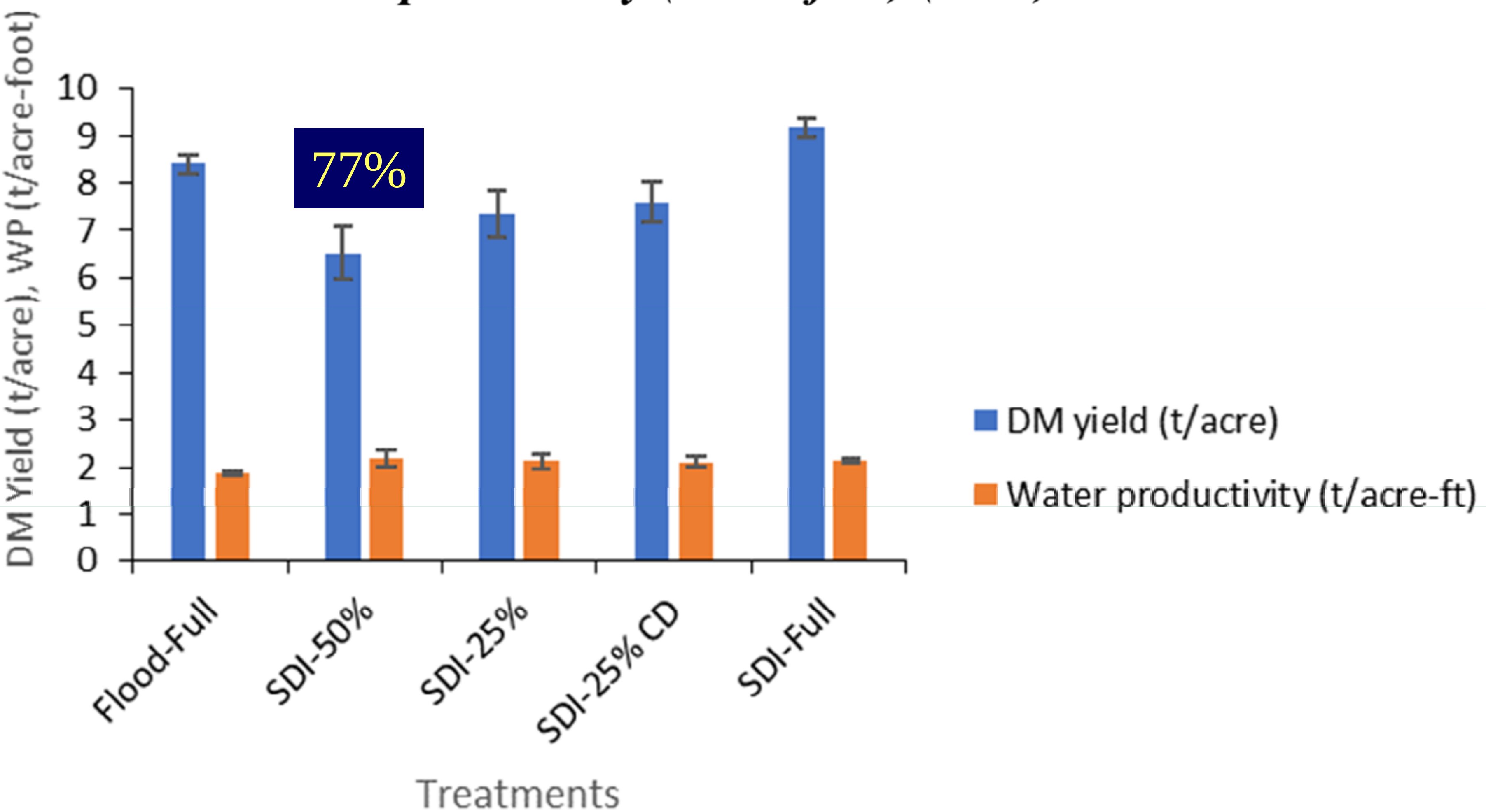
Kearney Trial (Fresno)

<---590'--->																							
Experiment I																					Experiment II		
border	Block I					Block II					Block III					Block IV							
border	1	2	3	4	5	5	4	3	2	1	1	5	3	4	2	2	3	5	4	1	Fert. Exp.	Fert. Exp.	Fert. Exp.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Tule System

- 100% ET Flood
- 100% ET drip
- 50% ET drip sudden cutoff
- 75% ET drip season-long deficit
- 75% ET drip sudden cutoff

Figure 6: Seasonal dry matter yield (t/acre) and water productivity (t/acre-foot) (2017)



Where

Flood-Full- 100% Applied ET

SDI- 50% Deficit of applied ET

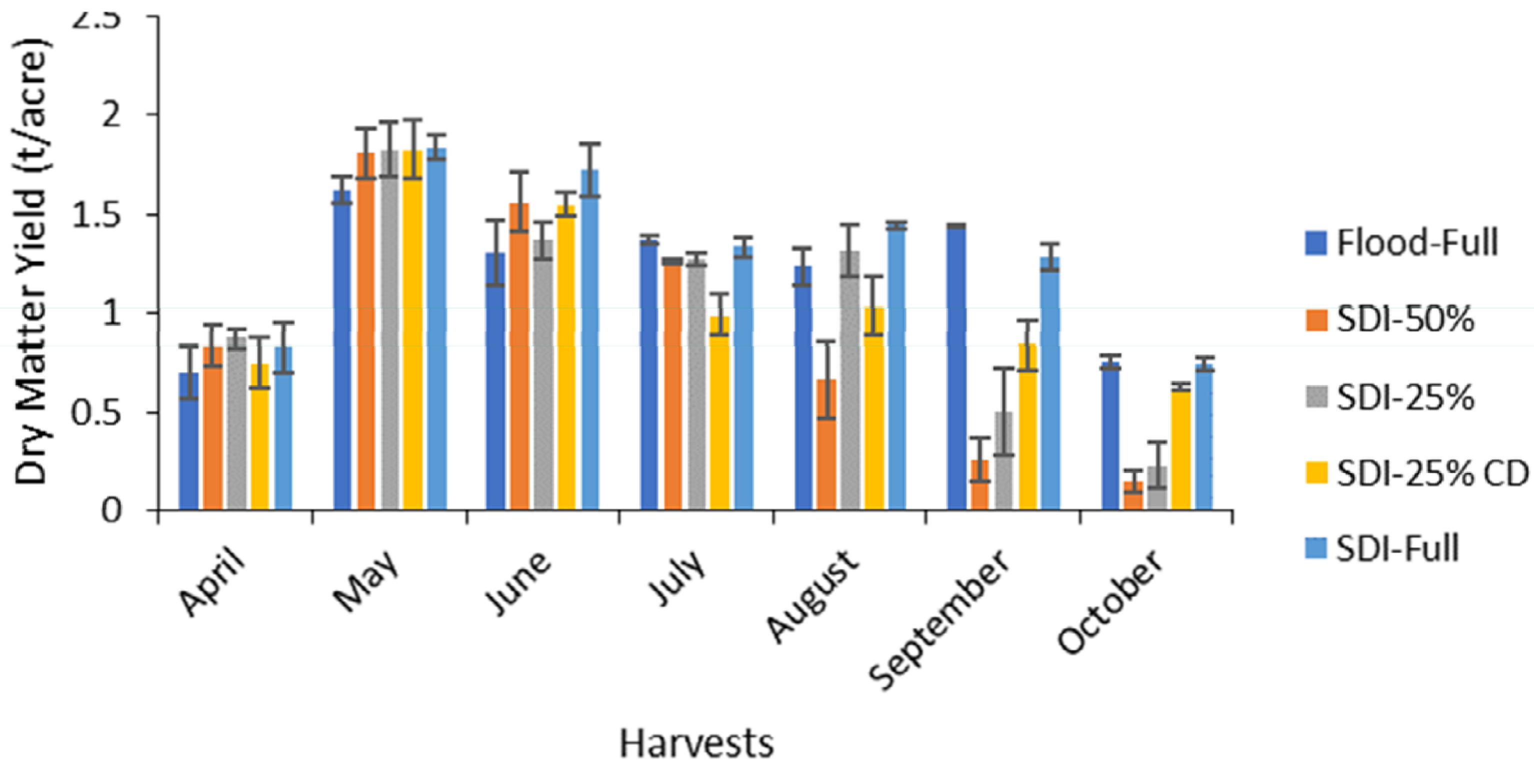
SDI-25% Deficit of applied ET

SDI-25% Continual Deficit (CD) of applied ET

SDI-Full- 100% Applied ET

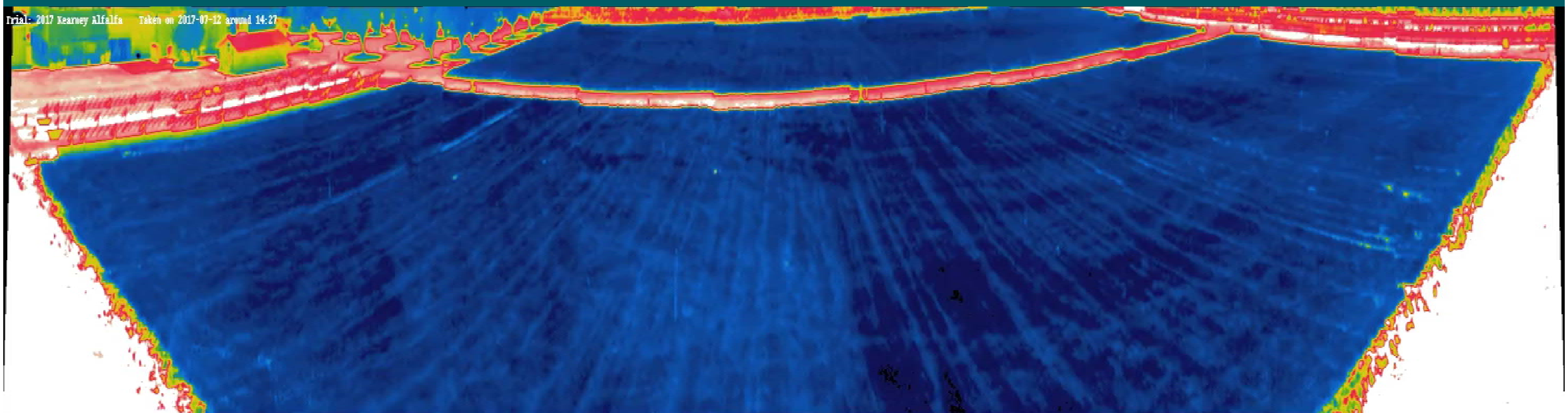
Kearney Results (Year 1)

Figure 5: Alfalfa dry matter yield (t/acre) as influenced by treatment effect (2017)



Where
Flood-Full- 100% Applied ET
SDI- 50% Deficit of applied ET
SDI-25% Deficit of applied ET
SDI-25% Continual Deficit (CD) of applied ET
SDI-Full- 100% Applied ET

Thermal Imaging -



Results of controlled trials

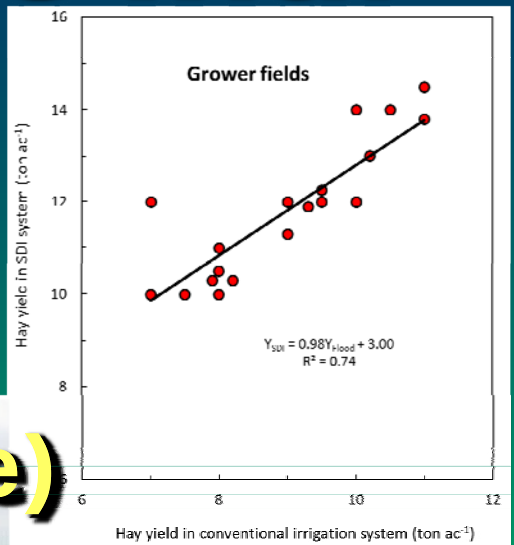
- Regulated deficit irrigation highly feasible with alfalfa
- ‘sudden cutoff’ superior to gradual deficits (water fully, then stop)
- Variety x irrigation interaction not significant in Davis experiment
- Yield losses under deficits
  - Compensation for water transfer?

Working with Farmers

- Large-scale production reveals factors not apparent in small-plot studies
- Case studies of ~30 SDI alfalfa growers

Grower Experience with SDI

- Many Positives
- Better field distribution (DU)
- Timing (quickly fill the profile)
- Lower labor
- +yields ~2-3 t/a
- High cost
- Maintenence



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Key Factors

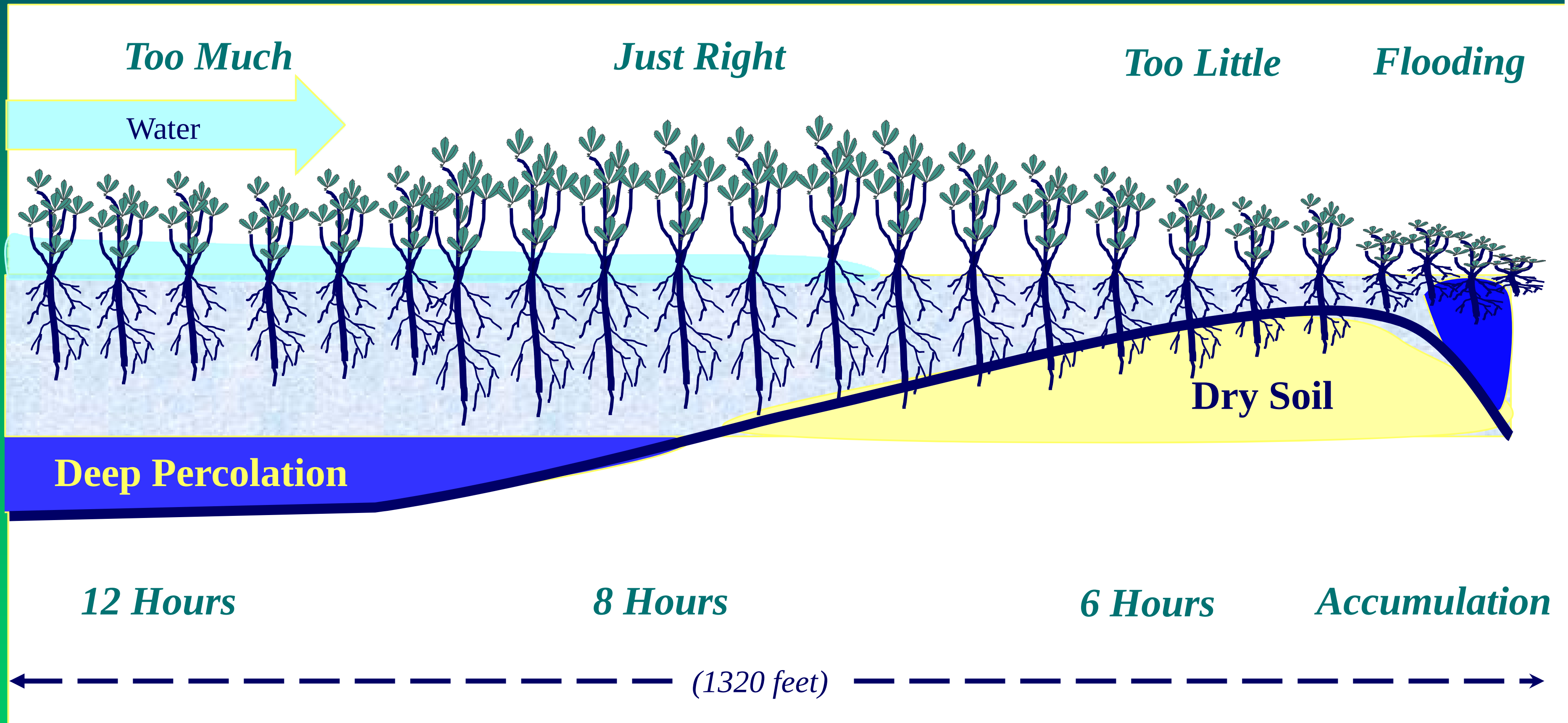
Superior Distribution Uniformity (in Space)

- Less difference between top and bottom of field
- Well known problems with surface systems
- Tail end management

Innate Problems with Flood Irrigation

(Distribution uniformity can be poor due to soil infiltration rate, flow, and set duration)

In a 12 hour irrigation set:



Superior Distribution Uniformity (in Time)

- Ability to 'charge' a field within hours, not days
- Most Flood-irrigated (and some sprinkle irrigated) fields require 4-12 days to irrigate, depending upon flow available.

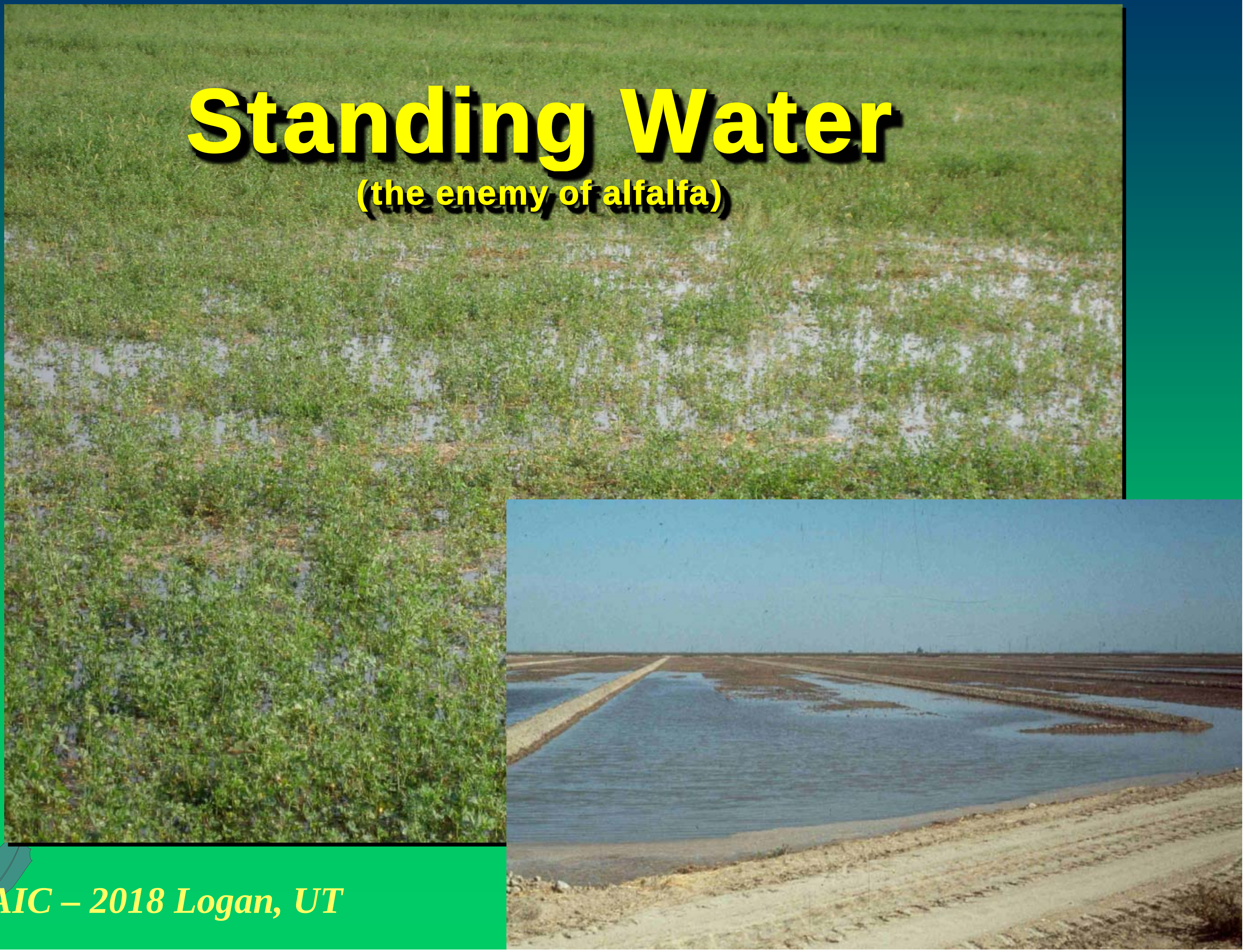
Well known Limitations of flood irrigation

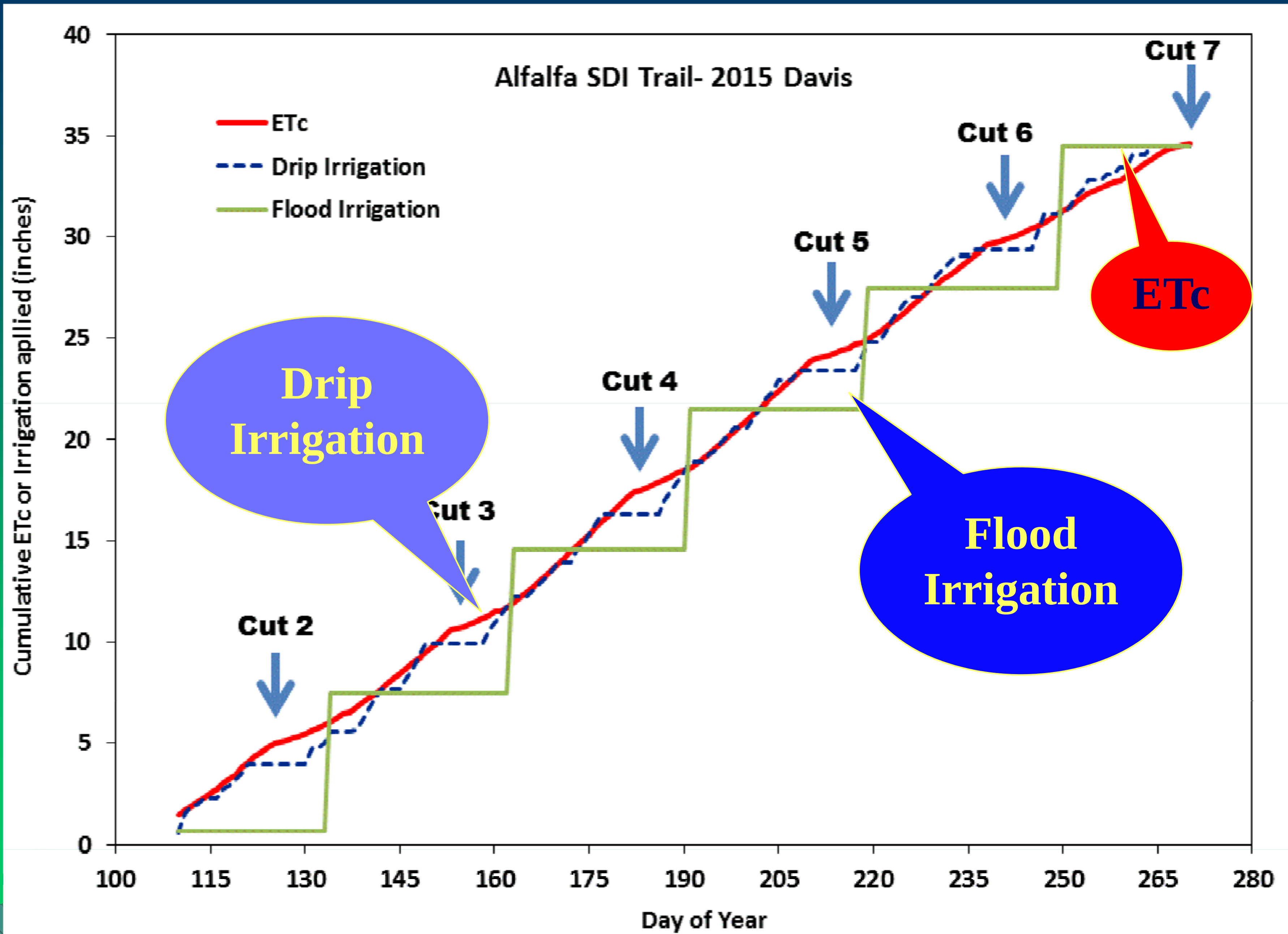
Well – known limitations of flooding

Weeds intrude in damaged areas

Standing Water

(the enemy of alfalfa)



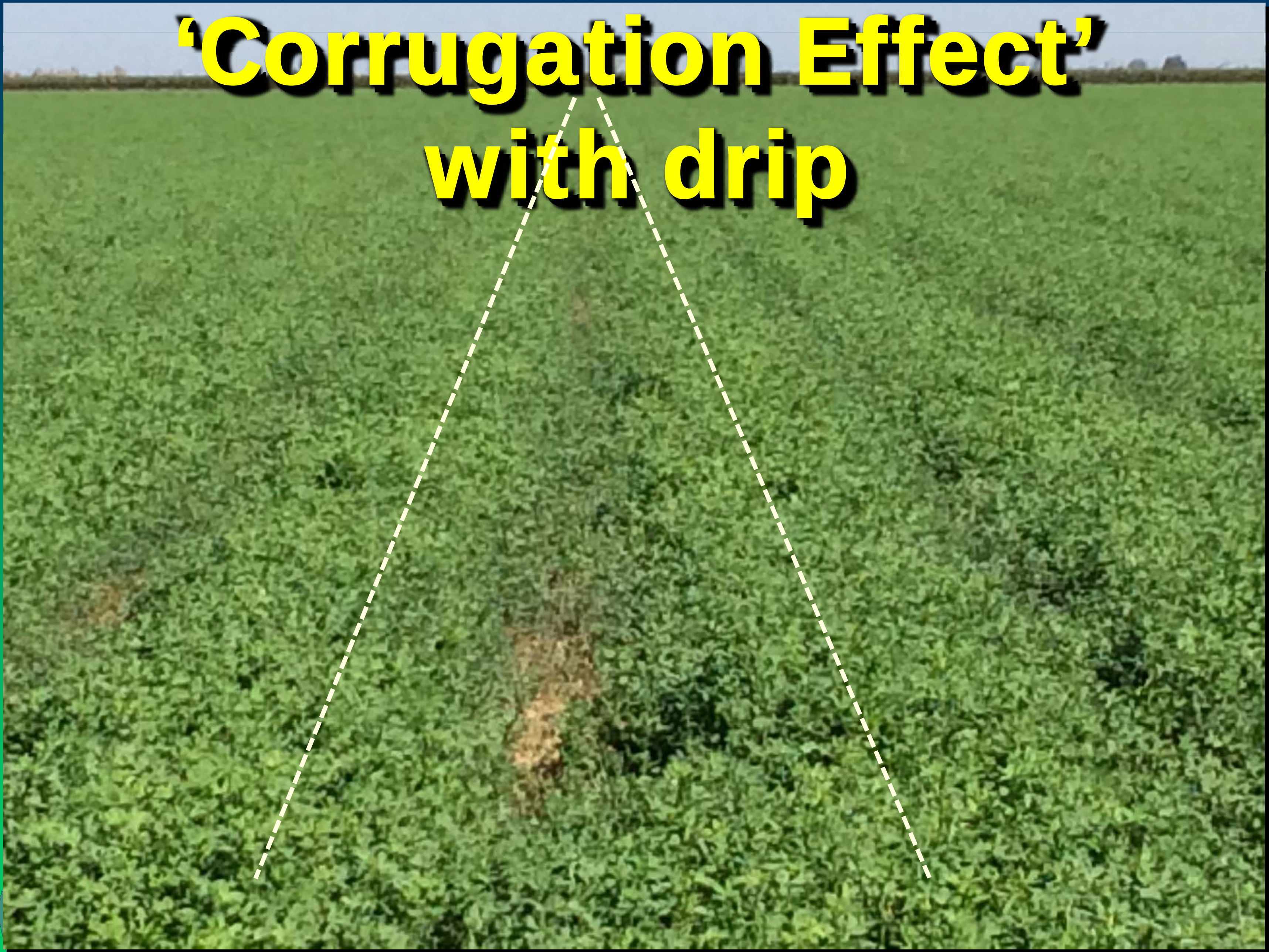


Alfalfa SDI Trail- 2015 Davis
ETc
Drip Irrigation
Flood Irrigation
Cumulative ETc or Irrigation aplied (inches)
Day of Year
Cut 2
Cut 3
Cut 4
Cut 5
Cut 6
Cut 7
Drip Irrigation
Flood Irrigation
ETc
0
5
10
15
20
25
30
35
40
100
115
130
145
160
175
190
205
220
235
250
265
280

Can a system follow ET?

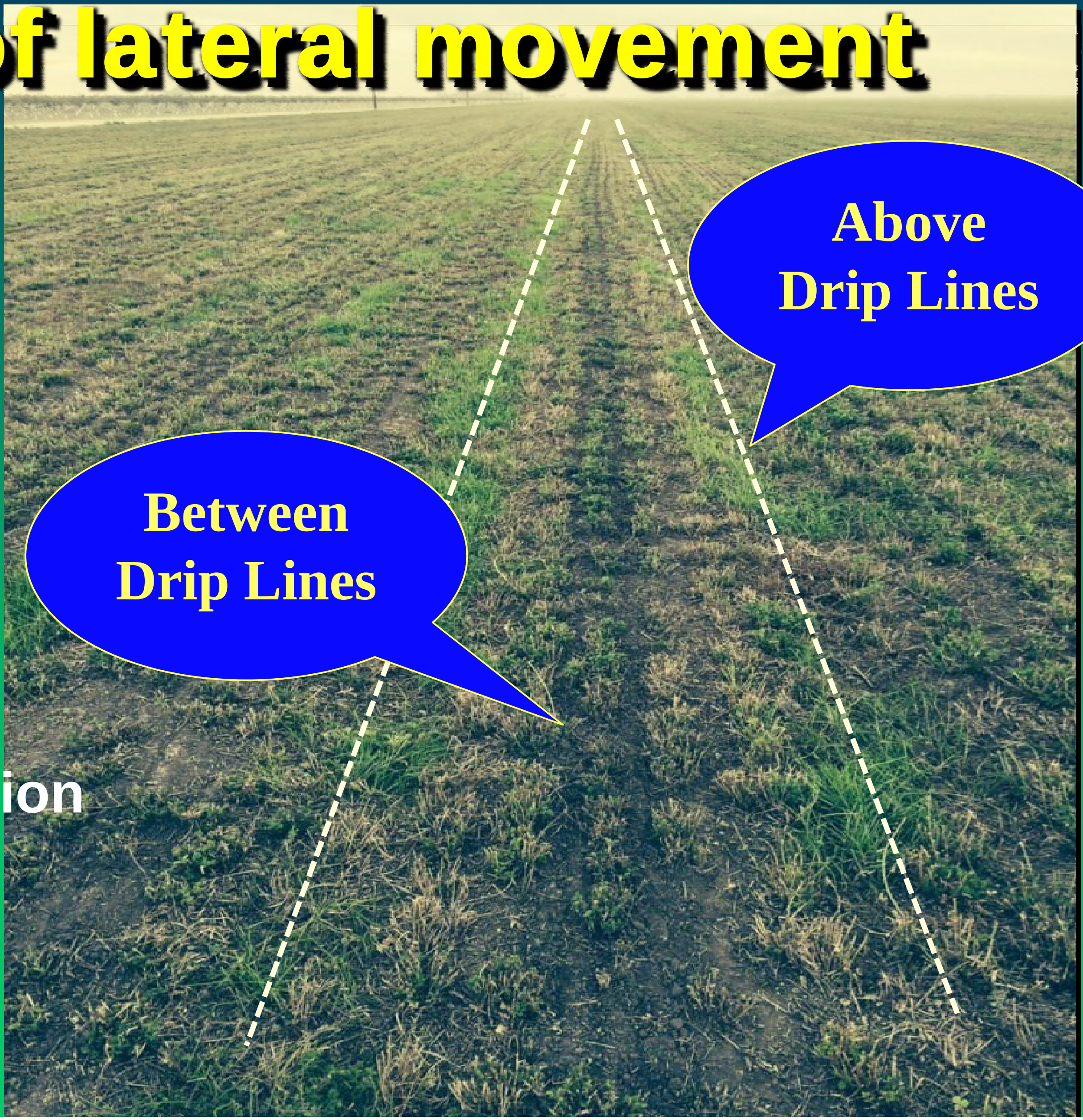
- Is it restricted in terms of applying small amounts?
- Can it recharge the profile?

‘Corrugation Effect’ with drip




Between Drip Lines
Above Drip Line
1 SUBJECT
70
Sheets
10.5" x 8" • College Ruled

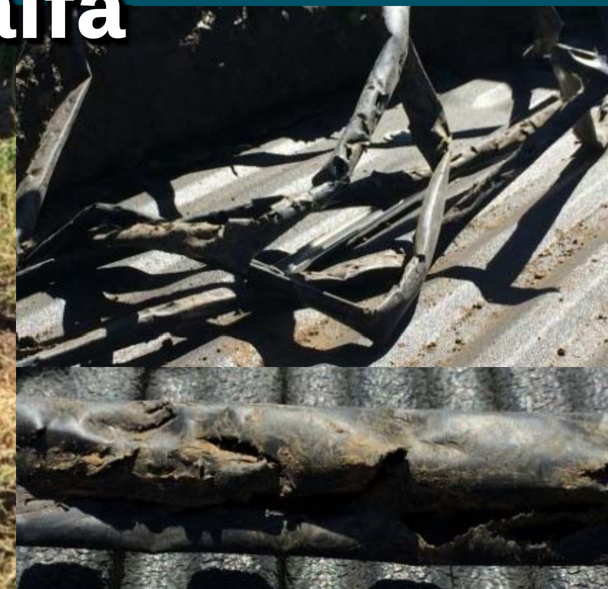
Over Irrigating to compensate for lack of lateral movement



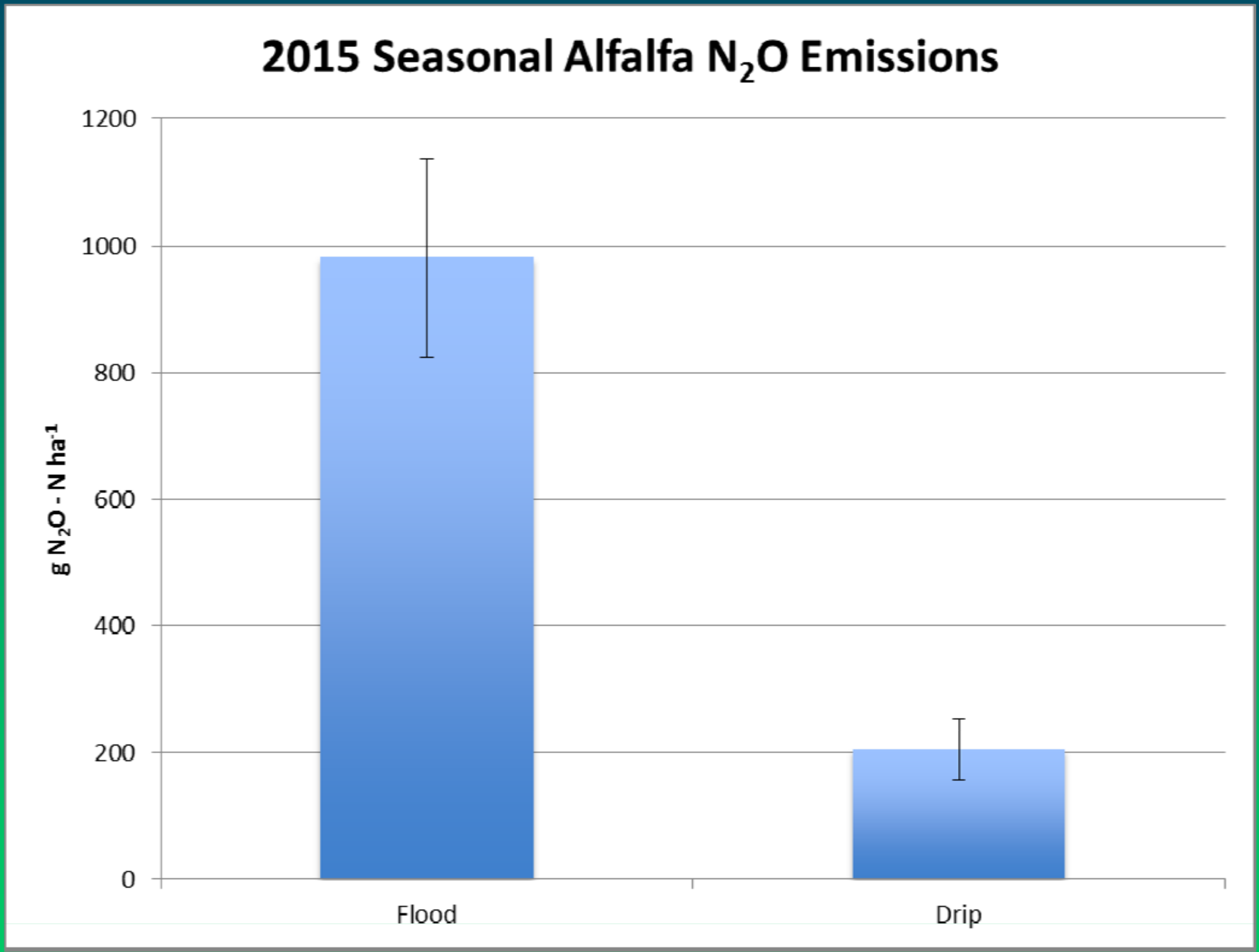
Standing Water,
Loss of Stand,
Grassy Weed Intrusion

Key Factors

Rodents are perhaps THE major challenge for SDI in alfalfa



GHG Emissisons



Data: Ryan Byrnes, Martin Berger, Will Horwath

Conclusions

- Alfalfa highly conducive to deficit irrigation strategies
- ‘Best Crop to Have in a Drought’
- In this study, no significant variety x deficit interactions
- SDI is a viable technique with possible yield increases and water savings
- Cost and maintenance (gophers) are major negatives

Many thanks!

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Agriculture and Natural Resources
Cooperative Extension