Sorghum Irrigation Management Field Evaluations – *Deficit to Full irrigation*

Bob Hutmacher, Jeff Dahlberg, Steve Wright, Jorge Angeles, Nicholas Clark, Mark Keeley, Raul Delgado

UC West Side REC & Univ. CA Davis Plant Sci. Dept;
University of CA Cooperative Extension – Kings &Tulare Counties
University of California; UC Kearney REC and West Side REC;
Todd Fernandez, College of Sequoias – Tulare Farm

University of California
Agriculture and Natural Resources

In assessments of water use, irrigation mgmt responses, consider:

1) height and % ground cover differences, photoperiod & maturity differences across types … potential to impact duration of leaf development, maturity timing & therefore water use

2) major differences in rooting patterns & depth known across types (and how they respond to re-watering)

3) bmr types and brachytic types have potential impacts not only on forage quality, but also on issues such as lodging (could impact water use if lodges)

- **Initial furrow-irrigated studies at College of Sequoia farm**
- Furrow-irrigated West Side REC & Kearney REC sites
- Expanded low-frequency surface drip-irrigated trials in 3-year study focused on water stress timing / intensity
- Sorghum / Corn SDI deficit irrigation x Nitrogen in 2016-2018

Planting / Soil Characteristics / Irrigation Method

COS Farm - two-year Silage sorghum studies (Hutmacher, Wright)

Soil Type	Tagus loam soil, Tulare-area College of Sequoias farm
Row Spacing	30 inch rows
Plot width / length	16 beds in width per irrigation treatment replication Approximately 125 feet plot length, 3 field reps

Depth range in soil profile (ft)	**Available Soil Water held Per foot of soil profile (inches)**
0 – 3	1.6 – 1.8
3 - 8	1.4 – 1.5

Deep rooting in this soil, high water holding capacity, gated pipe furrow irrig

Irrigation Method	10 inch gated pipe, one gate per planted row
	Typical amount / applic. = 4.5 to 5.5 inches

Irrigation Dates and Amounts –

Tulare COS Farm year 1 and year 2 Silage sorghum studies

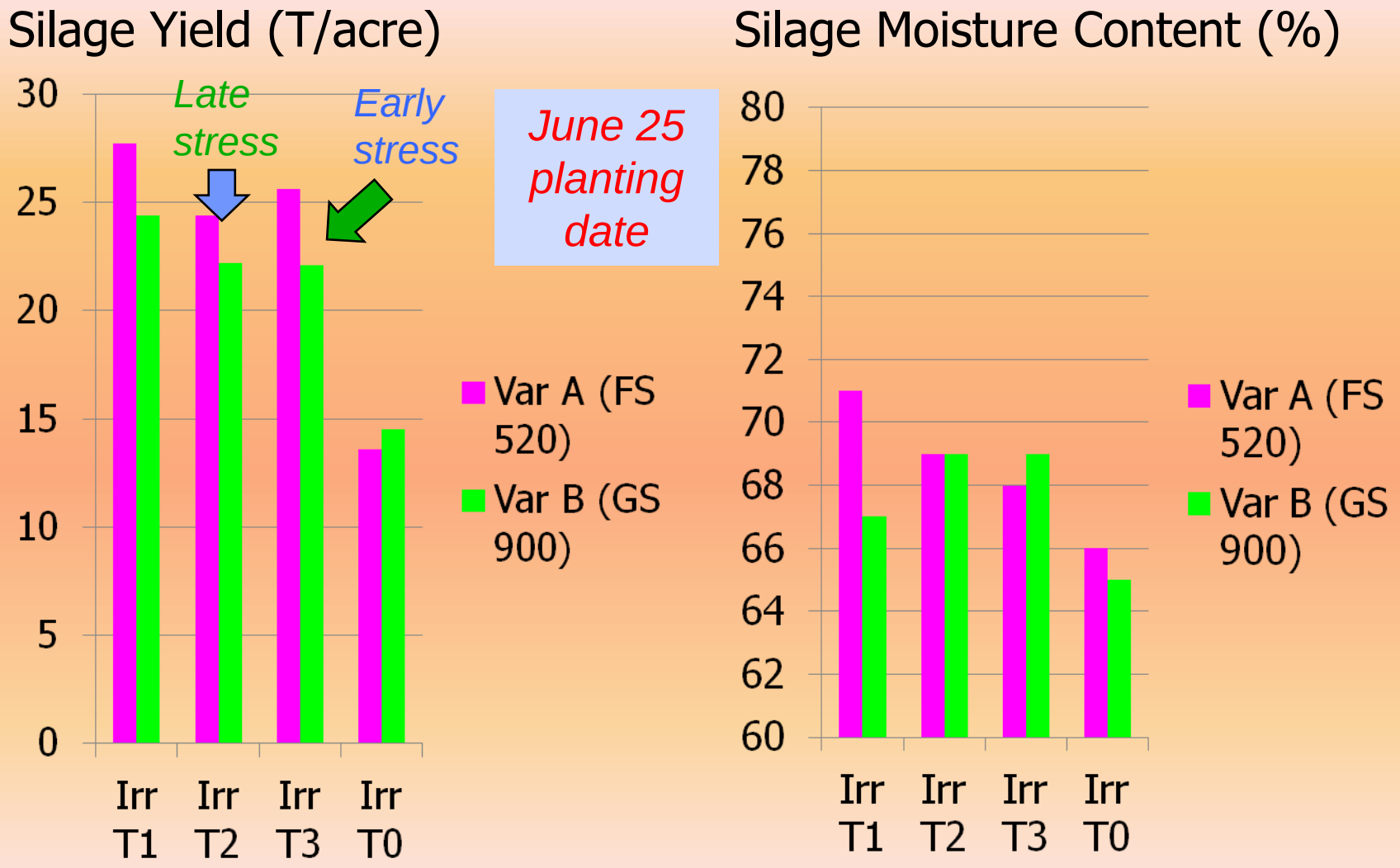
Irrig. Treat-ment#	**YEAR 1 Irrigation Dates and Amounts (inches water)** *Planted 6/25* ***Preplant irrigation of 7 inches***				**YEAR 2 Irrigation Dates and Amounts (inches water)** *Planted 8/04* ***Preplant irrigation of 8 inches***			
Date	7/29	8/18	9/10	Total	9/02	9/24	10/18	Total
Days after planting	34	54	77		29	51	75	
T1	5.7	4.7	4.9	**15.3**	6.1	4.5	3.9	**14.5**
T2 (-late)	5.7	4.6	-	**10.3**	6.1	4.4	-	**10.5**
T3 (-early)	-	5.2	5.3	**10.5**	-	4.8	4.6	**10.4**
T0	-	2.5	-	**2.5**	-	2.5	-	**2.5**

Sorghum Calculated Evapotranspiration

year 1 – COS site *(inches applied or soil water use) - loam soil*

Year	Type of Sorghum	Irrigation Trt #	In-Season Applied Water (inches)	Soil Water Use (in)	Total Est. Etc (in)
one	Grain Sorghum	1	15.3	-4.7	**20.0**
		2 (late str)	10.3	-6.1	16.4
		3 (early str)	10.5	-4.8	15.3
		0	2.5	-9.1	**11.6**
One	Forage Sorghum	1	15.3	-5.4	**20.7**
		2	10.3	-7.4	17.7
		3	10.5	-5.9	16.4
		0	2.5	-9.6	**12.1**

Sorghum Silage Yields and Average Moisture Content year one – COS site



- Initial furrow-irrigated studies at College of Sequoia farm
- **Furrow-irrigated WSREC and KAREC sites**
- Expanded low-frequency surface drip-irrigated trials in 3-year study focused on water stress timing / intensity
- Sorghum / Corn SDI deficit irrigation x Nitrogen in 2016-2018

Planting / Soil Characteristics / Irrigation Method

West Side and Kearney REC sorghum studies

Soil Types	WSREC (clay loam soil); Kearney REC (sandy loam soil)
Row Spacing	30 inch rows
Plot width / length	8 beds in width per irrigation treatment replication Approximately 65 feet plot length, 4 field reps

Depth range in soil profile (ft)	**Available Soil Water held Per foot of soil profile (inches)**	
	West Side REC	Kearney REC
0 – 3	2.0 – 2.3	1.3 – 1.45
3 - 8	1.9 – 2.2	1.2 – 1.4

Irrigation Method	First year used 6 inch gated pipe, one gate per planted row Years 2 to 4 used surface drip irrigation but large amt/low frequency (amount per irrig = about 2” Kearney, about 3.5” WSREC clay loam site)

Irrigation Dates and Amounts –

WSREC and KAREC - year one silage sorghum studies

Irrig. Trt #	**Year one West Side REC Irrigation Dates and Amounts (inches water)** *planted 6/23* - ***Large pre-plant irrigation (8-9 inches)***									
Date	6/26	7/01	7/23	7/29		8/20	8/30	9/10	9/19	Total
T1	3.2		3.0	1.6		3.4	3.0	2.9		**17.1**
T2 (-late)	3.2		3.0	1.6		3.4	2.1			**13.3**
T3 (-early)	3.2					3.4	3.0	3.7		**13.3**
T0	3.2	3.6								**6.8**

Soil conditions not suited to a non-irrigated treatment for T-0 treatment

Sorghum Calculated Evapotranspiration

year one – West Side REC site *(inches applied or soil water use) - clay loam soil - furrow irrigated*

Year	Type of Sorghum	Irrigation Trt #	In-Season Applied Water (inches)	Soil Water Use (in)	Total Est. Etc (in)
One	Grain Sorghum	1	17.1	-3.3	**20.4**
		2 (late stress)	13.3	-2.4	16.7
		3 (early str)	13.3	-2.8	16.1
		0	6.8	-6.9	**13.7**
one	Forage Sorghum	1	17.1	-5.8	**22.9**
		2 (late stress)	13.3	-7.1	20.4
		3 (early str)	13.3	-6.3	19.6
		0	6.8	-7.6	**14.4**

Sorghum Calculated Evapotranspiration

year one – Kearney REC site *(inches applied or soil water use)*

- sandy loam soil

Year	Type of Sorghum	Irrigation Trt #	In-Season Applied Water (inches)	Soil Water Use (in)	Total Est. Etc (in)
One	Grain Sorghum	1	16.6	-2.9	**19.5**
		2 (late stress)	12.7	-4.6	17.3
		3 (early str)	12.5	-5.5	18.0
		0	4.7	-6.9	**11.6**
One	Forage Sorghum	1	16.6	-4.7	**21.3**
		2 (late stress)	12.7	-6.1	18.8
		3 (early str)	12.5	-5.7	18.2
		0	4.7	-8.5	**13.2**

Soil water use & ETc at KAREC a little lower than WS

- Initial furrow-irrigated studies at College of Sequoia farm
- Furrow-irrigated WSREC and KAREC sites
- **Expanded low-frequency surface drip-irrigated trials in 3-year study focused on water stress timing / intensity**
- Sorghum / Corn SDI deficit irrigation x Nitrogen in 2016-2018

Irrigation Dates and Amounts –

KAREC year three - Grain and Silage sorghum studies

Irrig. Trt#	Year 3 - Kearney KAREC Irrigation Dates and Amounts (inches water) - *Planted 6/17* - ***Pre-irrigations to apply total of 5.5 inches***										
Date	7/07	7/14	7/24	7/30	8/10	8/17	8/29	9/02	9/15	9/23	Total
T1	2.4	1.9	1.6	1.8	1.7	1.8	1.9	1.6	1.9	1.9	**18.5**
T2 Late	2.4	1.9	1.6	1.8	1.7	1.8	1.9	1.6			**14.7**
T3 Early	2.4		1.6	1.8	1.7	1.8	1.9	1.6	1.7	1.0	**15.2**
T4 Mid	2.4	1.9			1.7	1.8			1.7	1.8	**11.3**
T5 Mid-late	2.4	1.9			1.7	1.8					**7.9**

Soil conditions not suited to a non-irrigated treatment for T-0 treatment

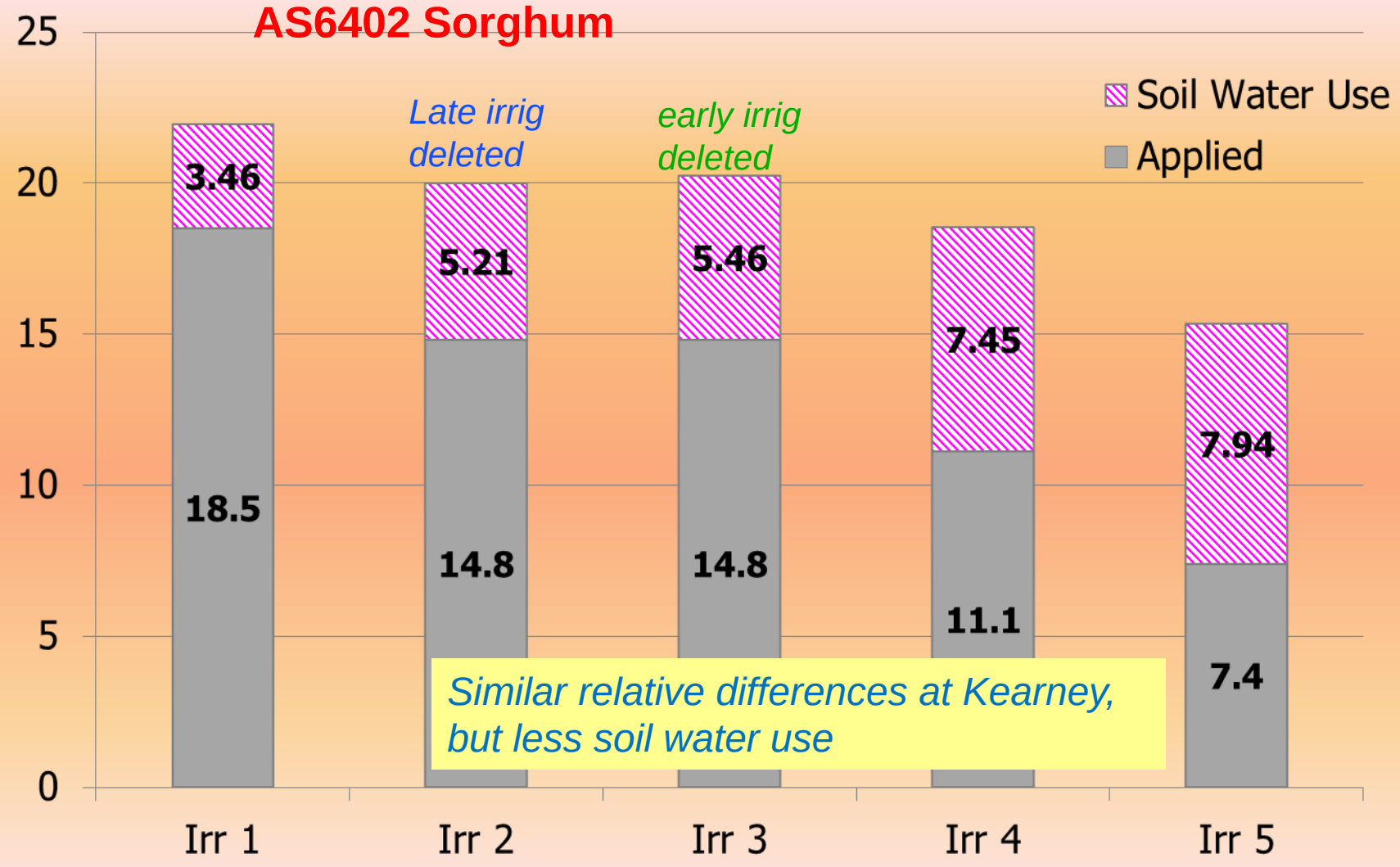
Irrigation Dates and Amounts –

WSREC year three - Grain and silage sorghum studies

Irrig. Trt #	Year 3 - West Side REC Irrigation Dates and Amounts (inches water) - *Planted 6/16* - ***Two pre-irrigations to apply total of 7.3 inches***									
Date		7/8-10		7/28-31		8/16-19		9/5-9		9/26-29	Total
T1		3.9		3.8		3.6		3.5		3.7	**18.5**
T2 Late		3.9		3.8		3.6		3.5		0	**14.8**
T3 Early		0		3.8		3.6		3.5		3.7	**14.8**
T4 Mid		3.9		0		3.6		0		3.7	**11.1**
T5 mid-late		3.9		0		3.6		0		0	**7.4**

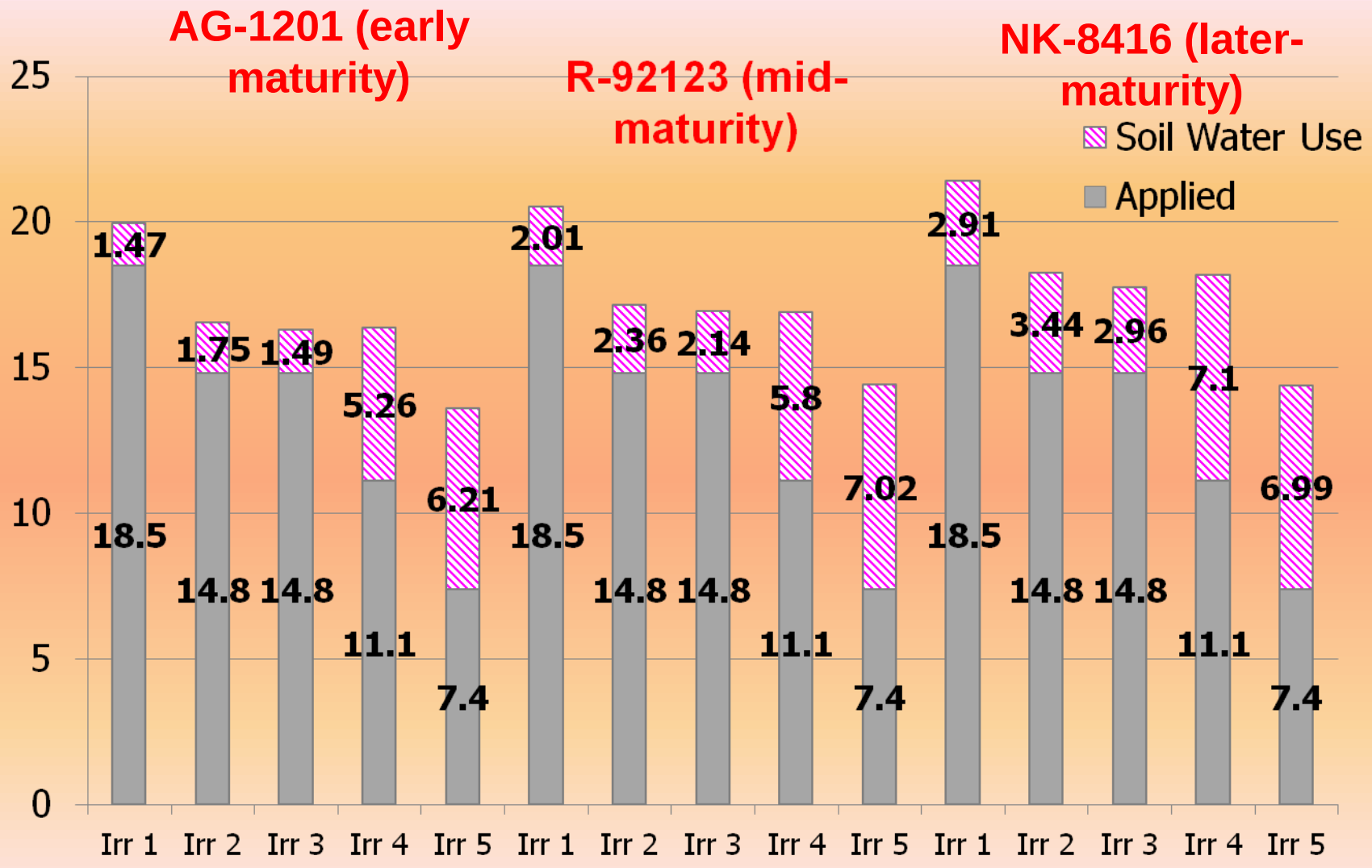
Soil conditions not suited to a non-irrigated treatment for T-0 treatment

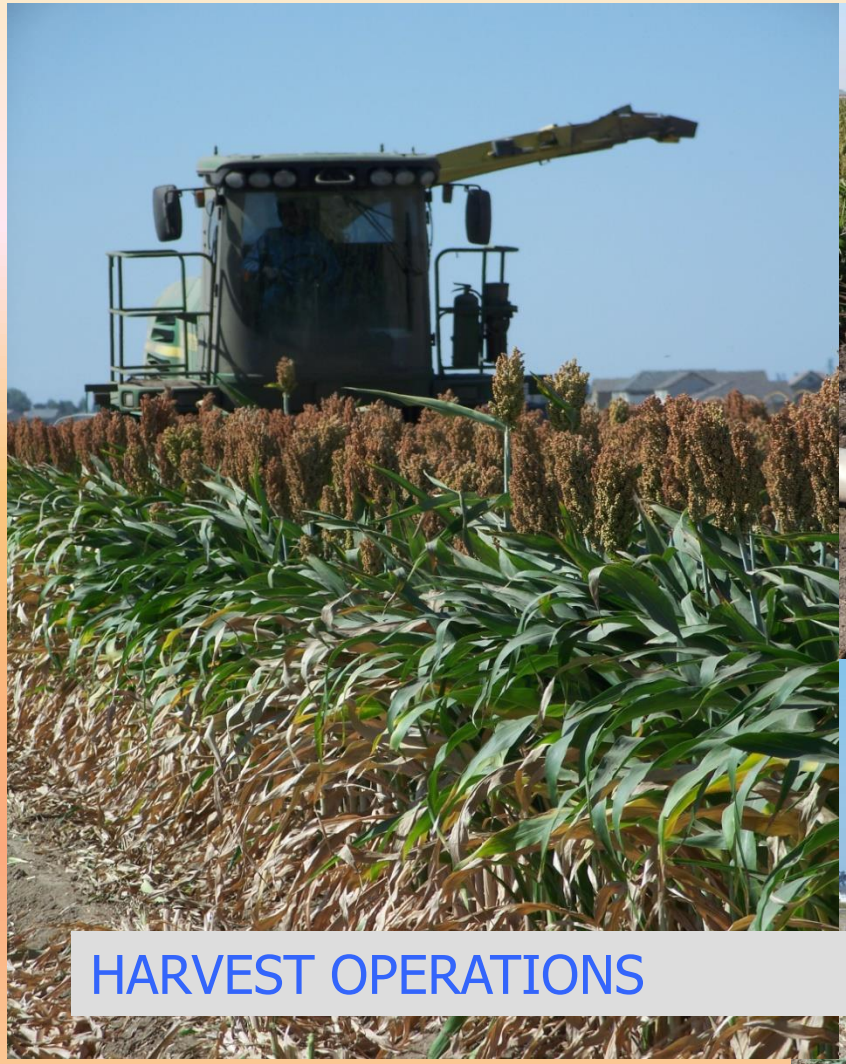
Select Forage Sorghum Applied Irrigation plus Soil Water Use
year 3 – WSREC site *(inches applied & soil water use)*



Select Grain Sorghum Applied Irrigation plus Soil Water Use

year 3 WSREC site *(inches applied & soil water use)*



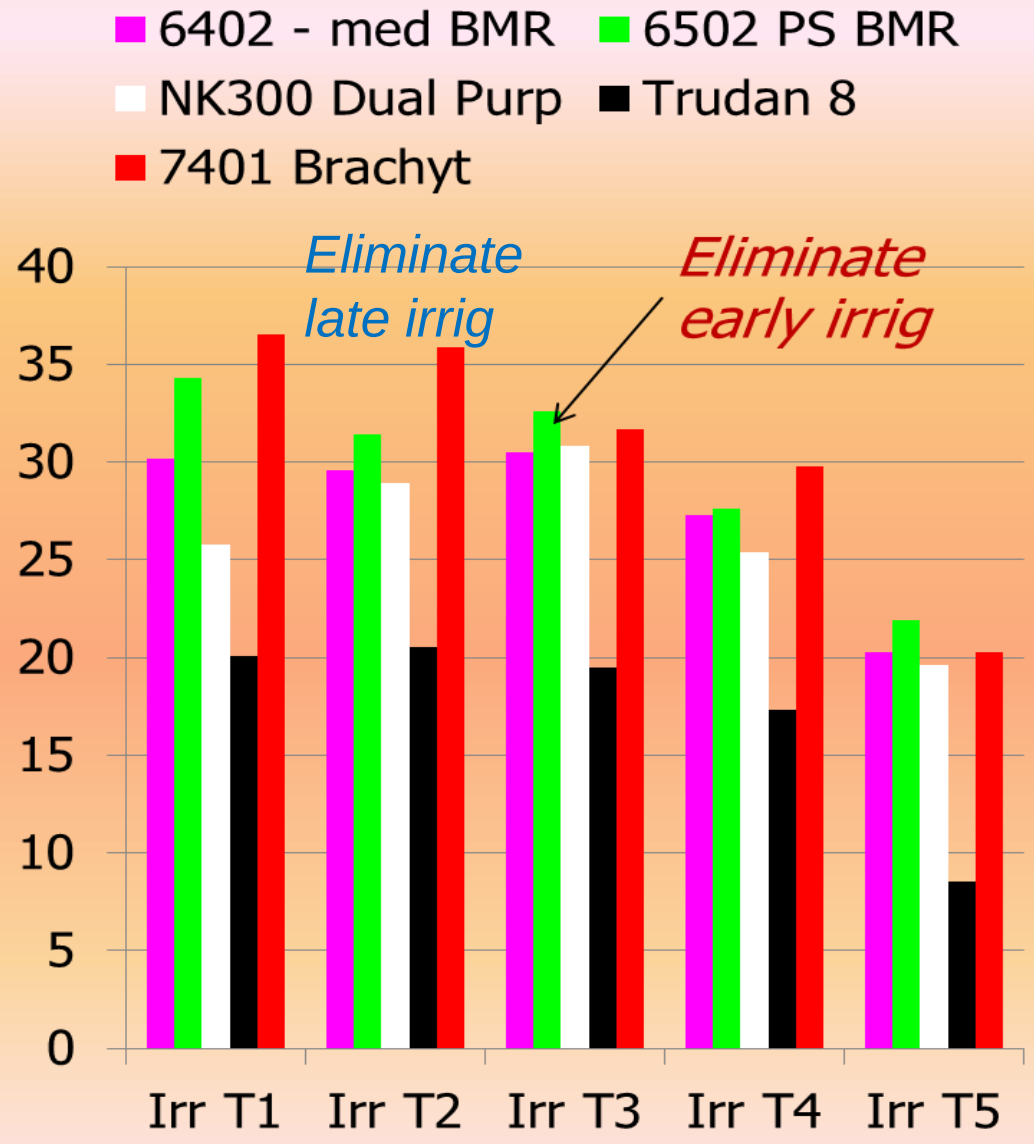


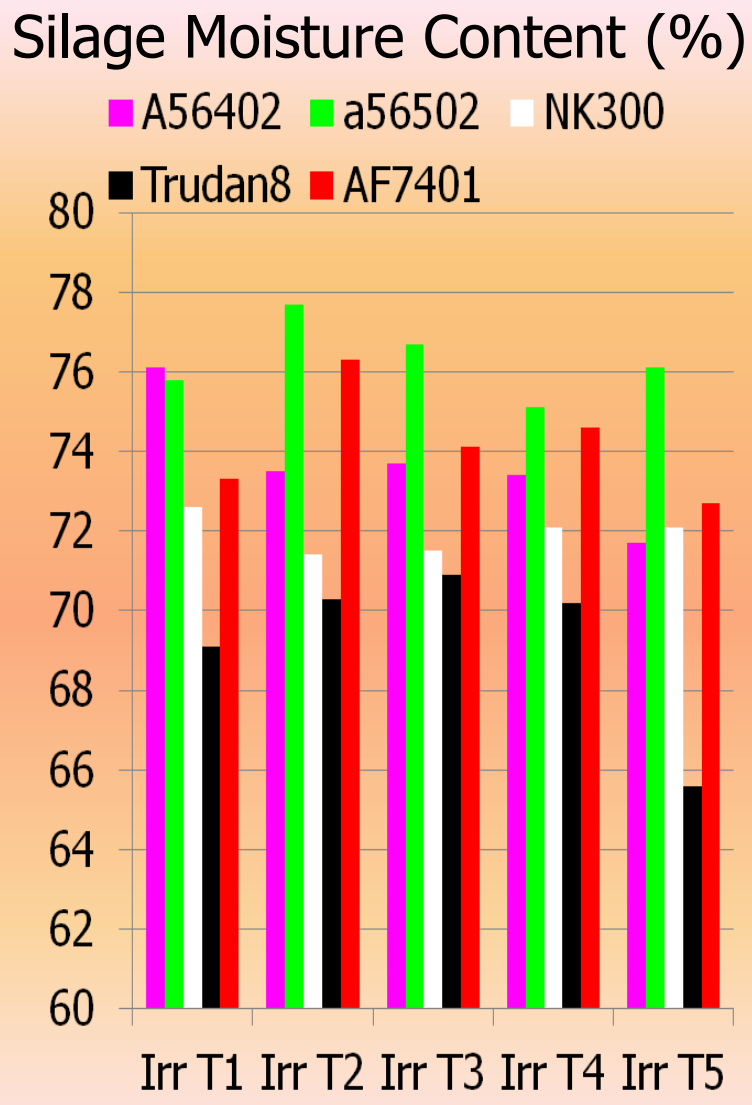
HARVEST OPERATIONS

Subsamples by hand for moisture %

FORAGE SORGHUM Yields and Average Moisture Content

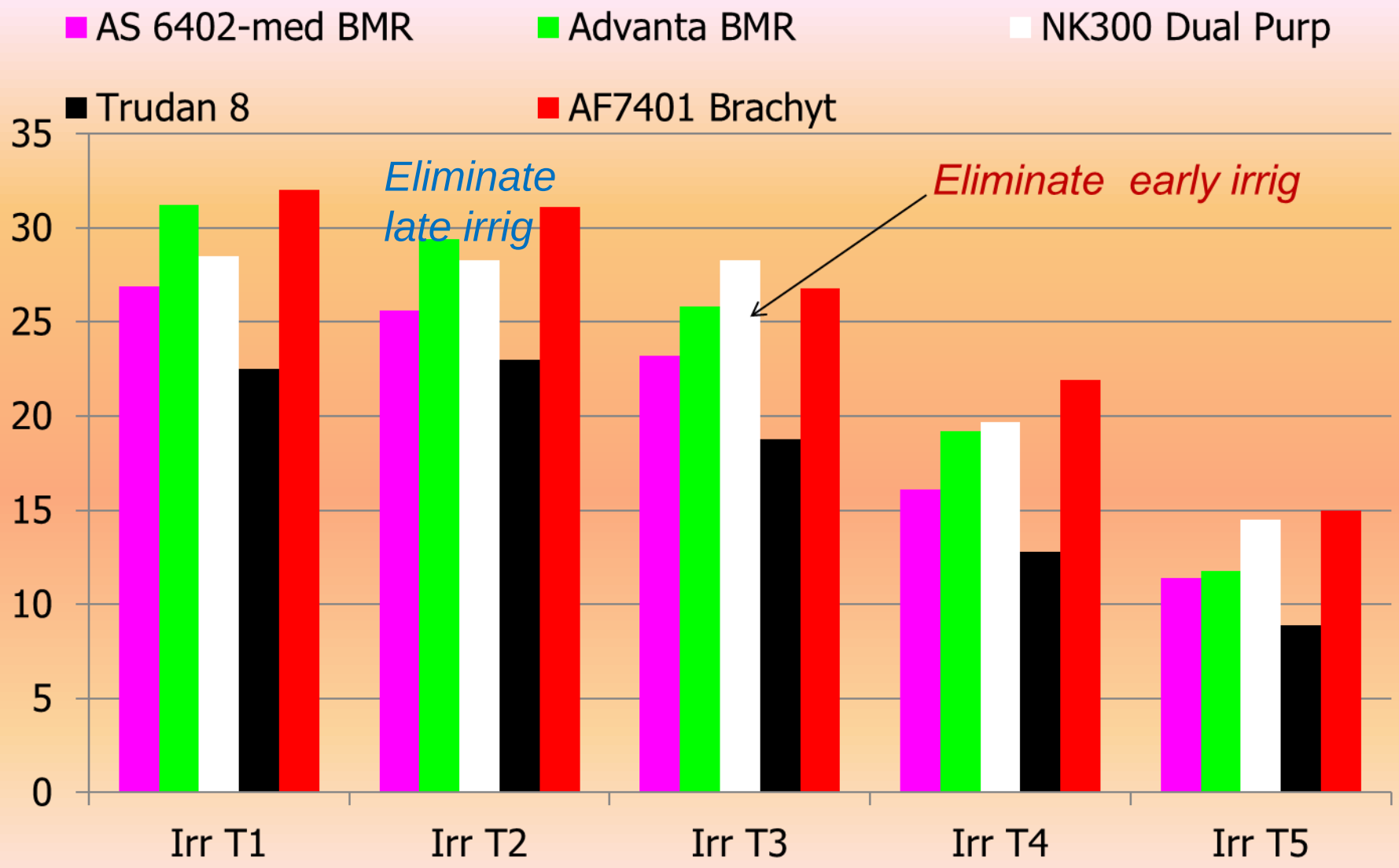
year 3 – Kearney REC site *(yields corrected to 70% moisture, **T/acre**)*



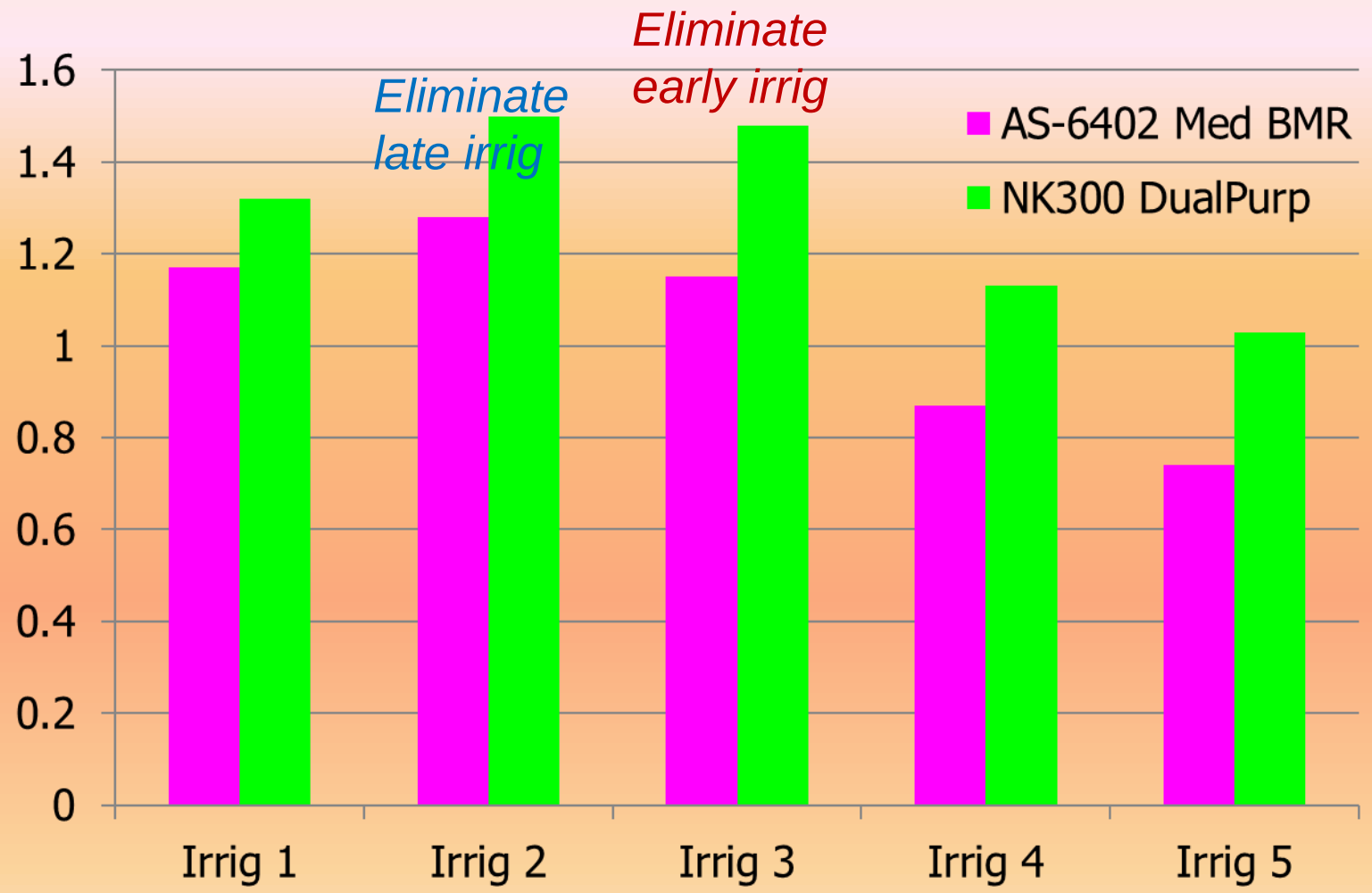


FORAGE SORGHUM Yields

Year 4 – West Side REC site *(yields corrected to 70% moisture, **T/acre**)*



Forage Yield (T/ac @ 65% moisture) per unit of ETc (in)



- Initial furrow-irrigated studies at College of Sequoia farm
- Furrow-irrigated WSREC and KAREC sites
- **Expanded low-frequency surface drip-irrigated trials in 3-year study focused on water stress timing / intensity**
- **Sorghum / Corn SDI deficit irrigation x Nitrogen in 2016-2018**

Sorghum/Corn Irrigation by Nitrogen

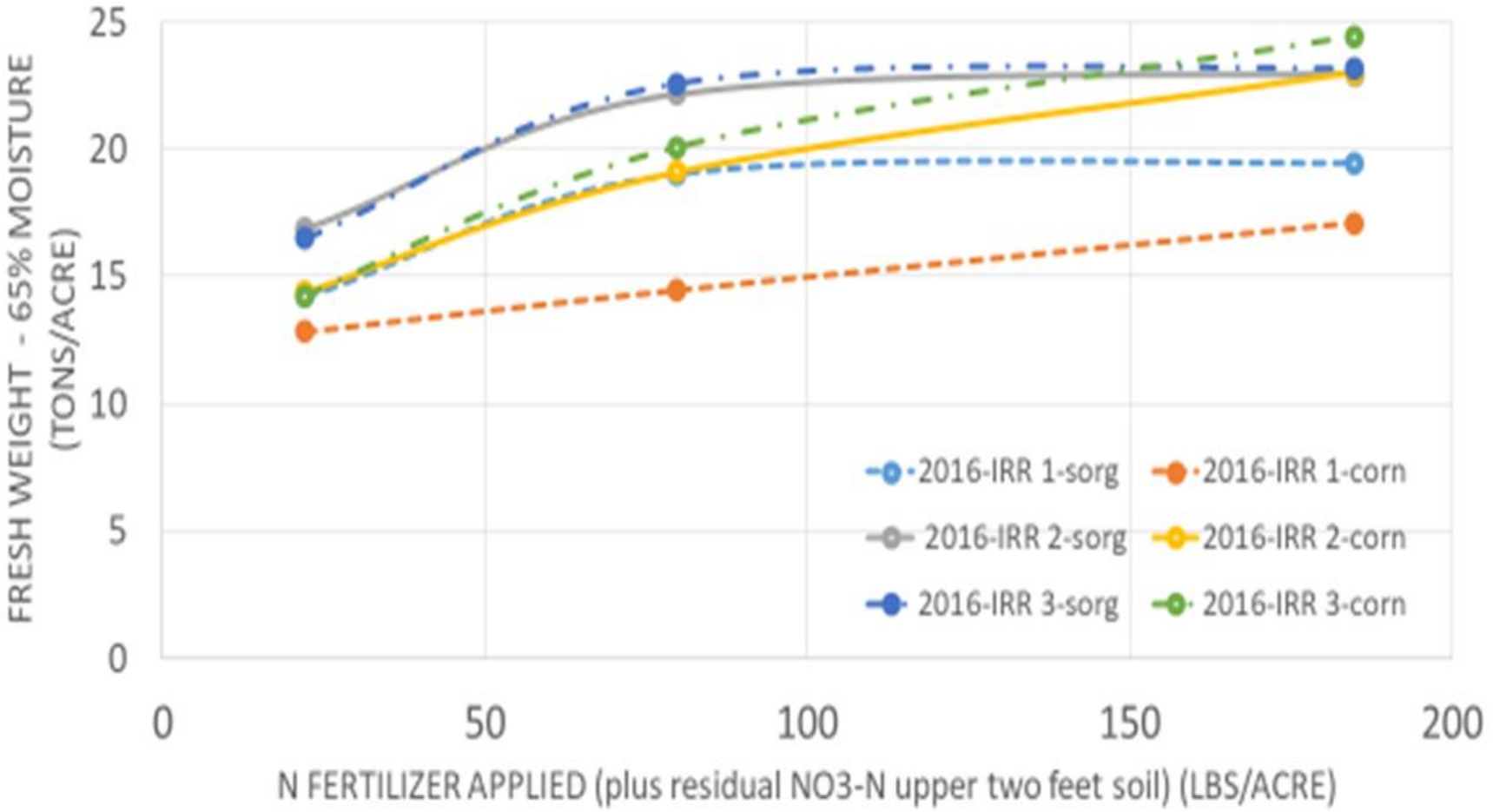
2016–2018 West Side REC

More of a continuous deficit irrigation since using SDI

YEAR	IRRIGATION TREATMENTS	Water Applic. amount in % of estimated ETc for **corn**	Total in-season applied water (inches)*	Average Soil water depletion during season in 8 ft profile (inches)		Total estimated water use (in-season applied + total soil water depletion (inches)	
**additional applied water 2-3" sprinkler for germination*				**sorg**	**corn**	**sorg**	**corn**
2016	IRRIG 1	50%	12.2	- 7.9	- 6.7	20.1	18.9
	IRRIG 2	75%	17.6	- 4.1	- 6.9	21.7	24.5
	IRRIG 3	100%	23.2	- 0.7	- 2.5	23.9	25.7
** Average soil water use = sorg (average of NutraKing & NK-300); corn (average)*							
2017	IRRIG 1	50%	12.4	-5.3	-3.9	17.7	16.3
	IRRIG 2	75%	18.1	-2.9	-3.9	21.0	23.0
	IRRIG 3	100%	24.0	1.1	-1.8	22.9	25.8
2018	IRRIG 1	50%	11.6	-4.0	-3.3	15.6	14.9
	IRRIG 2	75%	17.4	-4.7	-4.7	22.1	22.1
	IRRIG 3	100%	23.1	-1.0	-3.8	24.1	26.9

2016 – Sorghum & Corn Yields by Irrigation and Nitrogen treatment

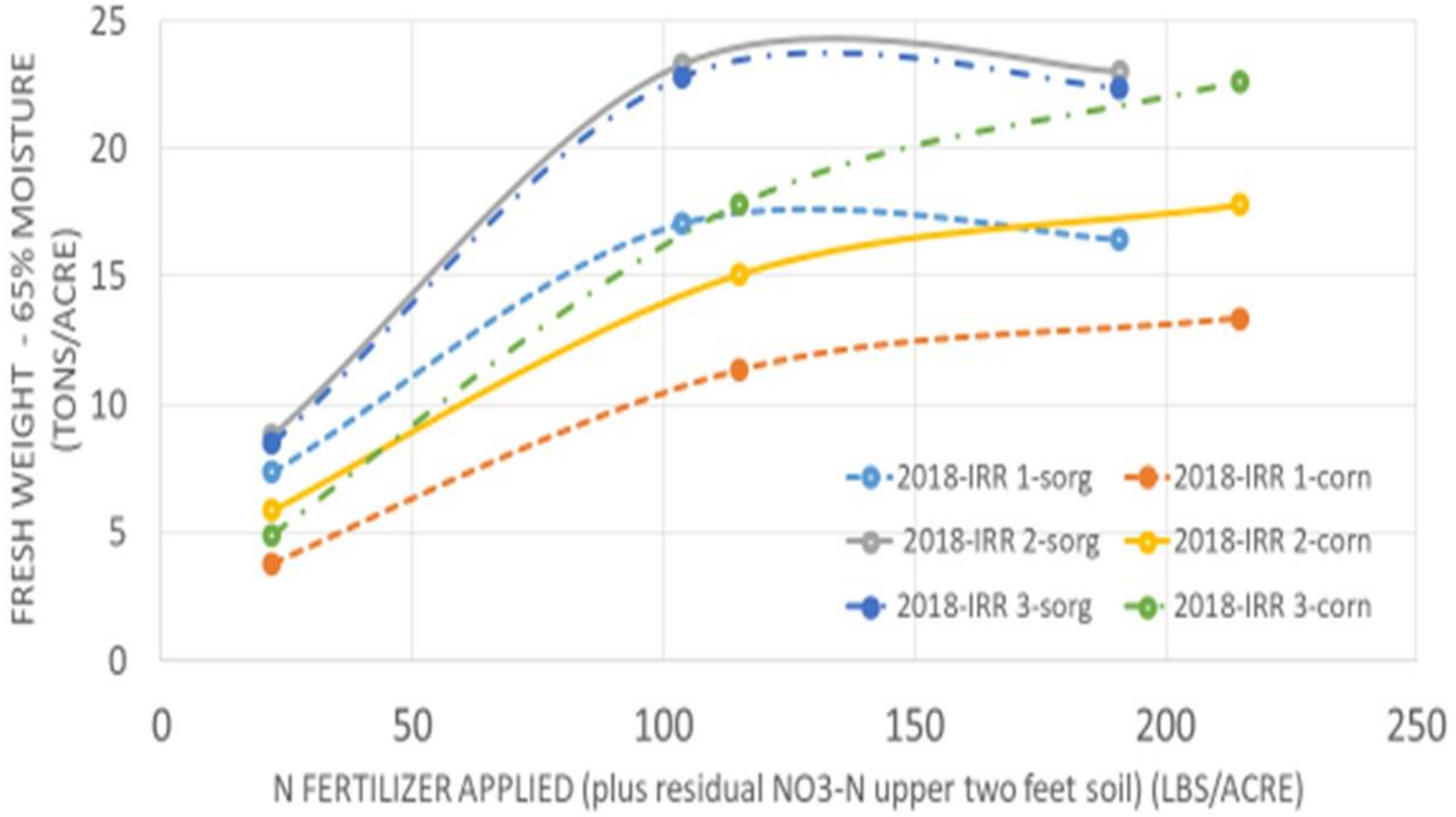
- values shown are averaged across 4 sorghum cultivars & across 2 corn cultivars



average harvest weights of 4 sorghum cultivars as a function of 3 irrigation trts (IRR-1, IRR-2, and IRR-3) and applied N fertilizer plus residual NO3-N in the top 2 feet of soil. Markers show actual data points.

2018 – Sorghum & Corn Yields by Irrigation and Nitrogen treatment

- values shown are averaged across 4 sorghum cultivars & across 2 corn cultivars



SUMMARY COMMENTS:

Most study sites discussed had significant pre-plant irrigations and/or rainfall to provide stored soil moisture in upper 4 - 5+ feet of soil profile

Forage sorghum entries used about 12-14” inches in lowest water application treatments, about 19-24” in highest application treatments

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

Grain sorghum entries had about 1-3” lower calculated total water use in same irrigation treatments used for moderate to later maturity timing forage sorghum entries – but total crop water use strongly related to time to maturity for harvest, as expected.

Generalizations Regarding When to Water Sorghum - *if you are deficit irrigating*

- **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 sorghum
  - 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*

University of California
Agriculture and Natural Resources