Sorghum Irrigation Management Field Evaluations

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University of California ANR support for years 2013-2015 trials
University of California West Side REC and Kearney REC;
College of Sequoias research sites used

- Furrow irrigated studies at Tulare Co. College of Sequoias
- Furrow-irrigated WSREC and KAREC sites in 2011-15
- Expanded low-frequency surface drip-irrigated trials in 2016 and ?

Types of Sorghum to study?

Our irrigation studies so far have mostly looked at #1, 2 and 4 (sorghums can be multipurpose types as well, focus of work on forage types and mention grain types)

1) Grain Sorghum (hybrids, etc.) - primarily for animal and human consumption
2) Forage Sorghum (hybrids, etc.) - silage, green chop
3) Hybrid Sudangrass - used primarily for hay production and some grazing
4) Sweet Sorghum - molasses, syrup, biofuel?
5) Biomass sorghum - developed for renewable bio-products

Diversity in types, amount of grain production, eventual height, photoperiod response, other characteristics

In assessments of water use, not all sorghums the same - consider:

1) Particularly in forage types, height differences, photoperiod & maturity differences across types … potential to impact duration of leaf development, maturity timing & water use (20+ days extra in some)

2) major differences in rooting patterns & depth known across types

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), possibly maturity

Planting / Soil Characteristics / Irrigation Method

Tulare COS Farm - year one and year 2 Silage sorghum studies

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
Irrig X Variety split	16 beds are split plot, with two varieties per irrigation rep

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

Irrigation Method	10 inch gated pipe, one gate per planted row
	Border ridge separates reps each end of plots
	Plots irrigated individually so water application amounts could be determined
	Typical amount / applic. = 4.5 to 5.5 inches

Planting / Soil Characteristics / Irrigation Method

West Side and Kearney REC 2012 - 2015 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	2012 6 inch gated pipe, one gate per planted row 2013-2014 surface drip irrigation (amount per irrig = about 2 inches Kearney, about 3.5 inches WSREC clay loam site)
	Plots irrigated individually so water application amounts could be determined
	Typical amount / applic. = 2.0 - 2.6 (KAREC); 3.5 - 4.0 inches (WSREC)

Deficit versus Full irrigation approaches tested

- As mentioned, some furrow/flood, some drip studies done with range of cultivars
- Different irrigation strategies tested included:
  - Full irrigation most of season (relatively non-stressed
  - Eliminate or reduce amount of some EARLY SEASON irrigations (within first 40-50 days)
  - Eliminate or reduce amount of LATER SEASON irrigations (closer to flowering and beyond)

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	5.7	4.6	-	**10.3**	6.1	4.4	-	**10.5**
T3	-	5.2	5.3	**10.5**	-	4.8	4.6	**10.4**
T0	-	-	-	**0**	-	-	-	**0**

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	-2.8	**18.1**
		2 (late str)	10.3	-4.0	14.3
		3 (early str)	10.5	-2.5	13.0
		0	2.5	-8.6	**11.1**
One	Forage Sorghum	1	15.3	-4.0	**19.3**
		2	10.3	-6.6	16.9
		3	10.5	-4.9	15.4
		0	2.5	-9.6	**12.1**

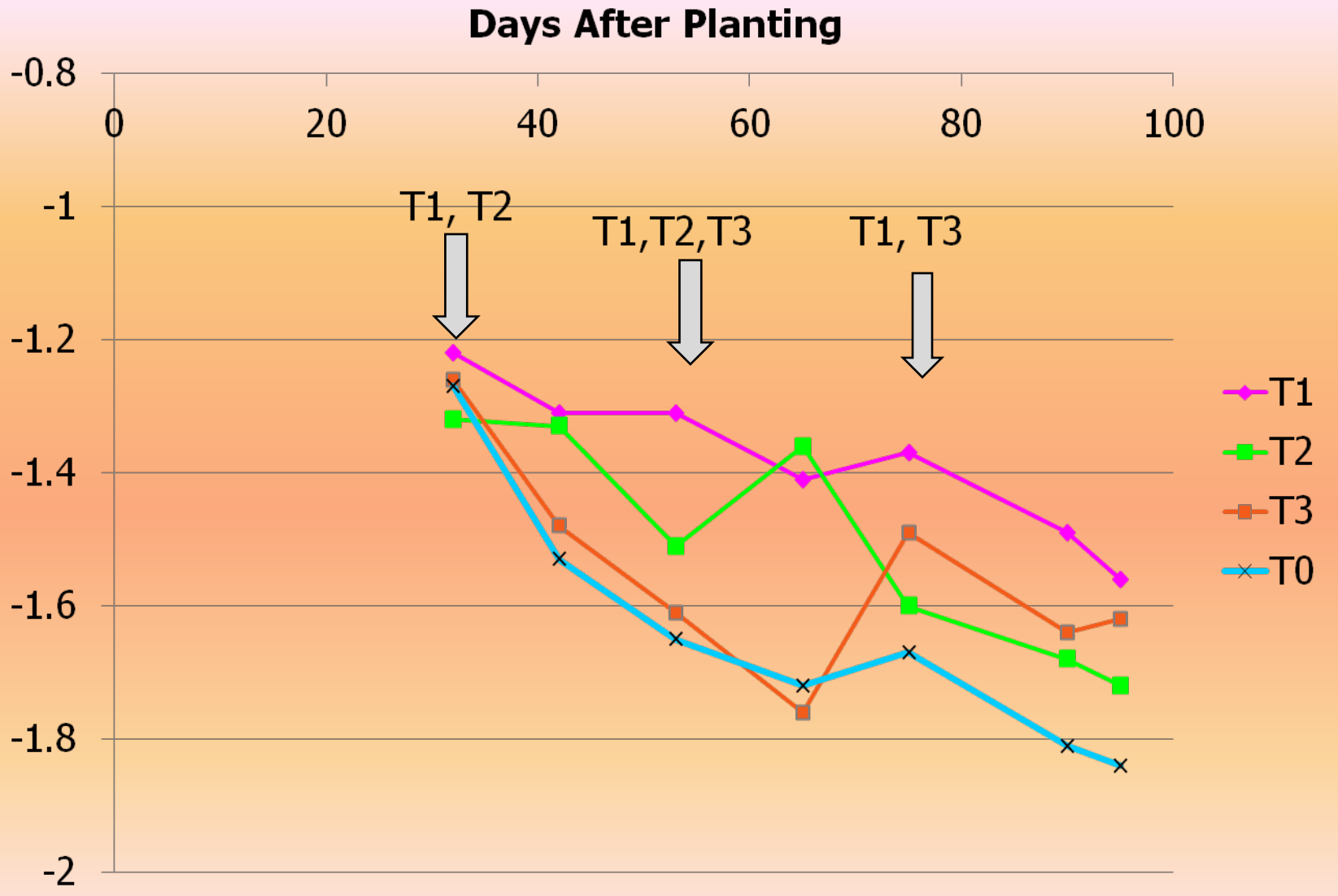
Sorghum Calculated Evapotranspiration

2010 – 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)
Two	Grain Sorghum	1	14.5	-0.6	**16.5**
		2	10.5	-2.9	14.8
		3	10.4	-1.4	13.2
		0	0	-8.9	**10.3**
Two	Forage Sorghum	1	14.5	-1.9	**17.8**
		2	10.5	-4.0	15.9
		3	10.4	-2.4	14.2
		0	0	-10.8	**12.2**

Leaf Water Potential (Bars)

College of Sequoias Farm – year one - Irrigation Trial



Irrigation Dates and Amounts –

WSREC and KAREC 2012 Silage sorghum studies

Irrig. Treat - ment #	2012 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	3.2		3.0	1.6		3.4	2.1			**13.3**
T3	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

2012 – West Side 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)
2012	Grain Sorghum	1	17.1	-3.3	**20.4**
		2	13.3	-2.4	16.7
		3	13.3	-2.8	16.1
		0	6.8	-6.9	**13.7**
2012	Forage Sorghum	1	17.1	-5.8	**22.9**
		2	13.3	-7.1	20.4
		3	13.3	-6.3	19.6
		0	6.8	-7.6	**14.4**

Sorghum Calculated Evapotranspiration

2012 – 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)
2012	Grain Sorghum	1	16.6	-2.9	**19.5**
		2	12.7	-4.6	17.3
		3	12.5	-5.5	18.0
		0	4.7	-6.9	**11.6**
2012	Forage Sorghum	1	16.6	-4.7	**21.3**
		2	12.7	-6.1	18.8
		3	12.5	-5.7	18.2
		0	4.7	-8.5	**13.2**

Irrigation Dates and Amounts –

KAREC 2013 Grain and Silage sorghum studies

Irrig. Treat-ment #	2013 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	2.4	1.9	1.6	1.8	1.7	1.8	1.9	1.6			**14.7**
T3	2.4		1.6	1.8	1.7	1.8	1.9	1.6	1.7	1.0	**15.2**
T4	2.4	1.9			1.7	1.8			1.7	1.8	**11.3**
T5	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 –

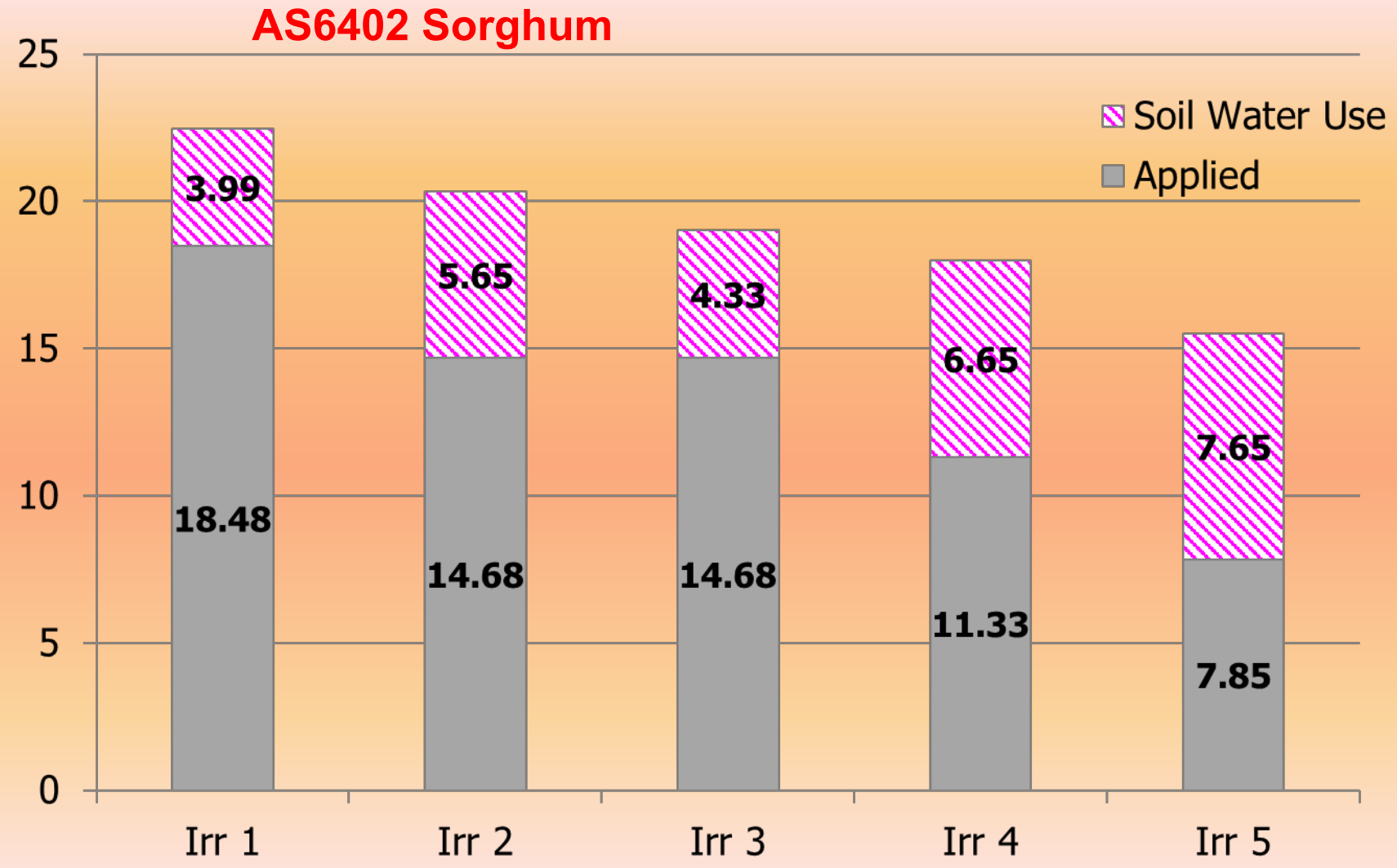
WSREC 2013 Grain and silage sorghum studies

Irrig. Treat-ment #	2013 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		3.7		3.7		3.7		3.7		3.7	**18.5**
T2		3.7		3.7		3.7		3.7		0	**14.8**
T3		0		3.7		3.7		3.7		3.7	**14.8**
T4		3.7		0		3.7		0		3.7	**11.1**
T5		3.7		0		3.7		0		0	**7.4**

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

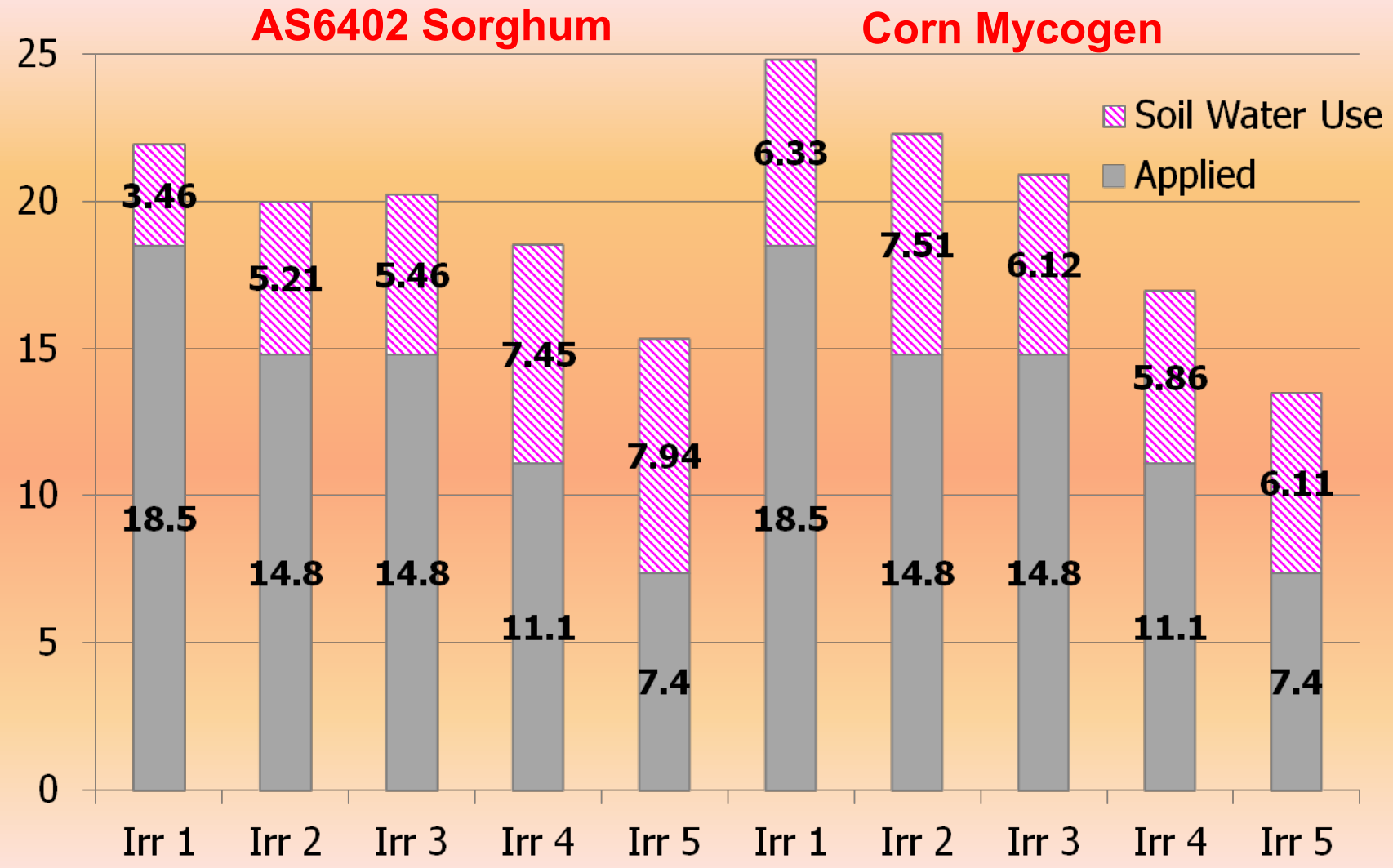
Select Forage Sorghum Applied Irrigation plus Soil Water Use

2013 – KAREC site *(inches applied & soil water use)*



Select Forage Sorghum Applied Irrigation plus Soil Water Use

2013 – WSREC site *(inches applied & soil water use)*



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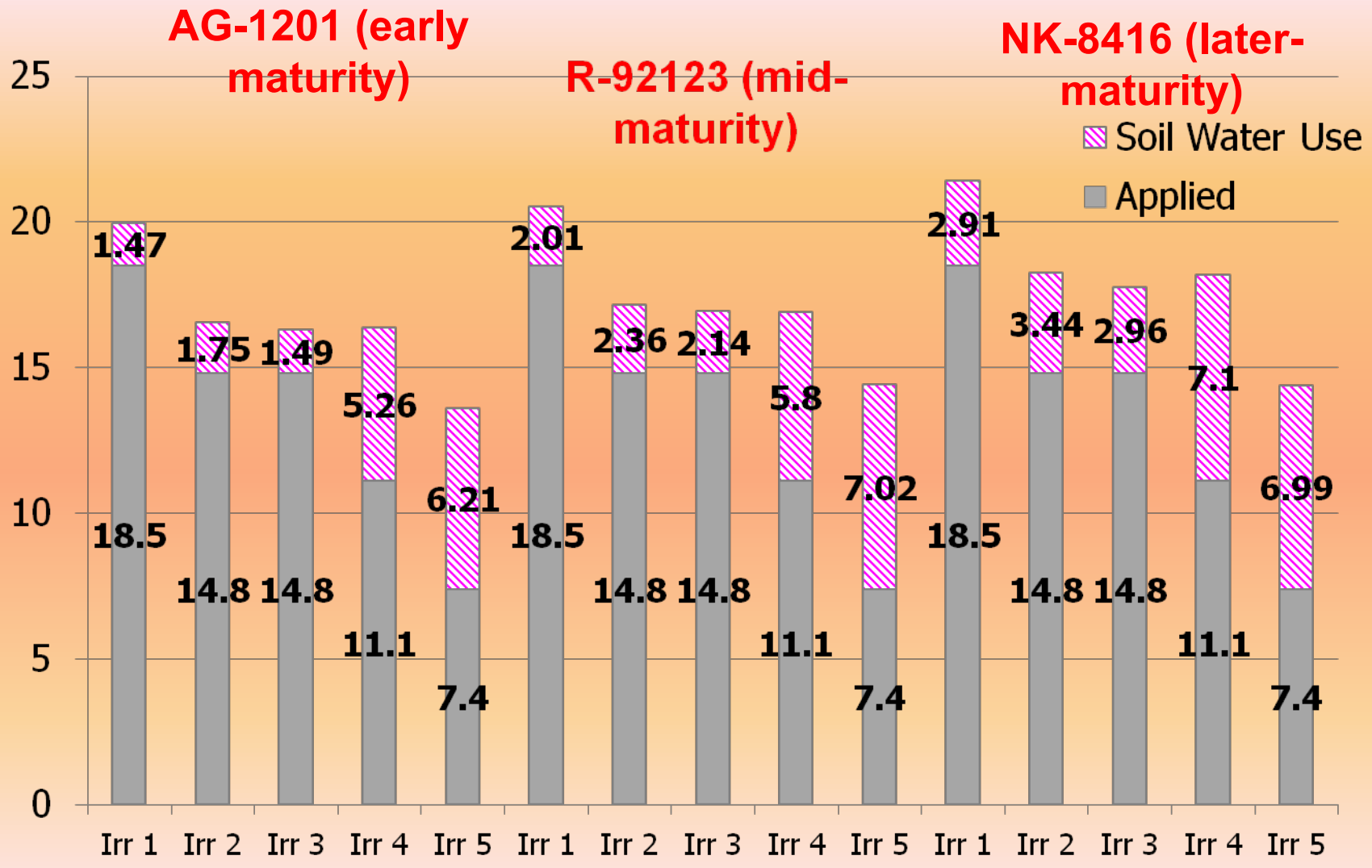
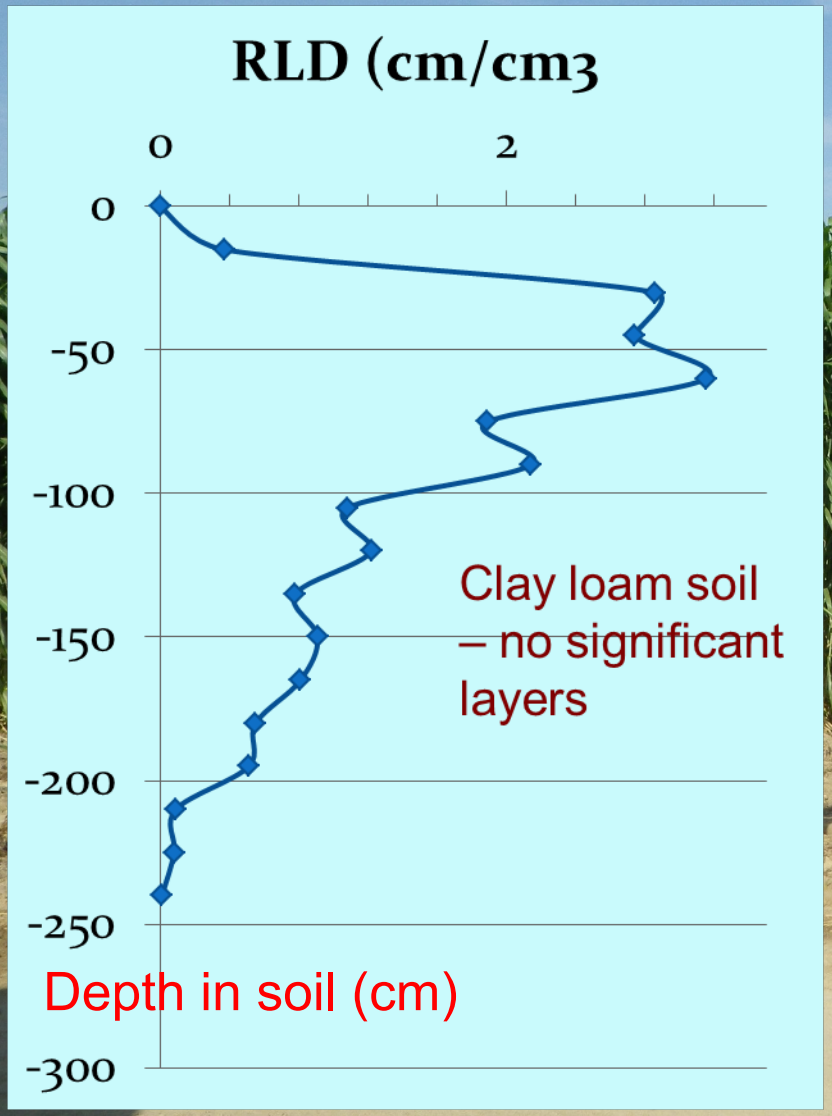
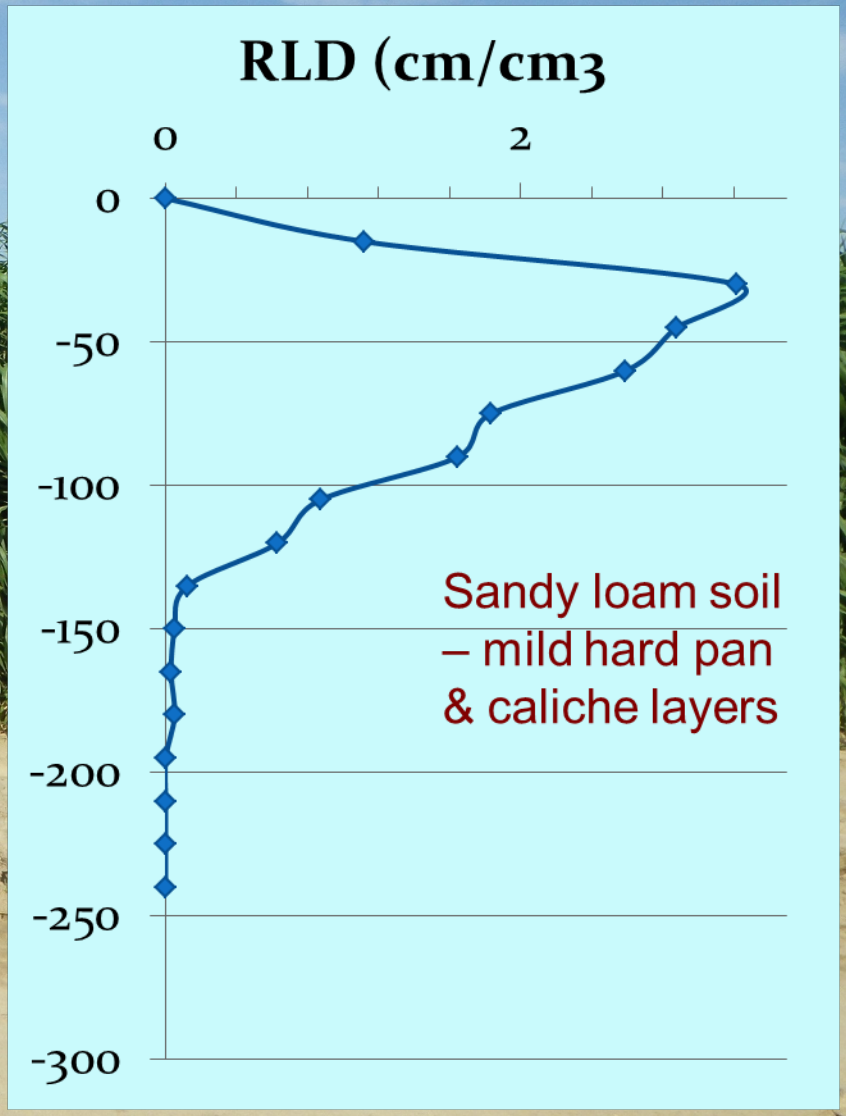


Sorghum Root Systems – Root length density 2 soil types





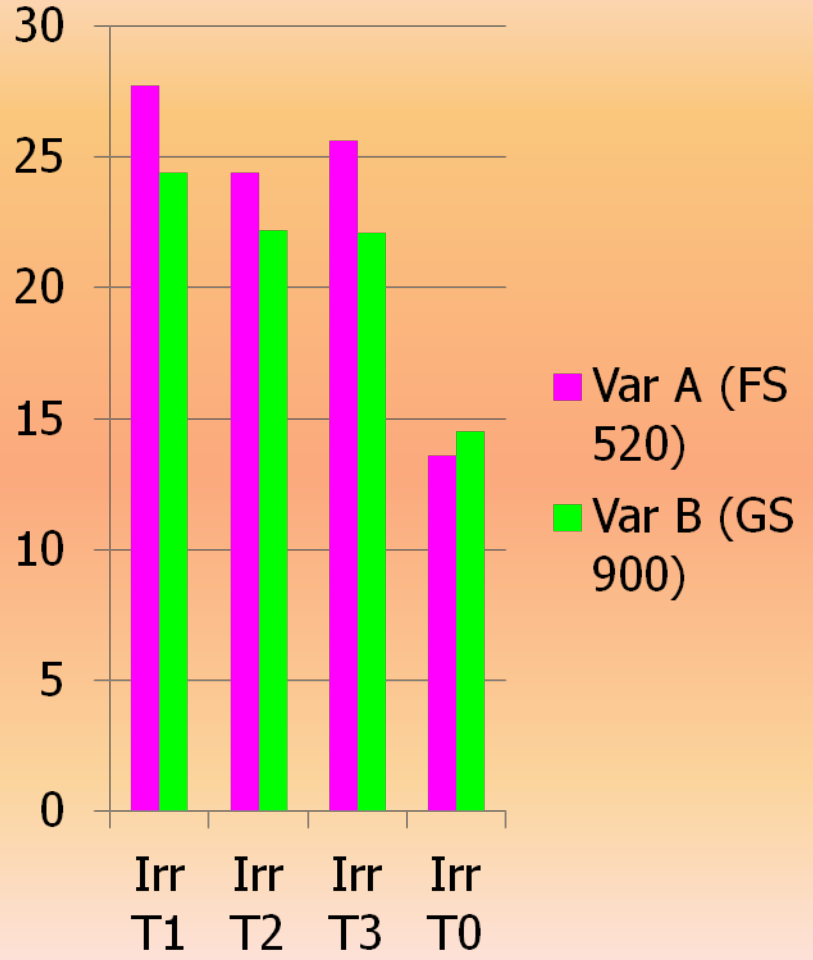
HARVEST OPERATIONS

1) At COS site = Commercial Silage Harvest equipment & whole plot weights
2) At REC sites = machine harvest silage, hand harvest grain trials

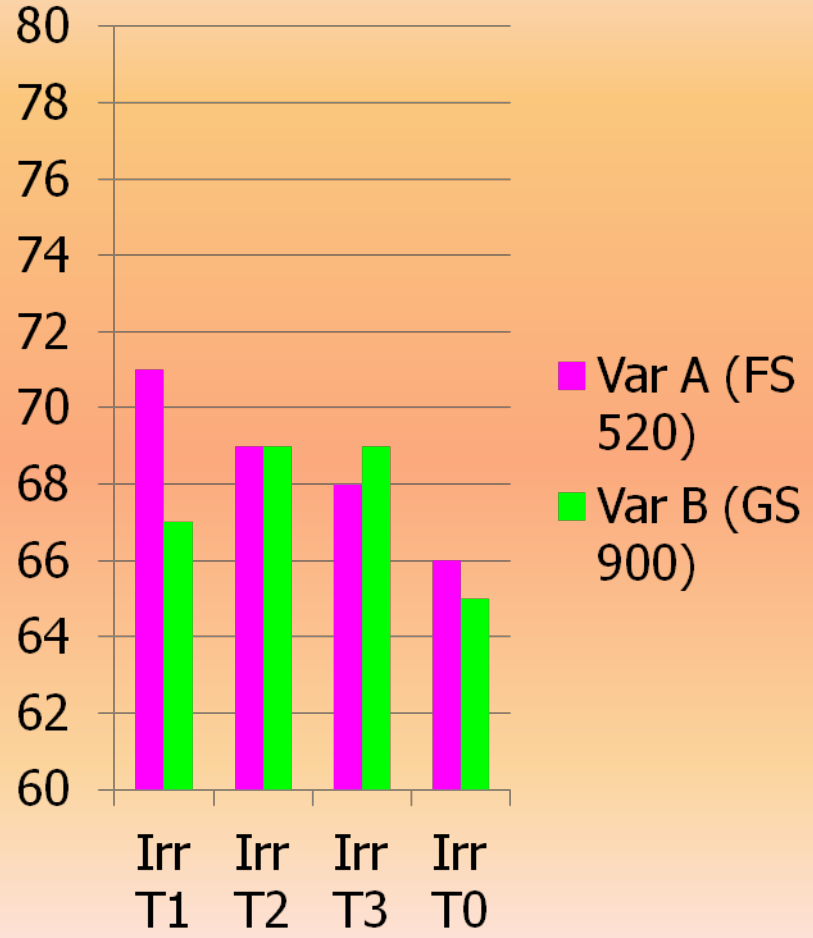
Subsamples by hand for moisture %

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

Yields (Tons/acre)

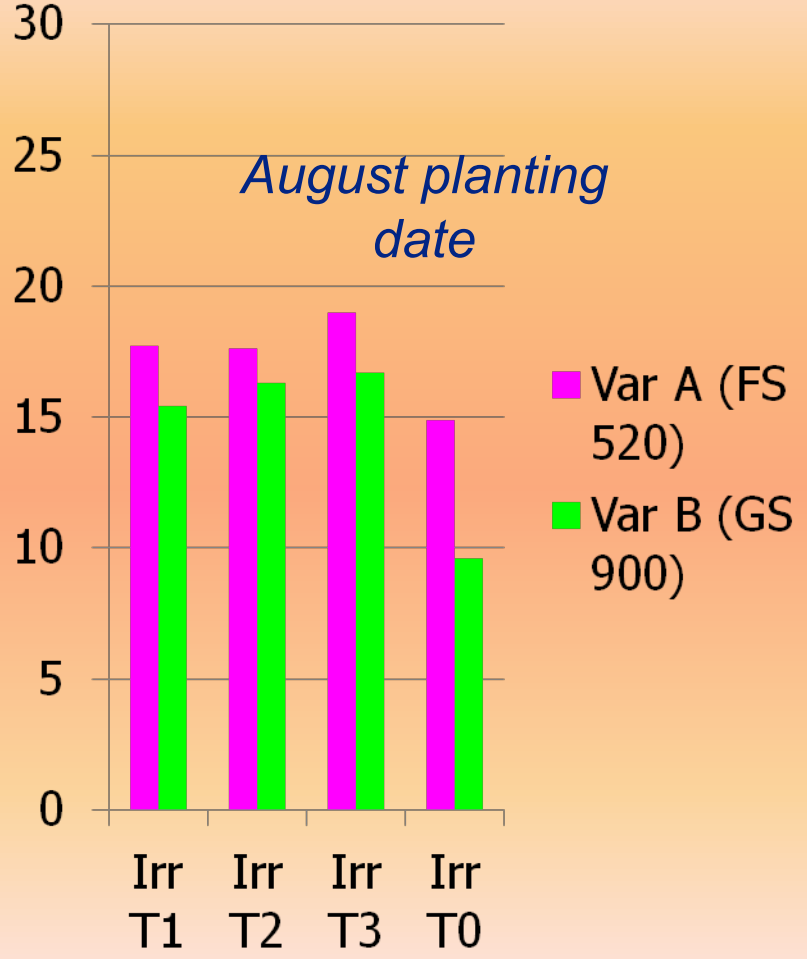


Silage Moisture Content (%)

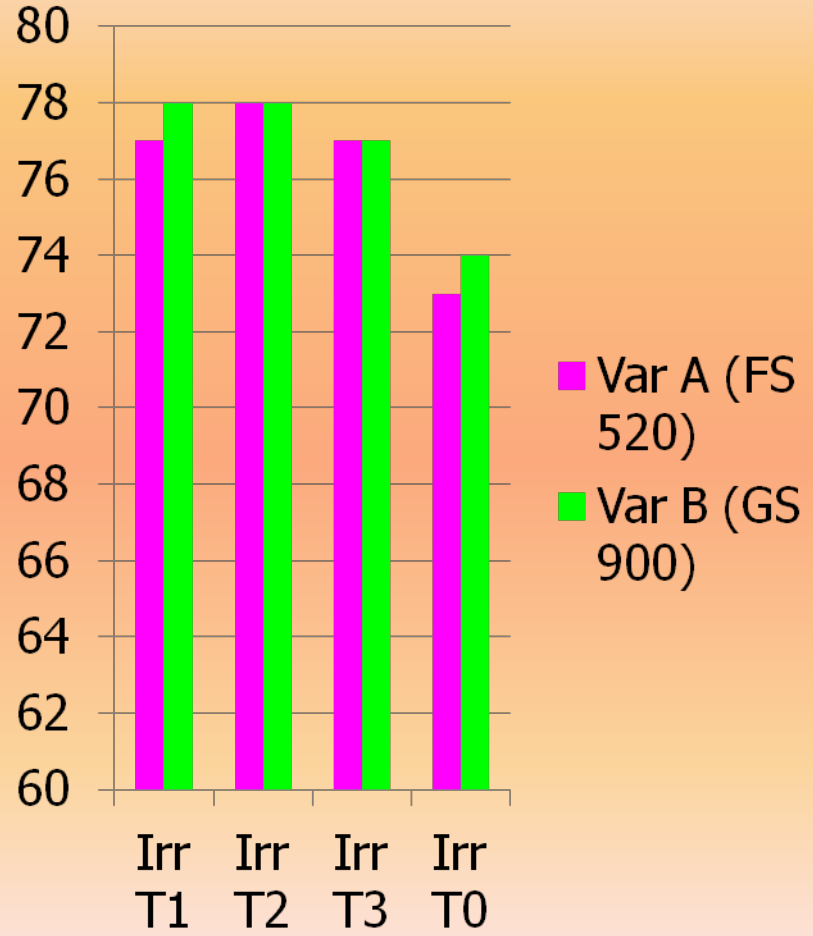


Sorghum Silage Yields and Average Moisture Content year two – COS site

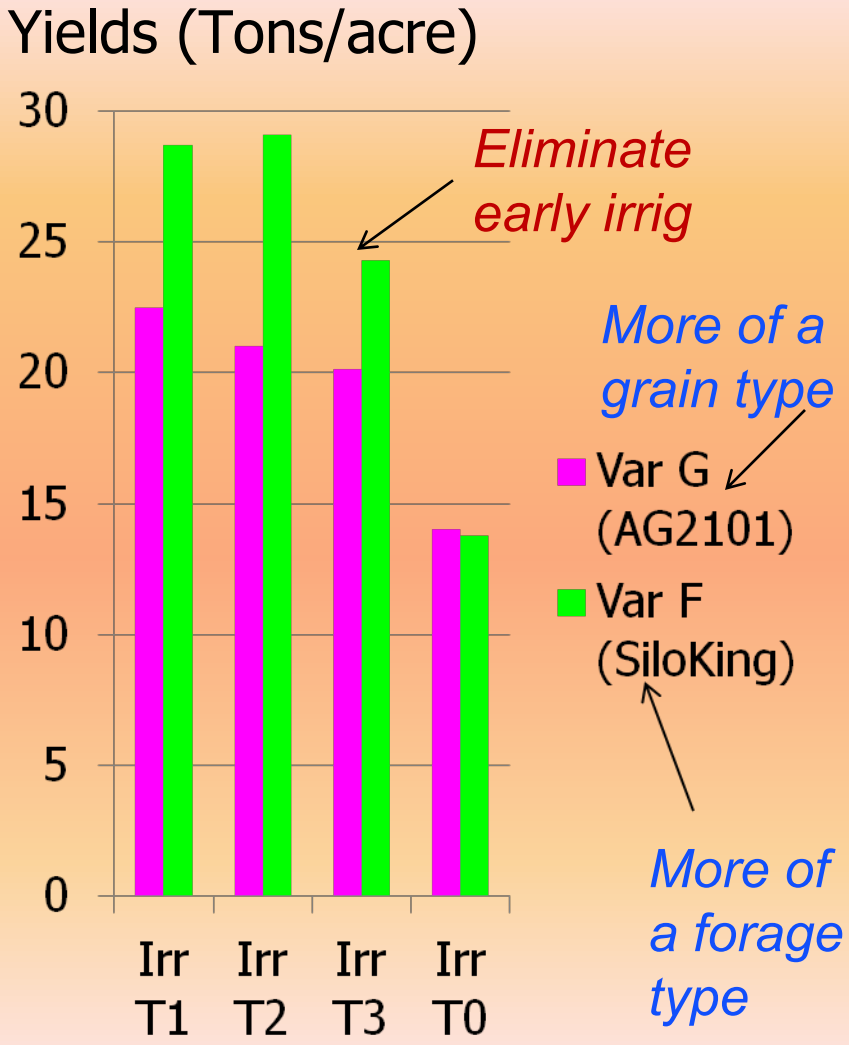
Yields (Tons/acre)

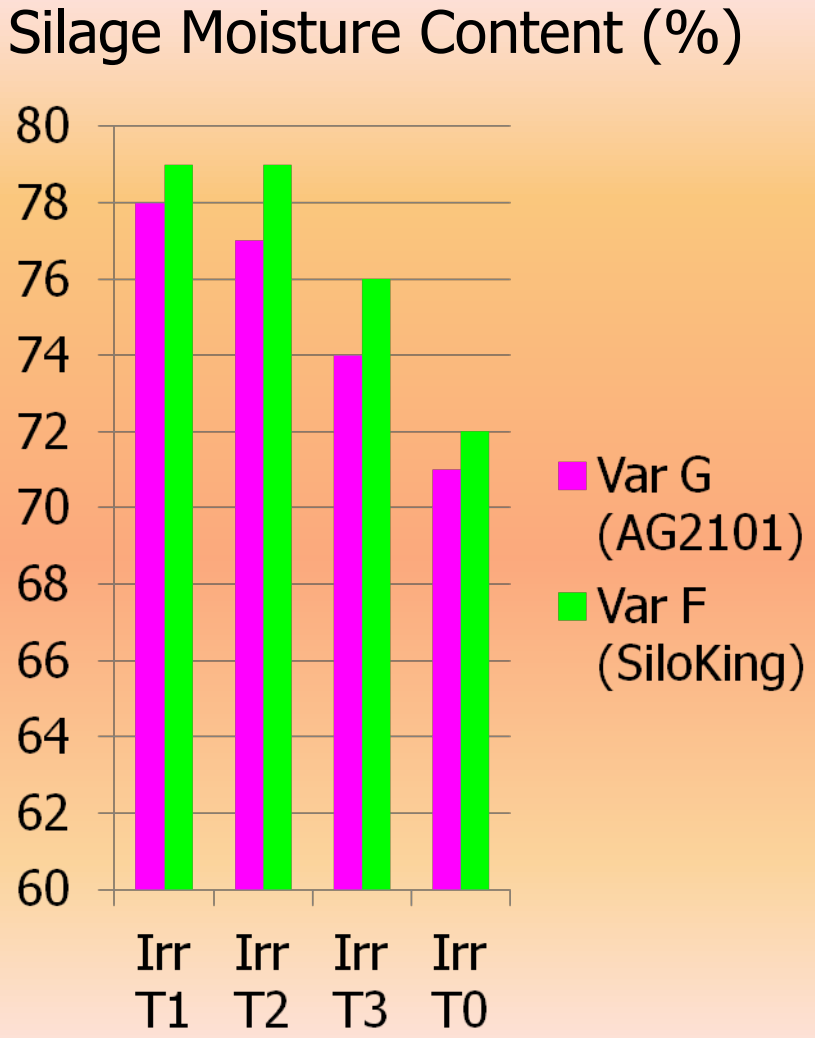


Silage Moisture Content (%)

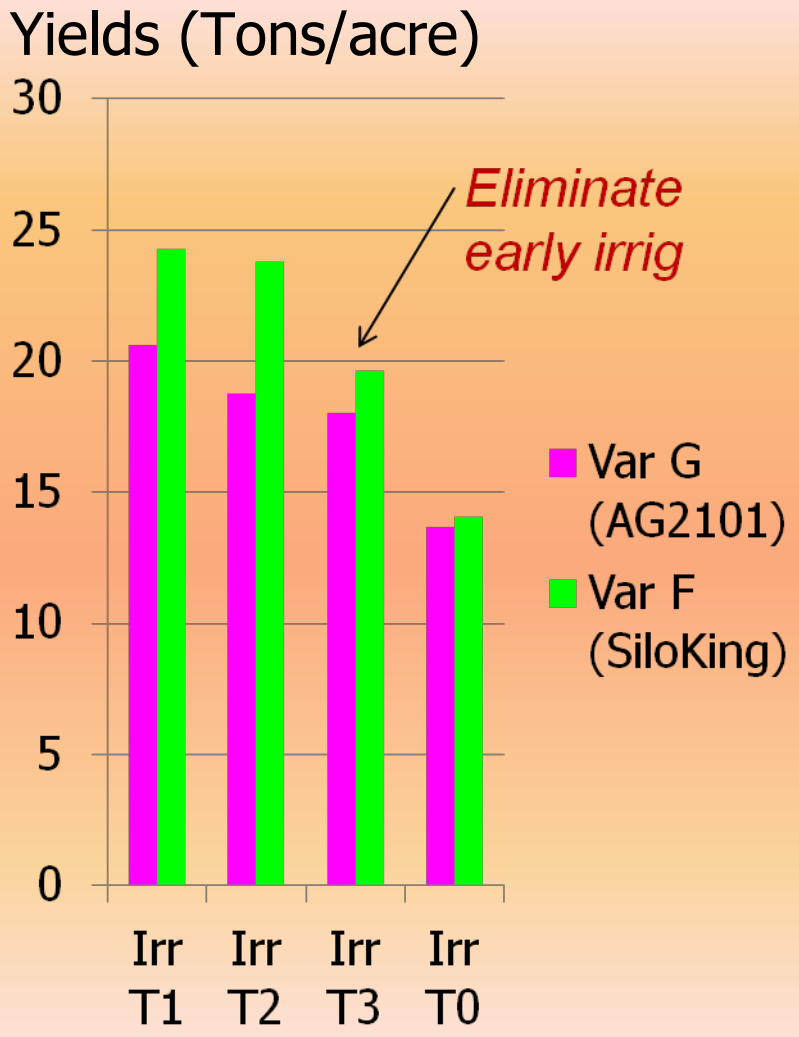


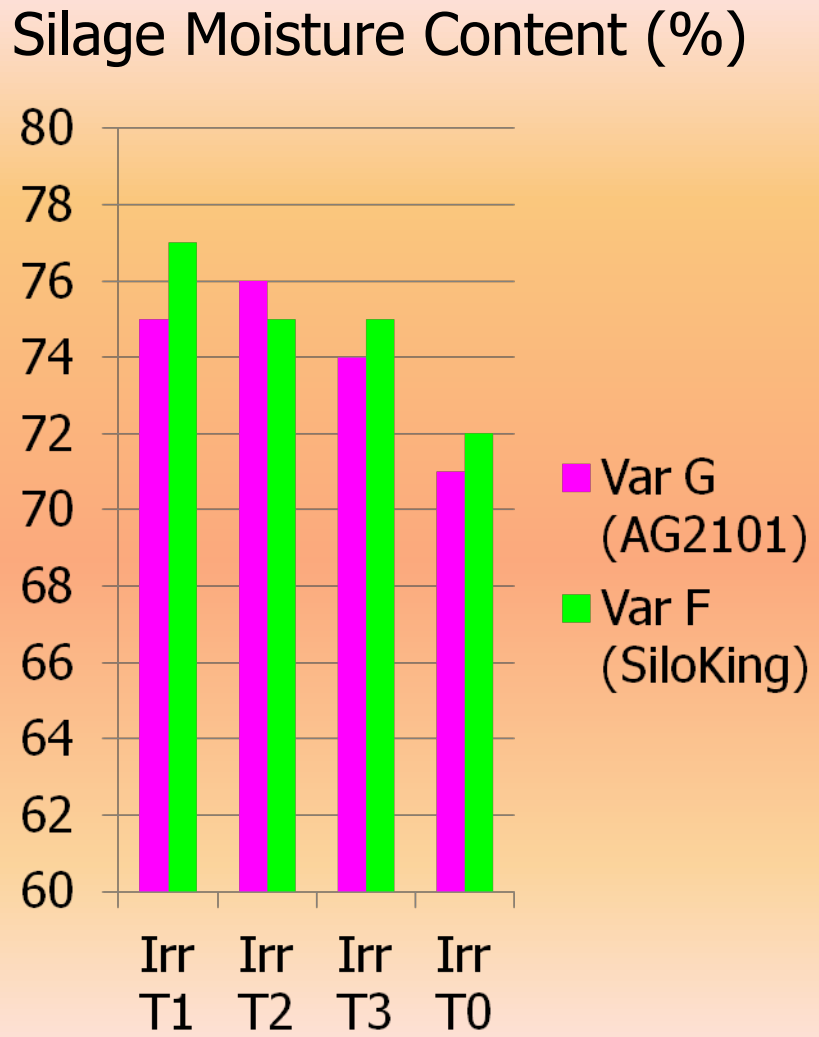
Sorghum Silage Yields and Average Moisture Content 2012 – Kearney REC site





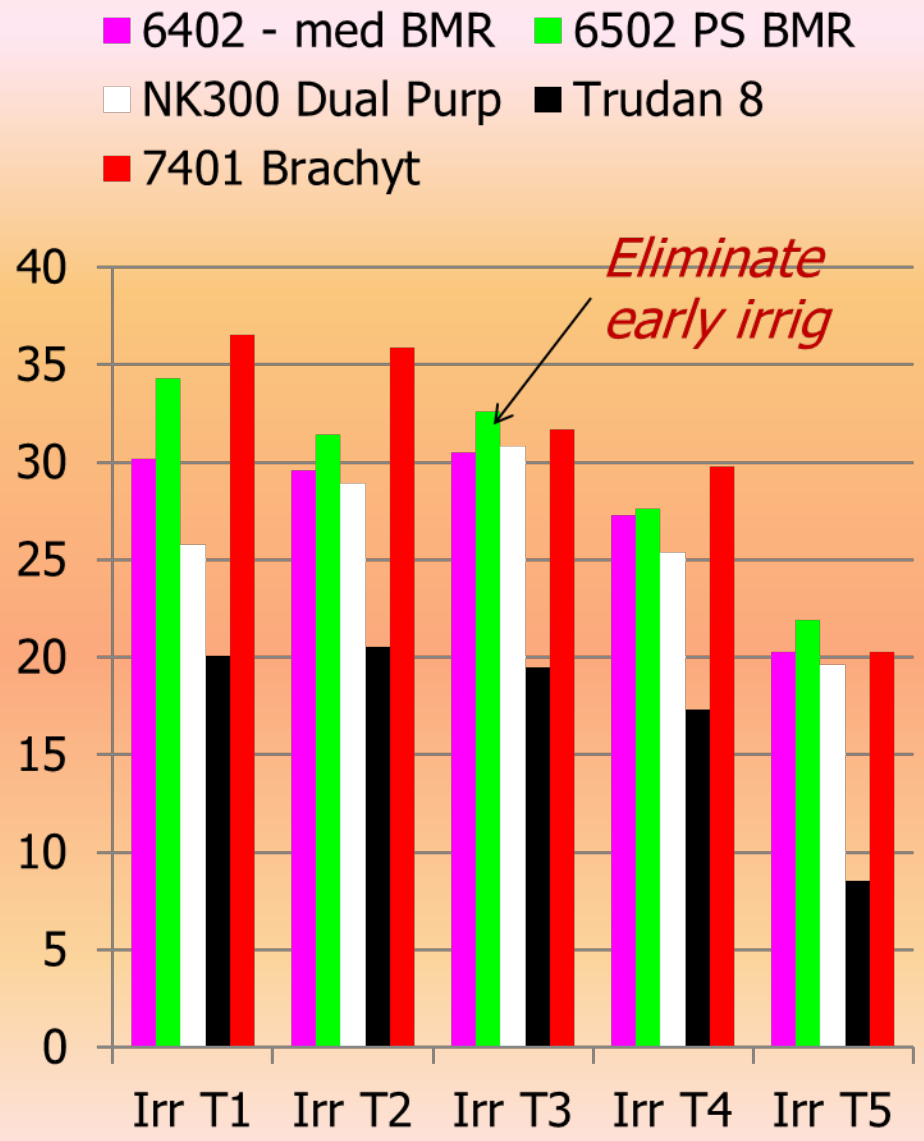
Sorghum Silage Yields and Average Moisture Content 2012 – West Side REC site

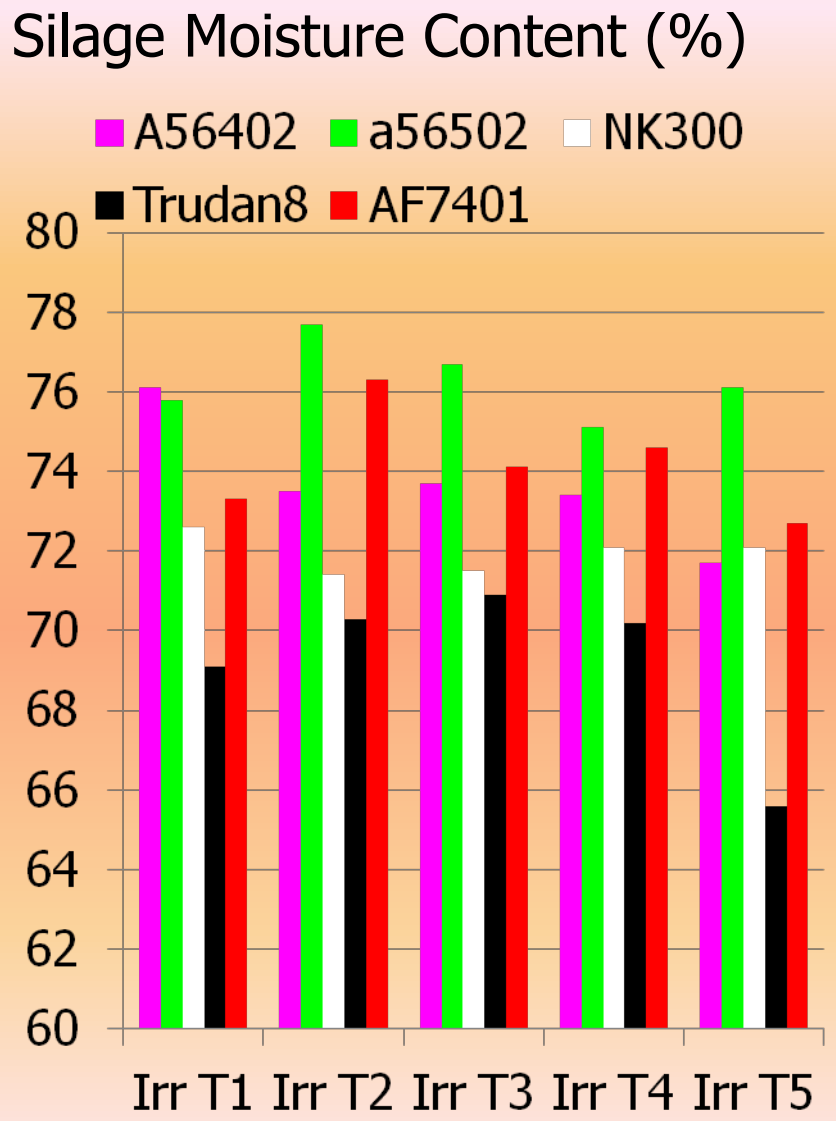




FORAGE SORGHUM Yields and Average Moisture Content

2013 – Kearney REC site *(yields corrected to 70% moisture, T/acre)*





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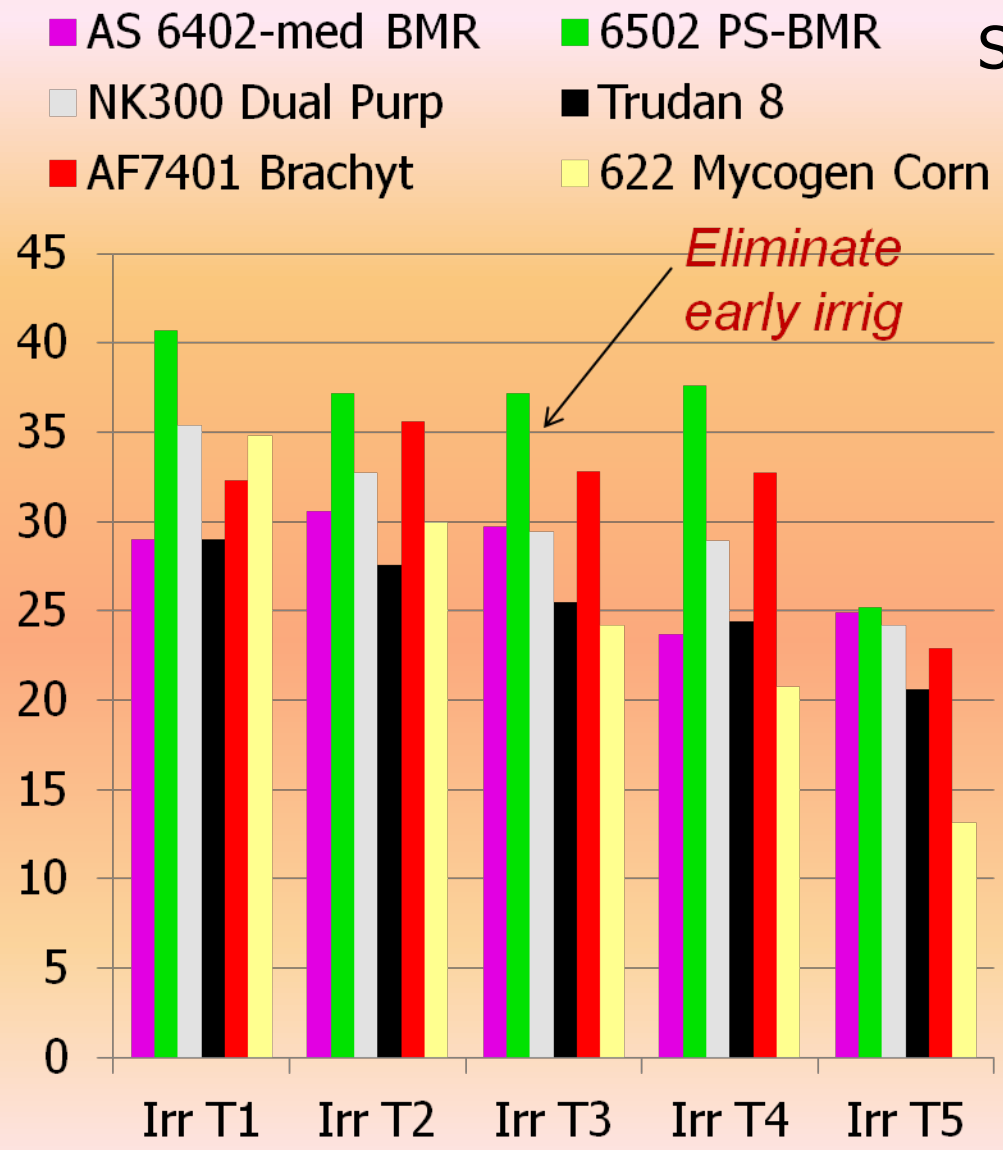
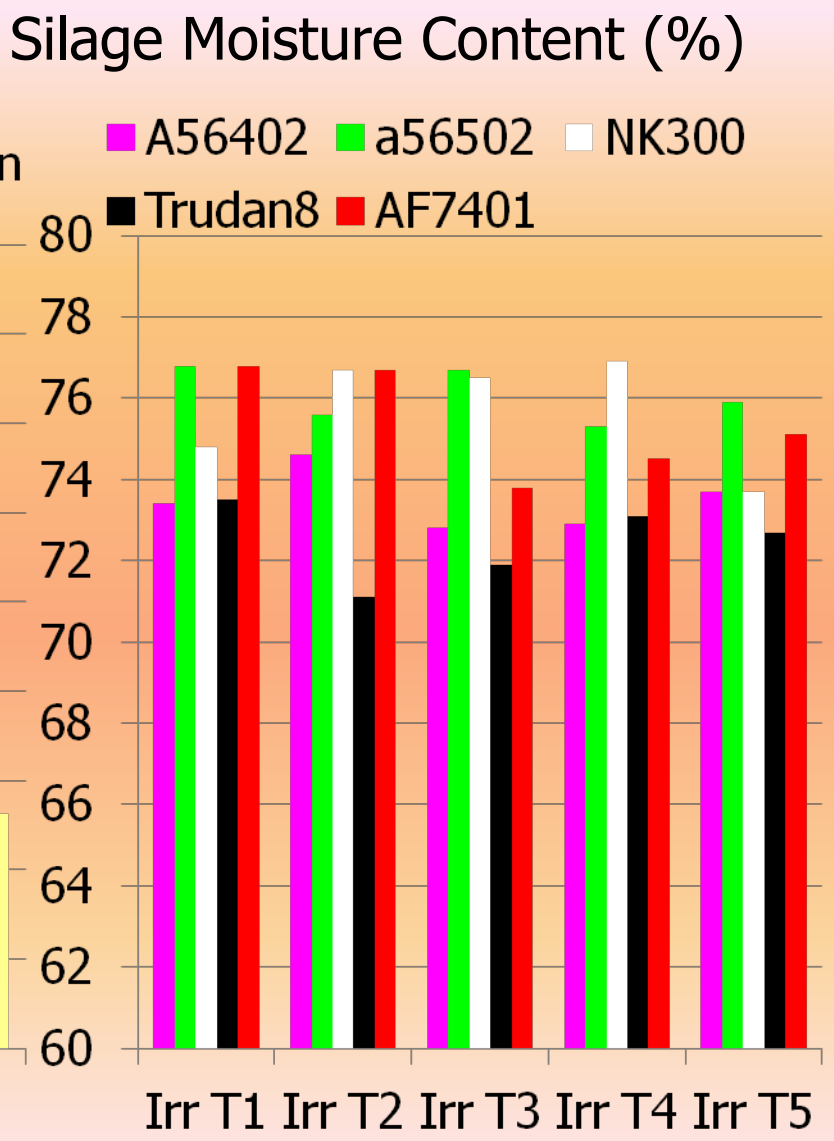
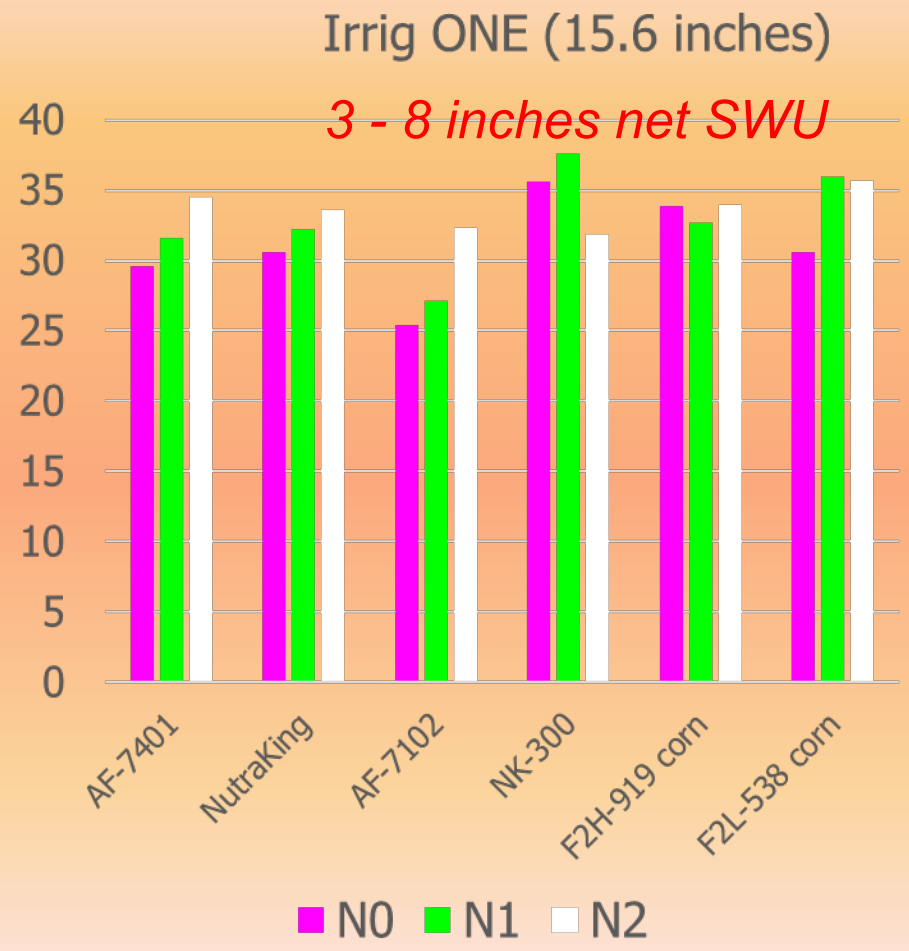
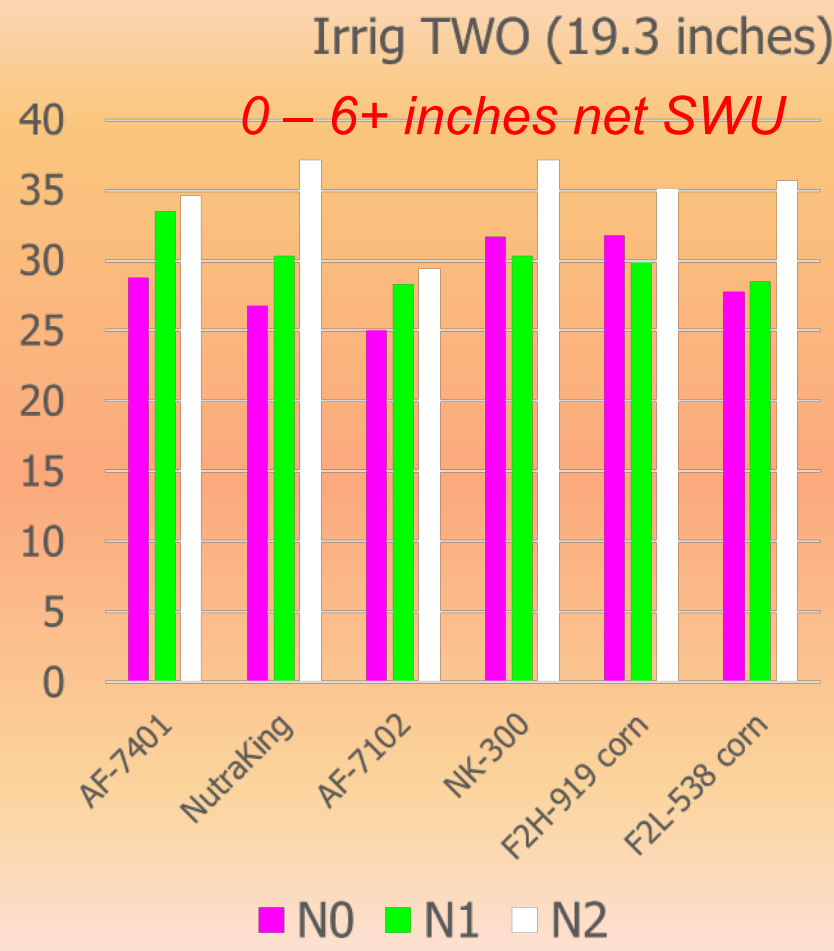




WSREC Forage sorghum & corn yields under drip irrigation *(T/ac @ 70% moisture) – as function of irrigation level and Nitrogen level (N1 = approx. 120 lbs N/ac; N2 = 240 lbs)*





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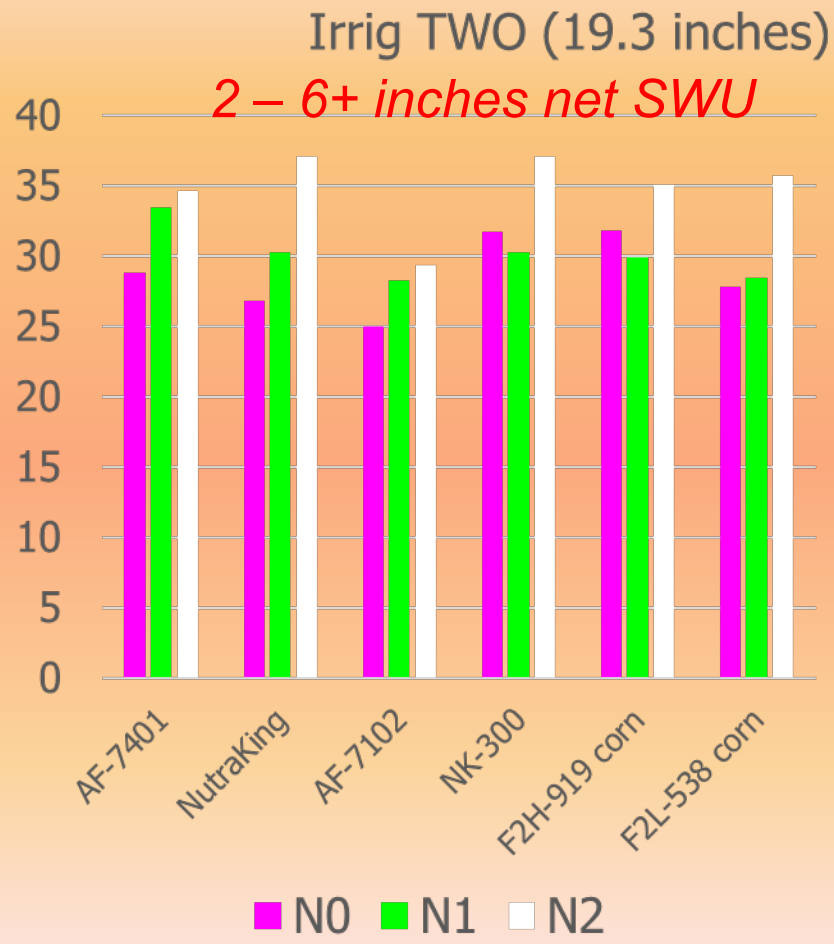

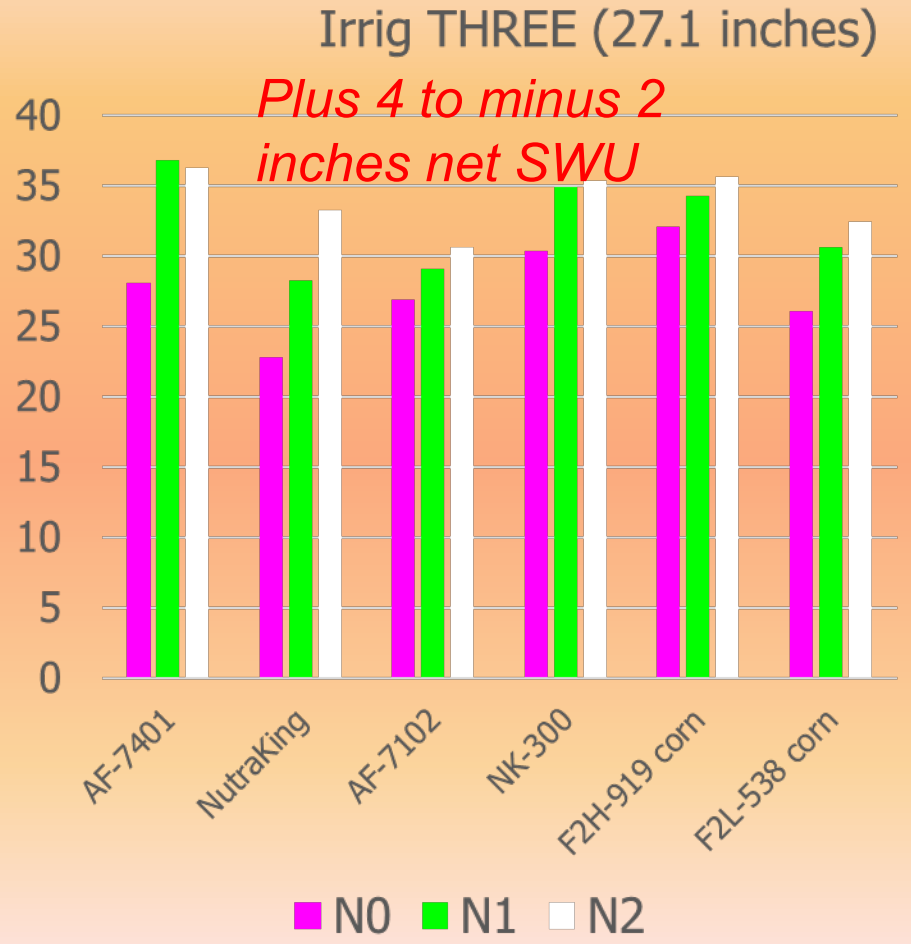

Generalizations regarding When to Water Sorghum if you are deficit irrigating

- **Grain sorghum**
  - If possible, avoid moderate to severe stress during first 30-35 days after emergence when panicle differentiation occurs (will reduce yield potential)
  - If water available, irrigate again prior to boot to limit severe water stress during flowering
  - During mid-to –late grain fill can tolerate greater levels of stress
- **Forage sorghums**
  - Similar to grain sorghum, but can get away with delaying the first irrigation, particularly if planting a long-season photoperiod sensitive sorghum that can make up for slow early growth
  - Under very dry conditions after planting, may need 2-3 inch irrigation at planting to encourage emergence and root system development (important if want plants to explore for soil water)

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

Nitrogen / nutrient management studies needed?

- Limited N nutrient management tests underway

- With forage sorghum, due to concerns for lodging potential with some cultivars, a safe starting N fertilizer approach might be:

  - (1) soil test upper 2 or 3 feet to identify available residual N
  - (2) apply 100-125 N/ac if moderate-high yield goals, good rooting depth potential, and residual N <40-60 lbs N/acre in top 2 feet (reduce if know lots of N available deeper depths
  - As more tests done, might expect much variability in N responses since cultivars differ in maturity (active periods of leaf growth, leaf age, grain % of DM)
  - Estimates from irrigated sites in TX, AZ are 7 to 9 lbs N/acre for every T/ac yield at 65% moisture – apply to CA?

SUMMARY COMMENTS – water issues:

All sites for trials had significant pre-plant irrigations and/or rainfall to provide stored soil moisture in upper 4-6+ feet of profile

Forage sorghum entries used about 12-14” inches in lowest water treatments, about 19-24” in highest irrigation trts (cultivar differences in water use in higher water treatments related to maturity differences).

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

On average, grain sorghum entries had about 1-4” lower calculated total water use in same irrigation treatments used for forage sorghum entries

University of California
Agriculture and Natural Resources