The Economics of Deficit Irrigation on Alfalfa

Water Savings and Yield Reduction

Khaled M. Bali

kmbali@ucanr.edu

Irrigation Water Management Specialist in Cooperative Extension

UCANR- UC Kearney Agricultural Research and Extension Center

Advances in Irrigation and Water Management

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Irrigated Agriculture in California

2022-2023 (Sierra Nevada snowpack)

More than 700 inches of snow (4/1/2023)

2nd-Snowiest Season On Record

(all-time record: 810 inches in 1952, 257% of average)

Snowpack: Runoff and GW Recharge

Precipitation: Soil moisture, runoff,

GW Recharge(wet years)

End of winter snowpack levels in the Sierra Nevada mountain range from 2020 through 2023. (NASA)

Drought Strategies for Alfalfa

The need for deficit irrigation:

- Limited water supplies
- Value of water
- Alfalfa is well adapted to deficit irrigation and drought conditions, when faced with limited water supplies/drought, alfalfa growers have the choice of:

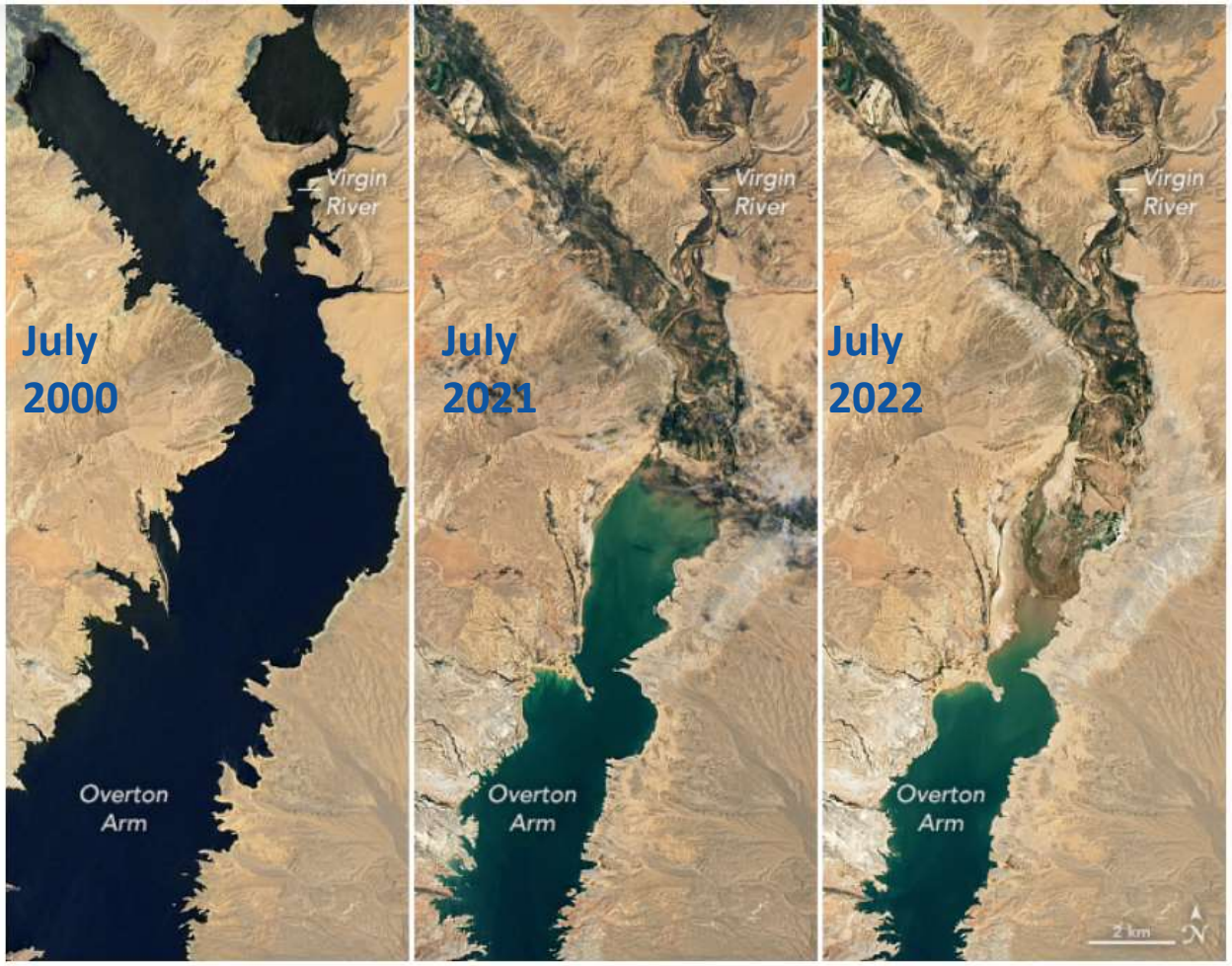
1- Reduce crop acreages

2- Partial irrigation over the entire season (starvation diet)

3- Full irrigation for portion of the season followed by complete dry-down (cold-turkey or midseason cutoff, deficit irrigation)

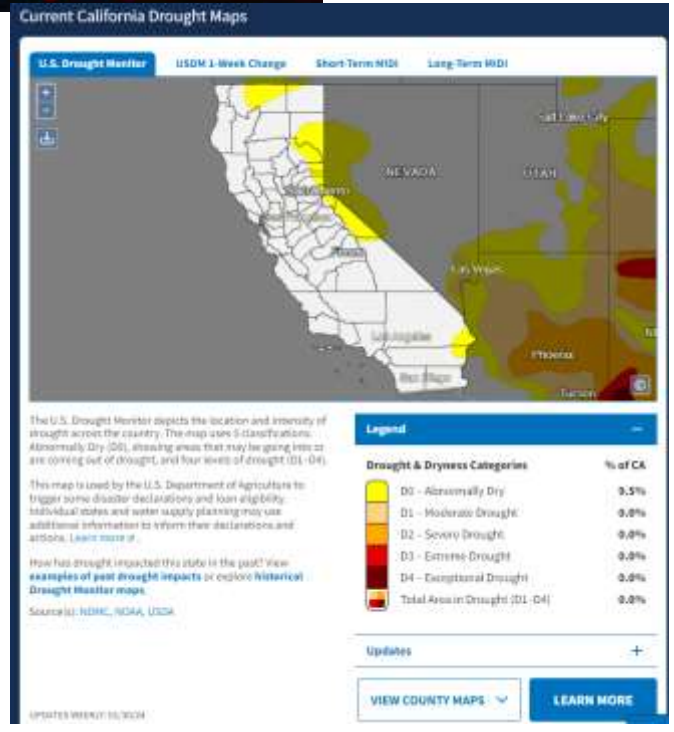
Focus here is on midseason or summer dry-down

- High reward/high risk when it comes to water savings/yield loss
- There are other deficit irrigation strategies



Satellite view of Lake Mead in July 2000, 2021, and 2022. Data: Landsat data from the U.S. Geological Survey. Photo: Lauren Dauphin / NASA Earth Observatory

Drought and Flooding in California



[California | Drought.gov](#)
Jan. 30, 2024

Alfalfa is a great crop to have in drought and wet years

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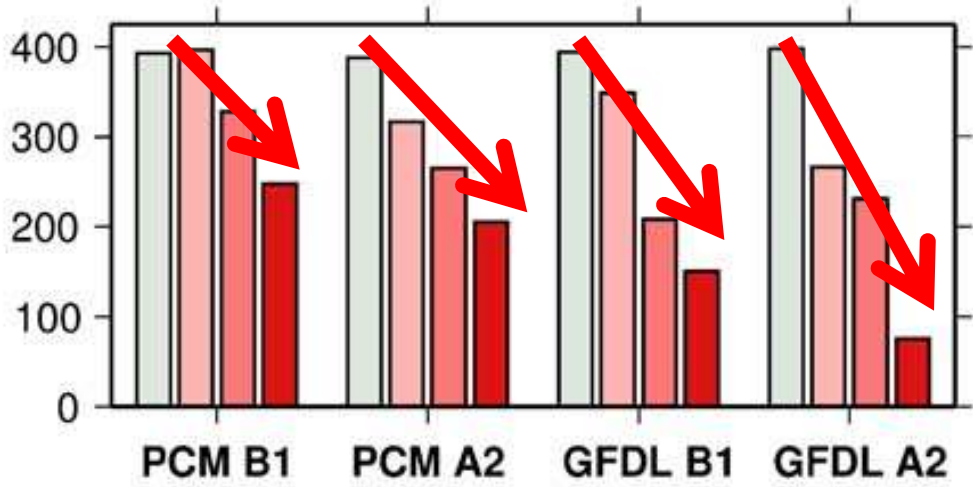
Less water for agriculture (2023 floodings are not normal, last similar floodings were back in 1982-83)

California statewide snowpack is projected to shrink drastically



↓ 25% of Sierra snowpack will be lost by **2050**

Department of Water Resources, State of California
Source: Tapan Pathak, Climate Adaptation in Agriculture - CE Specialist, University of California Merced

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GW Sustainability: Halt overdraft, balanced levels of pumping and recharge, etc (by 2040-2042)

Actions needed: Reduce demand, improve irrigation efficiency, GW Recharge, etc

Example: GW Recharge and Mid-summer or deficit irrigation- Alfalfa

As much as 50% reduction in available water in some severely over drafted aquifers

Almond: example if crop water use is ~48”/yr

CALIFORNIA DEPARTMENT OF
WATER RESOURCES

Water Basics | What We Do | Programs | Work

Home | Programs | Groundwater Management | SGMA Groundwater Management

SGMA Groundwater Management

On September 16, 2014, Governor Jerry Brown signed into law a three-bill legislative package, composed of AB 1739 (Dickinson), SB 1168 (Pavley), and SB 1319 (Pavley), collectively known as the Sustainable Groundwater Management Act (SGMA). For the first time in its history, California has a framework for sustainable, groundwater management - “management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.”

SGMA requires governments and water agencies of high and medium priority basins to halt overdraft and bring groundwater basins into balanced levels of pumping and recharge. Under SGMA, these basins should reach sustainability within 20 years of implementing their sustainability plans. For critically over-drafted basins, that will be 2040. For the remaining high and medium priority basins, 2042 is the deadline.

Source: California Department of Water Resources

Alfalfa production in California

Five leading counties:

- Merced
- Fresno
- Tulare
- Kern
- Imperial

Water use (ETa): 48-60”

Applied water: 55-70”

Growing season:

March-November in SJV (~ 50% of acreages in the Central Valley)

January- December in the low desert (~ 25% of acreages)

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Alfalfa production in California

Alfalfa (used to be number 1 crop in CA)

About 50% decline since 2012

From: 900,000 acres in 2012
To 450,000 acres in 2022

Almond is currently the number 1 crop in California
~ 1.35 million bearing acres in 2022

Field Crop Acreage, Production and Value, 2013-2022

Crop	Crop Year	Planted	Harvested	Yield Per Acre	Production	Value Per Unit	Total Value
Hay, Alfalfa [3]		*Acres*	*Acres*	*Tons*	*Tons*	*$/Ton*	*$1,000*
	2013	NA	830,000	7.00	5,810,000	206.00	1,196,860
	2014	NA	825,000	6.90	5,693,000	244.00	1,387,872
	2015	NA	790,000	6.90	5,451,000	181.00	986,631
	2016	NA	720,000	7.00	5,040,000	155.00	781,200
	2017	NA	700,000	6.80	4,760,000	178.00	847,280
	2018	NA	620,000	6.90	4,278,000	204.00	872,712
	2019	NA	580,000	7.10	4,118,000	204.00	840,072
	2020	NA	475,000	7.20	3,420,000	189.00	646,380
	2021	NA	500,000	7.40	3,700,000	241.00	891,700
	2022	NA	450,000	7.20	3,240,000	346.00	1,121,040

Source: CDFA : California Agricultural Statistics Review 2022-23

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Alfalfa Water Productivity

Yield loss due to deficit irrigation :

SJV: ~ 2.75 tons/ac-ft of saved water

CA low desert: ~ 2 tons/ac-ft of saved water

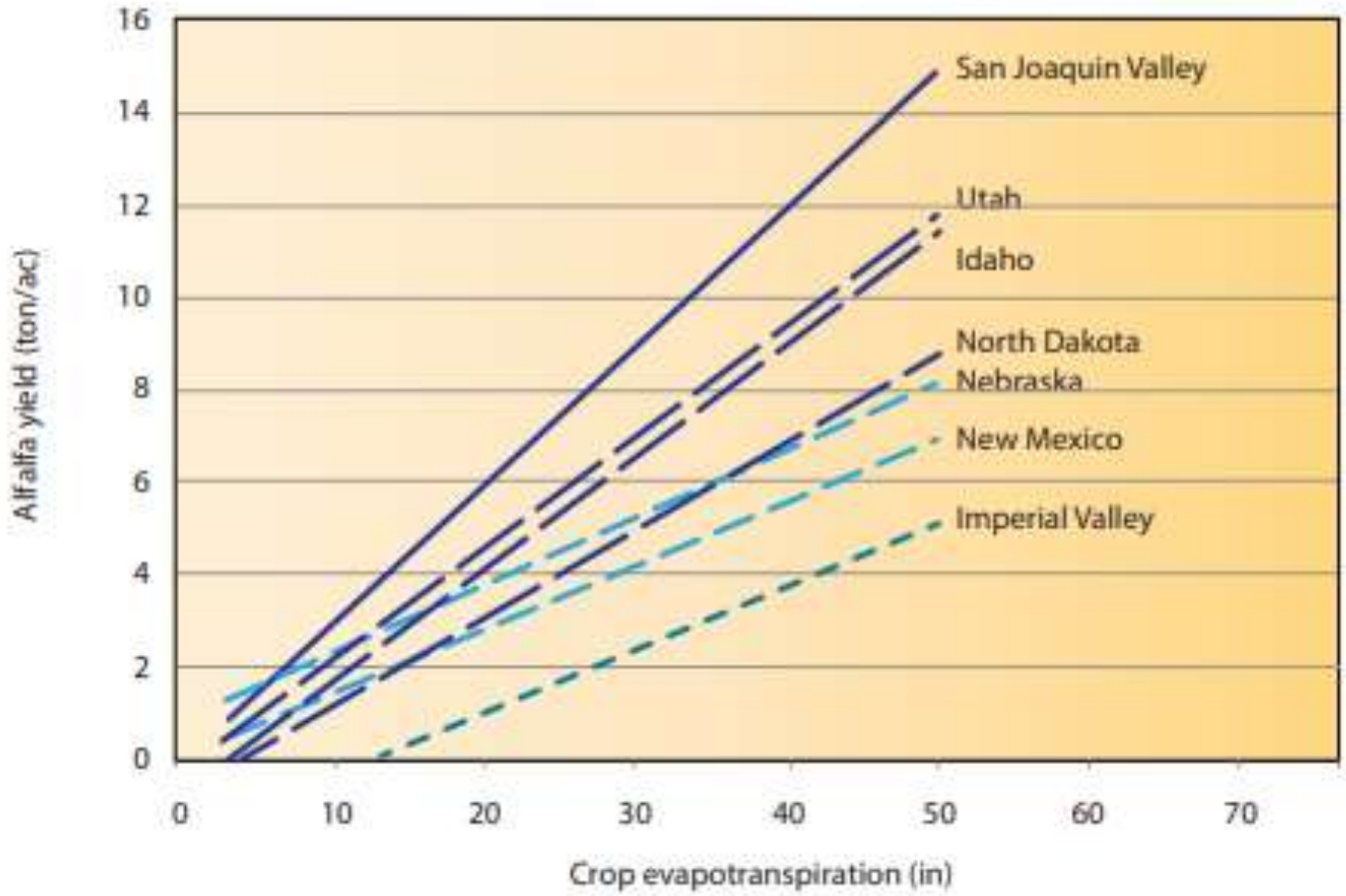

Figure 1. Relationship between alfalfa yield and evapotranspiration in selected western environments. *Source:* Hanson et al. 2009.

Alfalfa Water Productivity

San Joaquin Valley
Fresno County

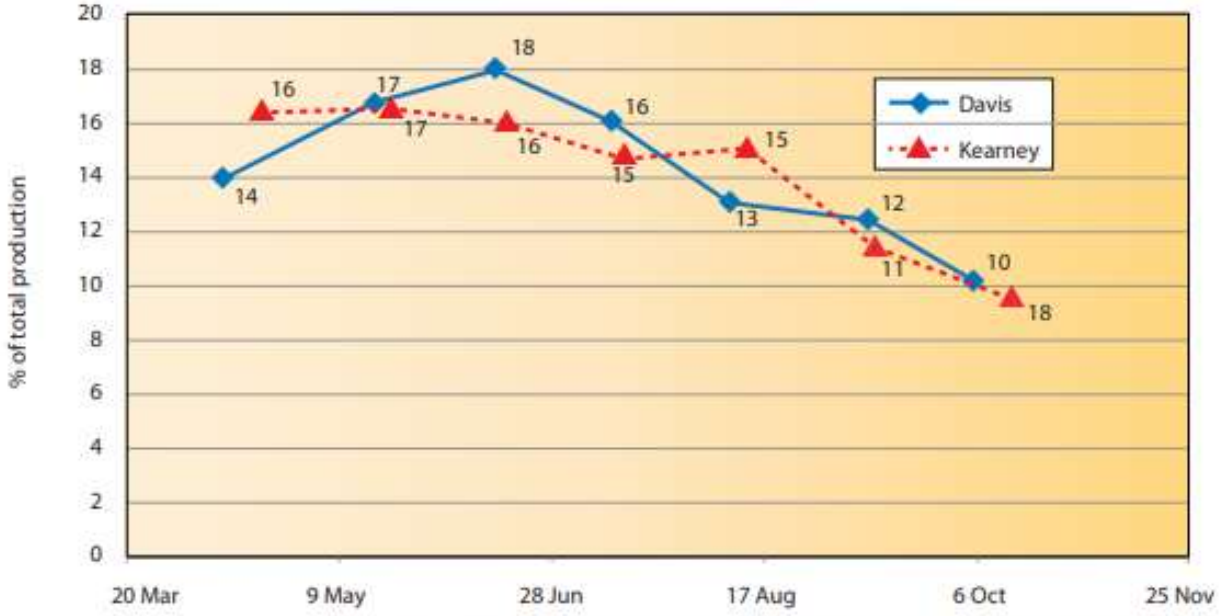

Figure 4. Percentage of total seasonal production that occurs at each cutting in Davis and at the Kearney Research and Extension Center in Fresno County.

Low Desert
Imperial County

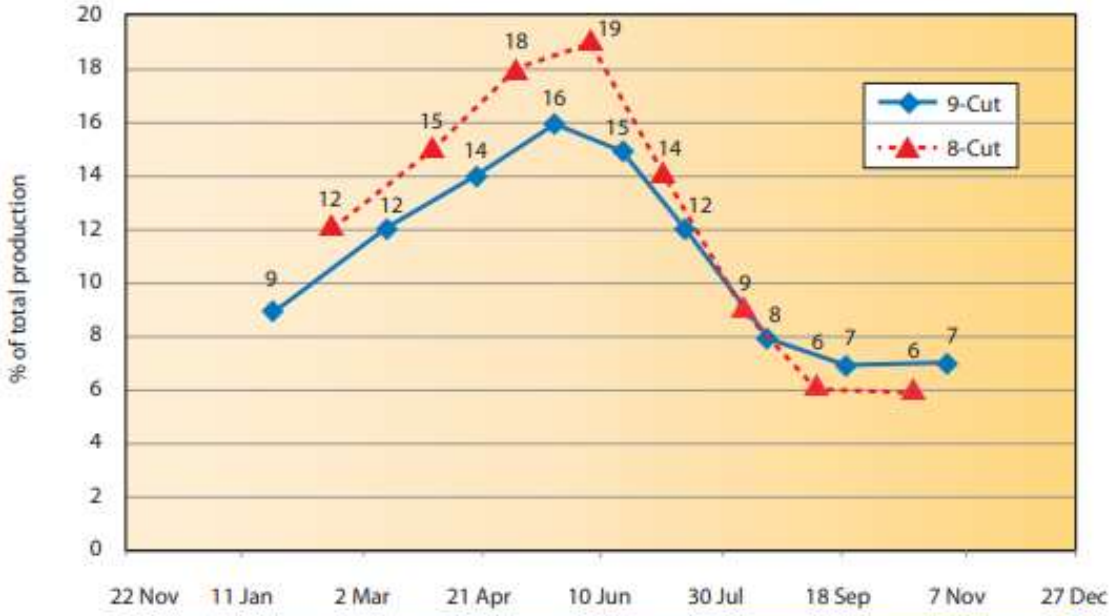

Figure 5. Percentage of total seasonal production that occurs at the Desert Research and Extension Center in Imperial County for 8 and 9 cutting schedules.

Most of the production is before mid summer
Water use efficiency is high before July

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Alfalfa Water Productivity

Water use efficiency (WUE) is high before July

WUE in the low desert is as high as 2 tons/ac-ft of applied water before July

WUE during the summer is about 1 ton/ac-ft of applied water

Potential water savings in the low desert is as high as ac-ft/ac if summer deficit irrigation is implemented between July and September

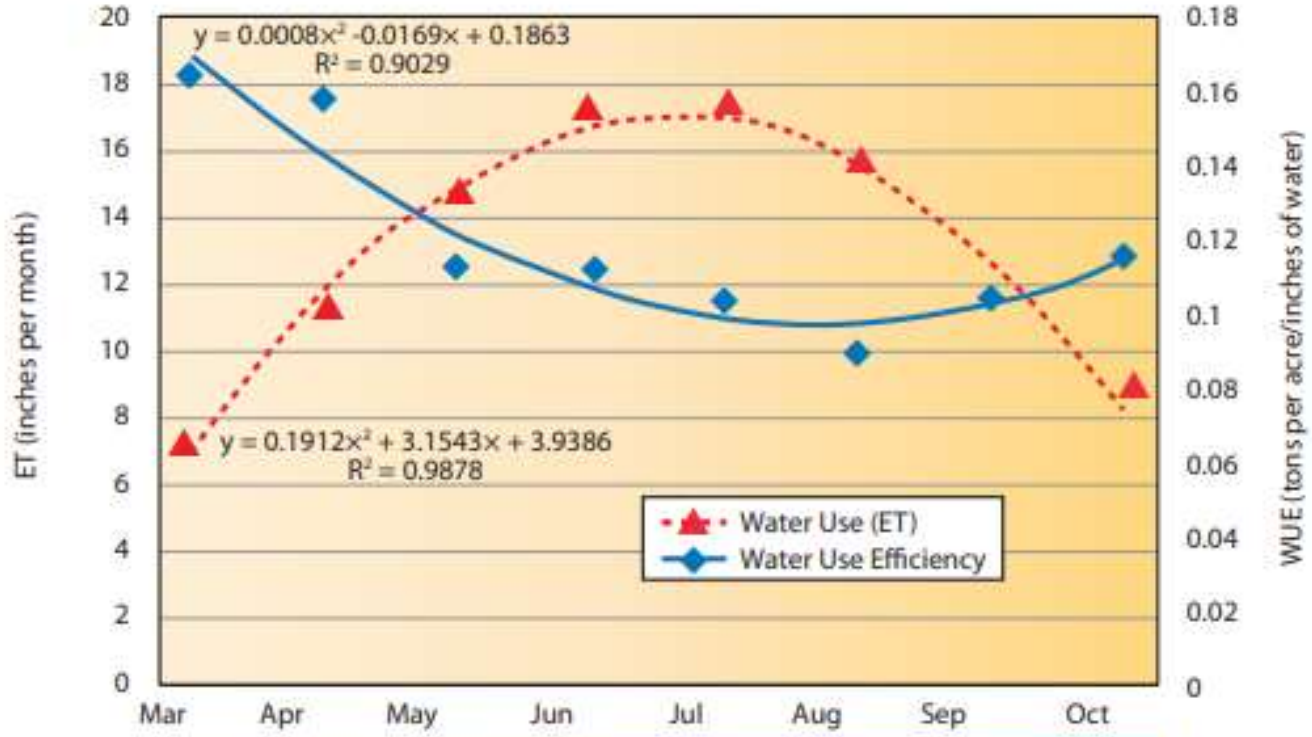

Figure 6. Changes in alfalfa water use (ET) and water use efficiency (WUE) over the growing season in the Sacramento Valley, CA.

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Full and Deficit Irrigation Practices on Alfalfa (2019-2022)

UC Kearney Agricultural Research and Extension Center, Parlier, CA

Alfalfa growing season:

- Full irrigation (standard practices): March- November (2 irrigations per cutting)
    - 7- 8 cuttings
- Deficit irrigation: March- August (2 irrigations per cutting)
    - Implement deficit irrigation after August cutting to conserve water
    - 5-6 cuttings

2019, 2020, 2021, and 2022 replicated study on 12 borders (1st, 2nd, 3rd, and 4th year stands)

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Full and Deficit Irrigation Practices on Alfalfa (2019-2022)

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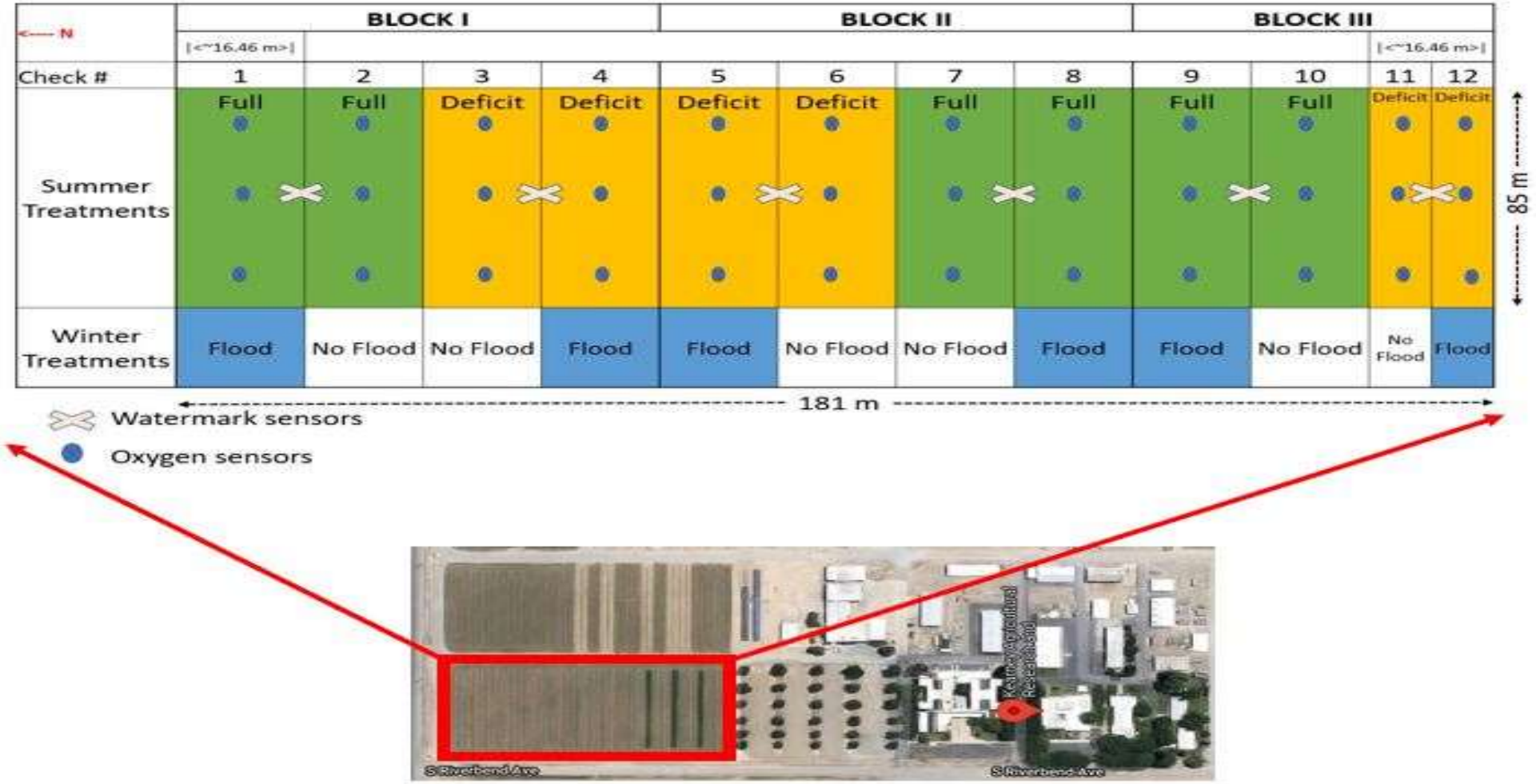

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Full and Deficit Irrigation Practices on Alfalfa (2019-2022)

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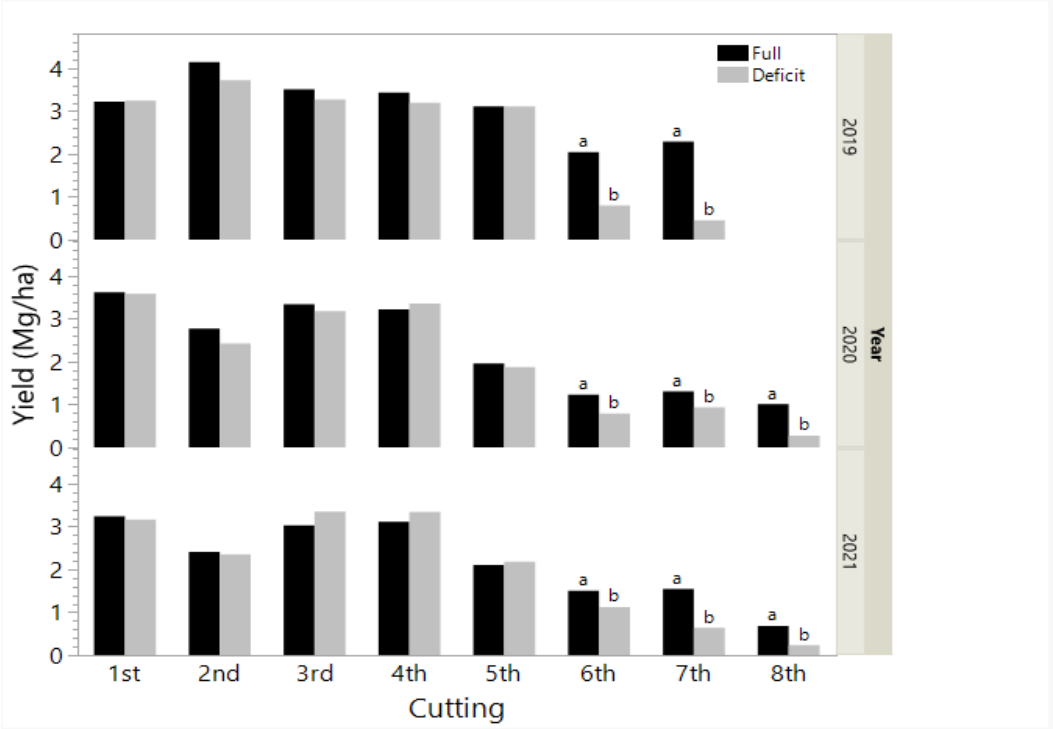
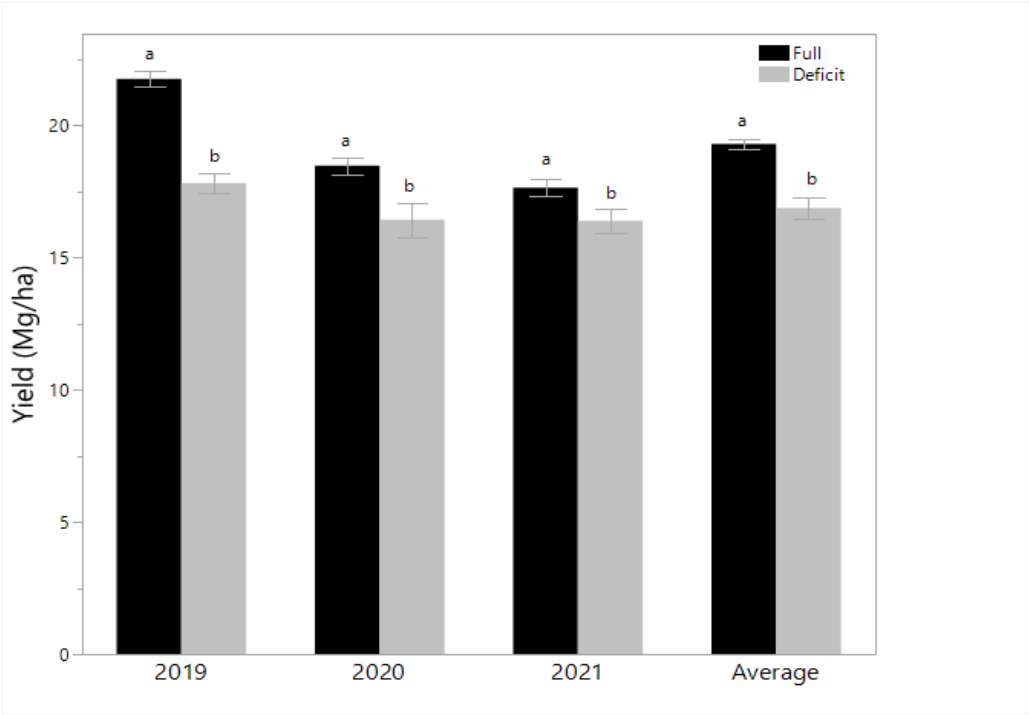
Dry matter (DM) yield



Yield of alfalfa at each harvest under fully and deficit irrigated treatment.



Total yearly yield and average yield of alfalfa between the fully and deficit irrigated treatments.

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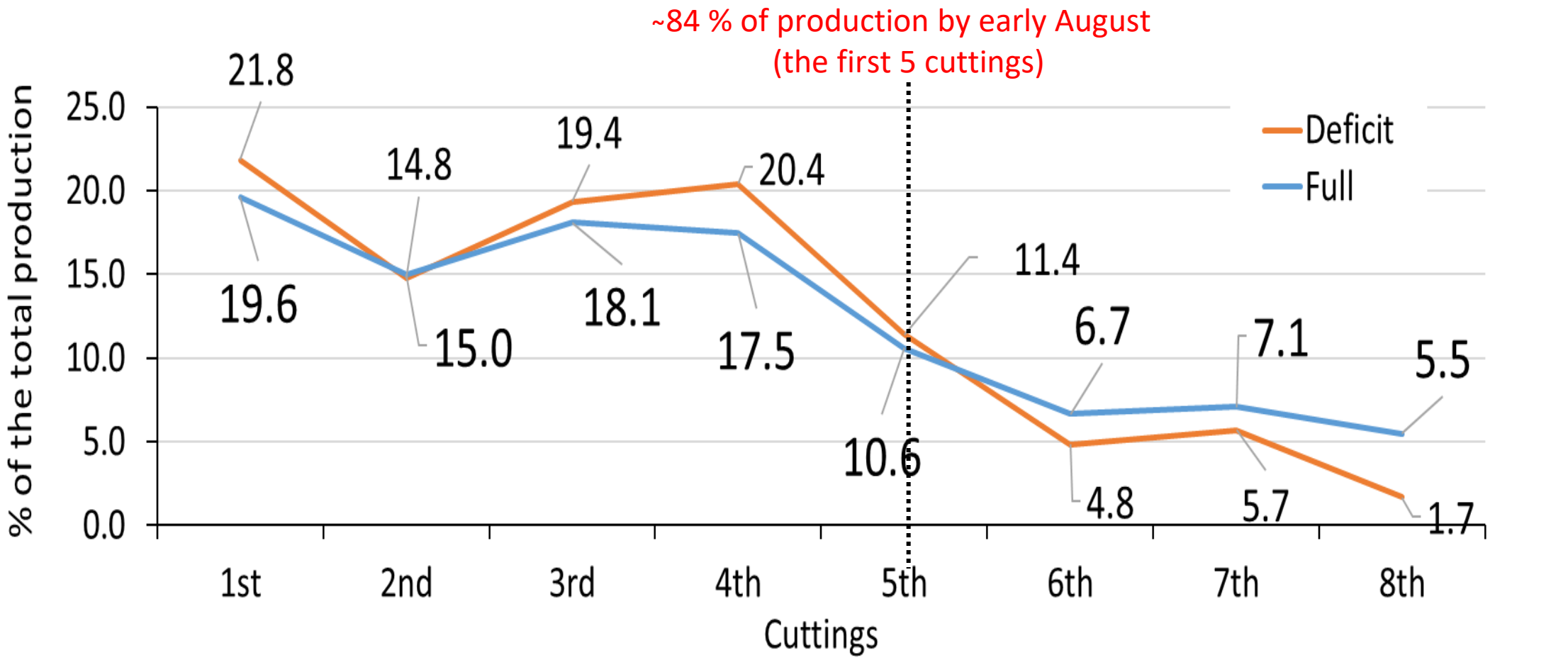
Percent of the total production for each cut (2020)



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Yield of the treatments and harvest dates of 2019, 2020 and 2021

Year	1	2	3	4	5	6	7	8	Total	Yield reduction (Mg ha^{-1})
2019										
Harvest date	5/6	6/3	7/2	8/1	8/29	10/2	11/14			
Full	3.22	4.14	3.50	3.41	3.11	2.03	2.33		21.73	**2.91**
Deficit	3.25	4.10	3.60	3.51	3.11	0.82	0.43		18.82	**13% reduction**
2020										
Harvest date	4/24	5/26	6/24	7/22	8/18	9/14	10/13	11/16		
Full	3.62	2.77	3.34	3.22	1.96	1.23	1.31	1.01	18.47	**2.03**
Deficit	3.58	2.42	3.18	3.35	1.88	0.79	0.94	0.28	16.43	**11% reduction**
2021										
Harvest date	4/7	5/5	6/8	7/7	8/4	9/1	9/29	10/28		
Full	3.24	2.41	3.03	3.11	2.11	1.50	1.549	0.683	17.63	**1.25**
Deficit	3.17	2.35	3.35	3.34	2.18	1.13	0.641	0.235	16.38	**7% reduction**

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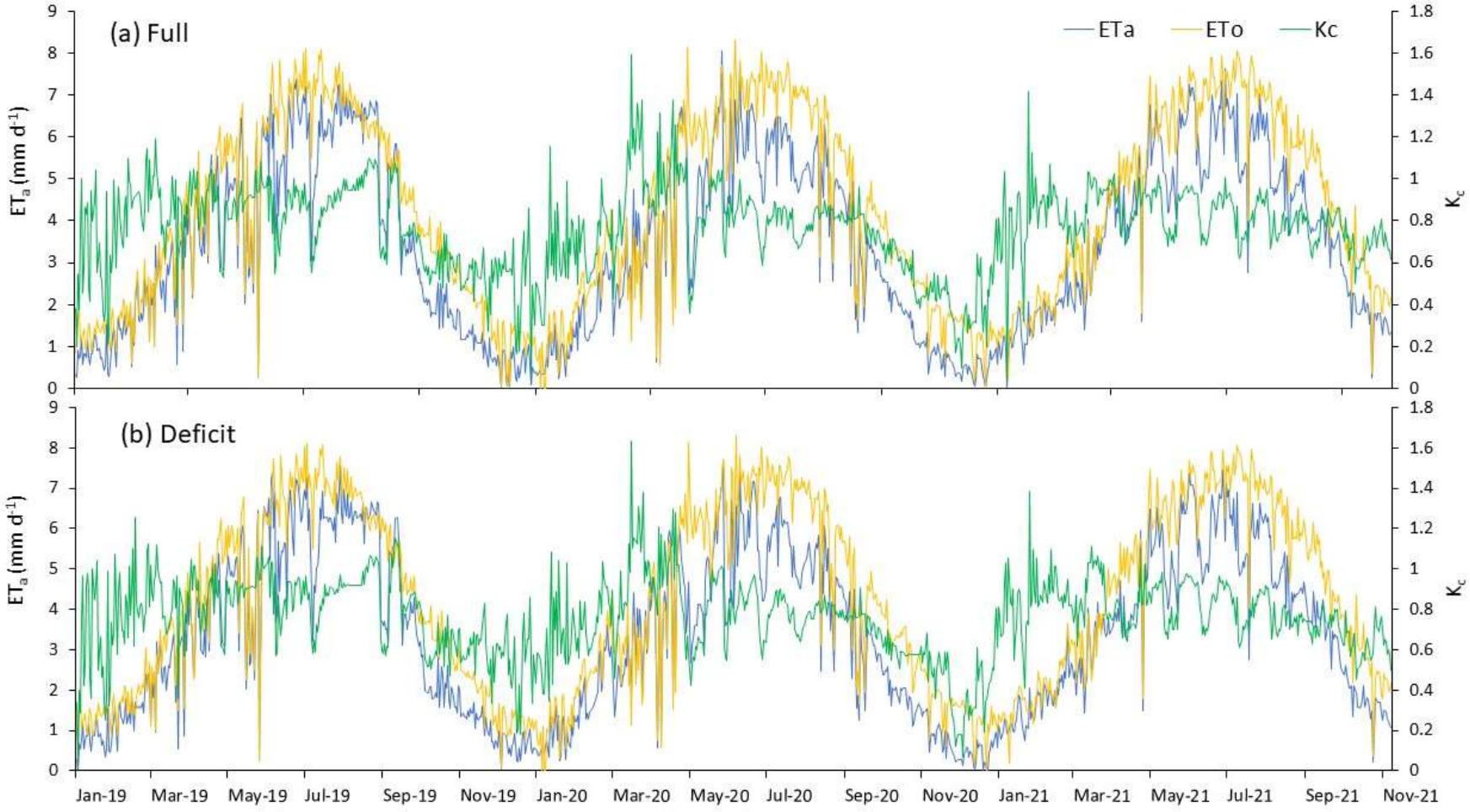
Tule Technologies (surface renewal) Daily ET_a for fully irrigated and deficit irrigated alfalfa (2019-2021)



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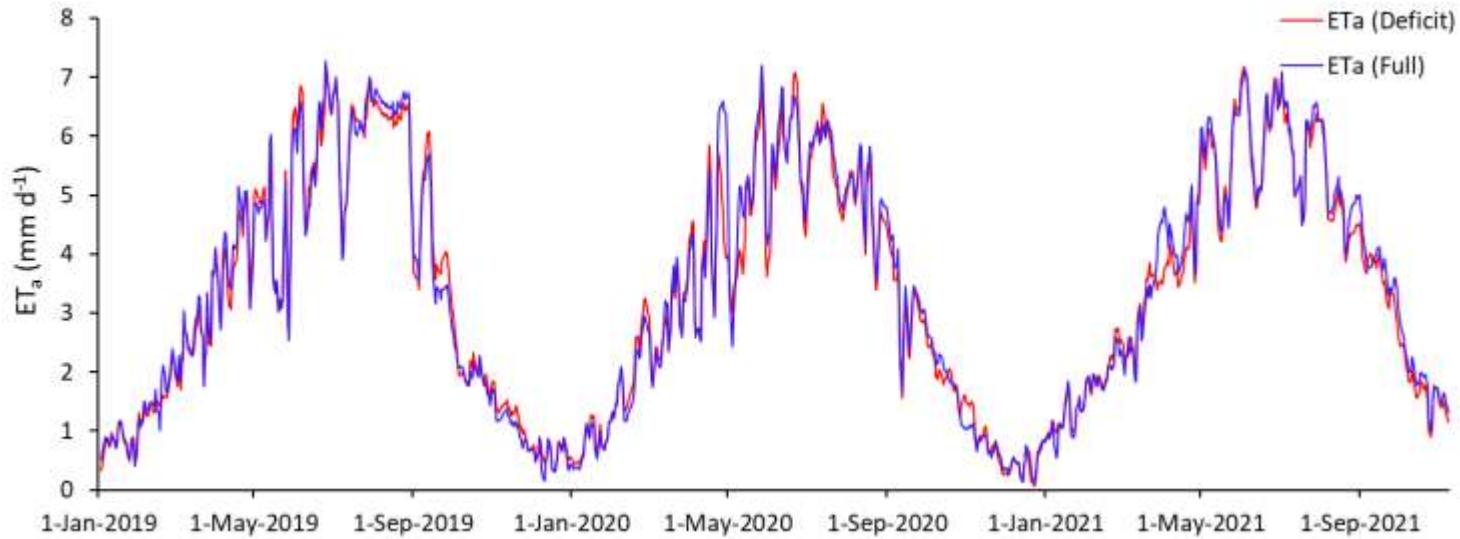
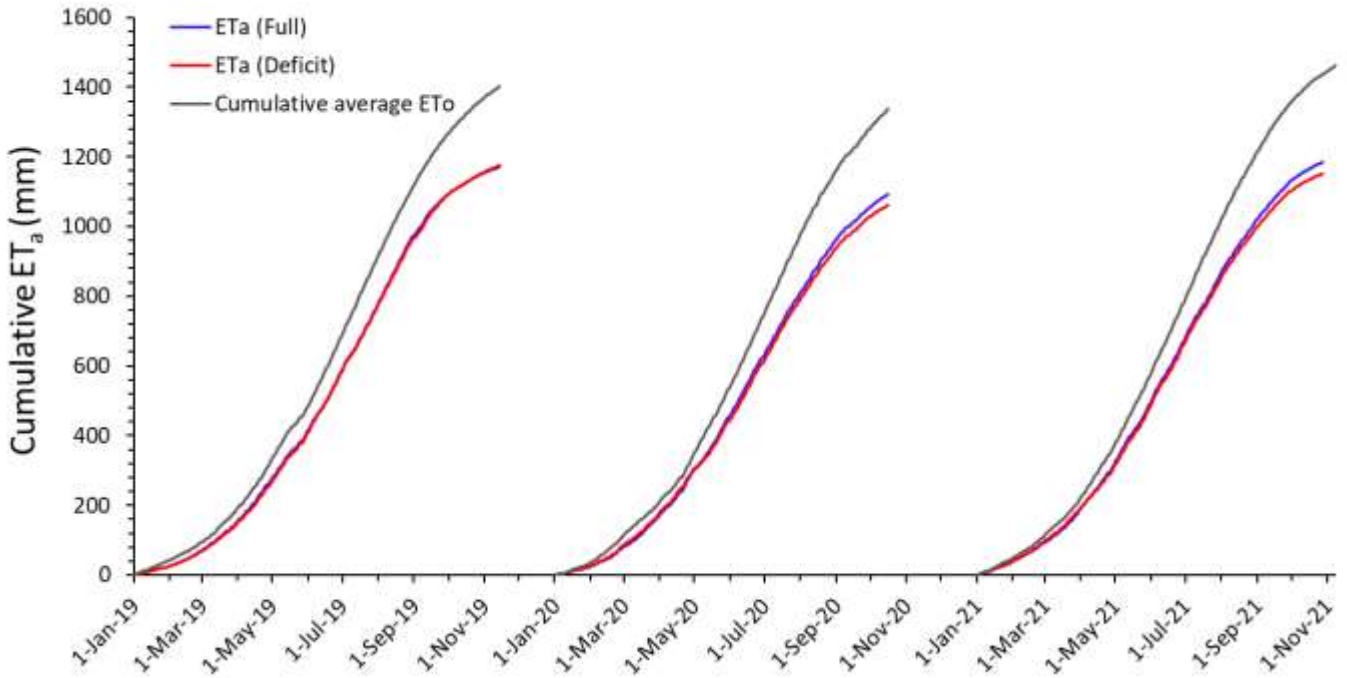


A 3-day average actual evapotranspiration for fully and deficit irrigated treatments



Cumulative actual evapotranspiration for fully and deficit irrigated treatments and the cumulative average reference evapotranspiration over the study period

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Water Savings (in) Based on Applied water

SJV: Avg. 1.95 ac-ft/ac of water savings
Yield loss: 2.75 tons/ac

Low desert: Avg. of 2 ac-ft/ac of water savings
Yield loss: 2 ton/ac

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Imperial- Deficit irrigation site in mid November
Alfalfa recovery: site specific (Weeds, stand loss, reseeding)
NOV 14 2007

Palo Verde
Field 126, December 5, 2008

Deficit B Full

Economics of deficit irrigation- SJV

SJV: Water Savings (in)
Based on Applied water

- Avg. 23.4” of water savings (3-year average,

- Yield loss: 2.75 tons/ac
- Alfalfa price $150 to $450

- Production costs for 5 cuttings (deficit) vs 8 cuttings (full irrigation)
- Costs associated with reseeding if any
- Cost associated with salinity buildup

- Value of conserved water is function of alfalfa price, production costs and stand establishments, salinity buildup
- Value of conserved water f(hay price @$450/ton, other costs associated with deficit): $635 per ac-ft of conserved water

- Value of conserved water f(hay price @$150/ton, other costs associated with deficit): $212 per ac-ft of conserved water
- Actual value of conserved water depends on several factors

Palo Verde Deficit Irrigation 2008
Average value of conserved water and water transfer

Value of conserved water	Hay price ($/ton)			
	$100/ton	$150/ton	$200/ton	$250/ton
$/ac-ft of conserved water	$114	$171	$228	$285 $0.23/m^3
$/acre (1.9 ac-ft/ac water)	$533	$800	$1,067	$540 or more per ac Value of conserved water/ac has to be related to hay prices, etc


Questions?
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Drought Strategies for Alfalfa

Direct link: https://alfalfa.ucdavis.edu/-files/pdf/Drought_Tip_Drought_Strategies_for_Alfalfa_8522.pdf

University of California
Agriculture and Natural Resources

ANR Publication 8522 | July 2015
http://anrcatalog.ucanr.edu
UC PEER REVIEWED

DROUGHT TIP

Drought Strategies for Alfalfa

Alfalfa is well adapted to drought conditions and deficit irrigation strategies. When faced with a drought, alfalfa growers have the choice of

- reducing crop acreage ("triage," or elimination of irrigation on some fields)
- partial irrigations over the entire season ("starvation diet")
- full irrigations for portions of the season followed by complete dry-down ("cold turkey" midseason cutoff)

STEVE ORLOFF, University of California Cooperative Extension County Director and Farm Advisor, Siskiyou County; DAN PUTNAM, Extension Forage Specialist, Department of Plant Sciences, University of California, Davis; KHALED BALI, University of California Cooperative Extension County Director and Irrigation/Water Management Advisor, Imperial County

Summary

Yields will be affected in all cases, but some forage production can be sustained. We recommend a combination of triage and midseason cutoff strategies. Marginal stands can be abandoned and not irrigated or removed in favor of better stands during water shortages, depending on the economics of various crops. Due to the higher yields early in the season, midseason cutoffs are likely to maximize yield and water use efficiency and result in cost savings by eliminating one or more cuttings compared with a starvation diet strategy. Survival of alfalfa through drought periods depends strongly on the soil and the environment, but we have observed that alfalfa generally survives short-term periods of no irrigation and can recover upon rewatering to yield normally in subsequent years.

Introduction

Drought and diminished water supplies for irrigation affect many western states and can be especially acute in California. Periodic droughts are expected to be recurring issues in California and other irrigated areas. Inadequate water for irrigation has plagued nearly every alfalfa production region in the state at some time. Drought conditions often limit water supplies below those needed for maximum yield, forcing growers to make difficult decisions as to which crops they should irrigate. Strategies are needed to minimize economic losses during drought and lessen any long-term impacts.

Unlike many other perennial crops (orchards in particular), alfalfa offers a high degree of flexibility during droughts due to its ability to successfully survive severe irrigation deficits and produce some yield—a valuable attribute when deciding how to allocate scarce water.

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Summary

- The ability of alfalfa crop to survive water deficits depends on
  - Length of drought
  - Soil conditions, water holding capacity, soil texture
  - Presence of shallow water table
  - Variety
  - Rooting depth (1st year stand vs 3rd year)
  - In most cases, alfalfa will survive dry-down periods, but stand can be damaged in some regions depending upon the above factors
  - Experience in the low desert region, reseeding is needed after summer dry-down under most conditions
  - Experience in the SJV, alfalfa can survive summer dry down with minimal impact on yield after the end of the summer dry down
  - Alfalfa can utilize shallow groundwater if present at 5-7 ft up one summer (salinity buildup in the root zone to the point where alfalfa can no longer extract salty water (15 dS/m or higher)

Figure 7. Five-year-old alfalfa variety trial after 2 years of drought conditions, 2013 and 2014 (Western Fresno County, CA). Alfalfa has a remarkable ability to survive long droughts due to its deep roots and ability to enter into a drought-induced dormancy. *Photo:* D. Putnam.

Summary

Water savings and yield loss

- San Joaquin Valley late summer deficit irrigation
  - Up to 22 inches of water savings
  - Up to 1.3 tons/ac of yield losses
  - Estimate of the water value (various factors but hay prices is the key)
- Low desert mid-summer deficit irrigations
  - Up to 2 ac-ft/ac of water savings
  - Up to 2 tons/ac of yield losses
  - Estimate of the water value (various factors but hay prices is the key)

Figure 7. Five-year-old alfalfa variety trial after 2 years of drought conditions, 2013 and 2014 (Western Fresno County, CA). Alfalfa has a remarkable ability to survive long droughts due to its deep roots and ability to enter into a drought-induced dormancy. *Photo:* D. Putnam.