Irrigation Management under Drought Conditions

Considerations for COTTON

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Different approaches in cotton production – *impacts on water needs?*

- Full Season
  - Plant early
  - Use varieties suitable for full season production
  - Harvest as late as possible
  - Try to maximize period for boll production
- Shorter Season
  - Choose varieties suitable for shorter season
  - Reduce active growing season by 2 to 6 weeks
  - Manage and then Terminate crop for 1 fruiting cycle (no 2-cycle cotton)
  - Deficit irrigation ?

To use or consider deficit irrigation requires:

- Identification of crop growth stages sensitive to deficit irrigation, if any
- Development of irrigation scheduling approaches that are based on not meeting full crop water requirements during some growth stage(s)
  - These efforts may include defining tools (plant or soil measurement) to monitor or make sure plant water stress is not excessive

Water Deficit Responses in Cotton

- Most CA research suggests:
  - Growth stages least sensitive to water deficits are
    - Early vegetative growth to about 7-9 nodes
    - After peak flowering into boll maturation
    - Hutmacher, 1995, Munk et al 1994, Grimes and Yamada, 1982
  - Most sensitive growth stages are
    - Flower bud formation through early flowering
  - Later flowering intermediate in sensitivityWater deficits in early season expressed as smaller plants, with fewer leaves & fruit, and less leaf area to support bolls produced
  - With pre-flower deficits, continued growth of sympodial branches, production of 2nd, 3rd position flower sites is more sensitive than 1st position fruit

Options to consider to reduce total applied water & drainage

- Use considerations of plant growth stage and plant mapping data later in the season to avoid *(where possible)* :
  - EARLY SEASON WATER APPLICATIONS that are "too early" and not necessary – since plants quite insensitive to water deficits until 7-8 node stage
  - LATE SEASON WATER APPLICATIONS that are not needed in some situations where late boll load may be light

May avoid one or more irrigations in some years when extra water unimportant to yield

IF YOU ARE CONSIDERING DEFICIT IRRIGATION …

- Where are the roots? What changes in fertilization practices beneficial?
- Where does salt accumulation occur, and how deal with accumulations (not addressed here)
- What is the effective rooting volume and how does it change during the season?

Options to consider to reduce total applied water & drainage

- Improve irrigation scheduling *(decisions on the amount as well as the timing of irrigations)*
- Make better use of tools such as:
  - Plant water status indicators
  - Soil water status measurements
  - Climatic evapotranspiration monitoring (evaporation pans, weather stations)
  - Computer models of ET, water use

Cotton sensitivity to water deficit periods

- To help decide on irrigation scheduling with allowable but not too severe deficits, there are a number of well-researched tools useful in assessing plant water stress in cotton:
  - Leaf Water Potential (Grimes and Yamada, 1982; many others)
  - Crop Water Stress Index / infrared thermometry (Howell et al, 1984, Hutmacher, 1995, others)

Leaf Water Potential Recommendations for 1st Irrigation *(Grimes et al – Univ of CA)*

- Highest yields with –16 bars LWP for first within-season irrigation
- Earlier irrigation at –13 bars increased vegetative growth, delayed maturity & reduced yield in some years
- Negative yield impacts of allowing –18 bars ranged from negligible to 4%, according to extent of root system

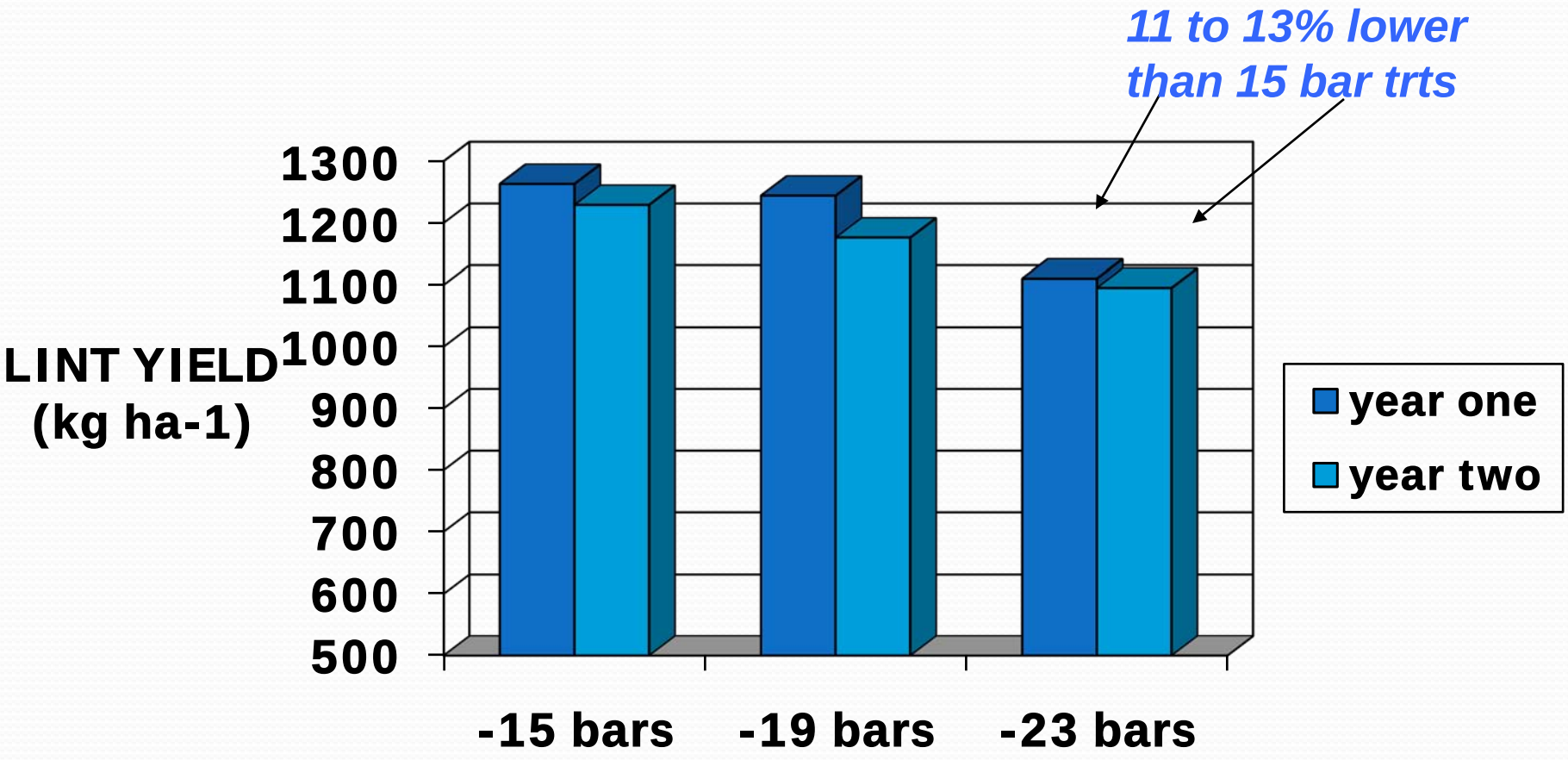
FIRST IRRIGATION TIMING

Univ. of CA, USDA – ARS (CA) and Univ. of Arizona studies

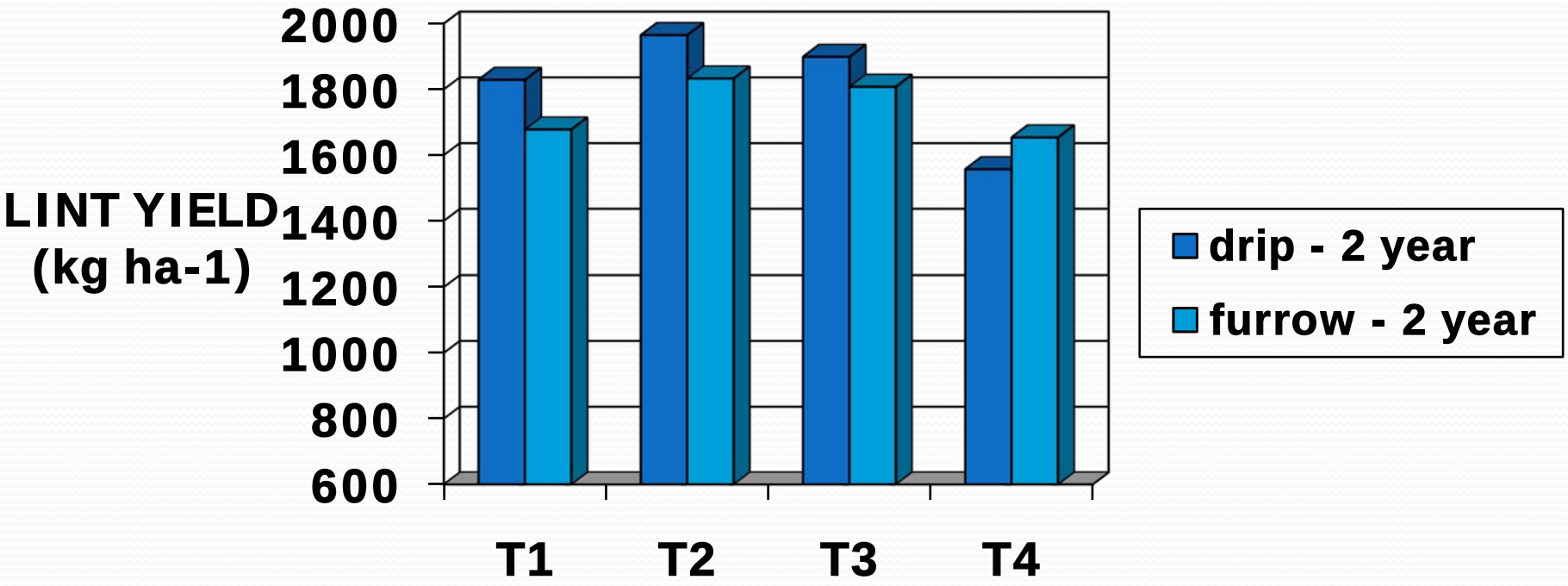
(Steger, Silvertooth and Brown; Grimes, Yamada;

Hutmacher, Davis, Phene et al)

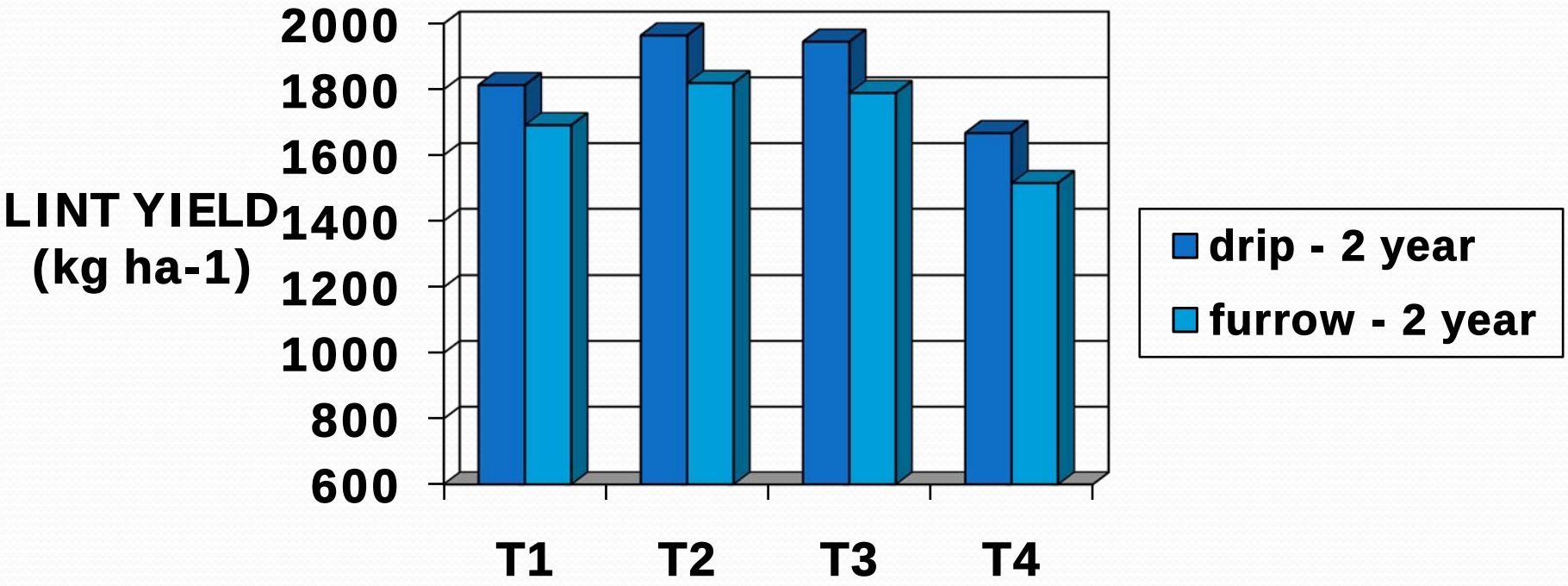
1st IRRIGATION STUDIES (Univ of AZ) T1 = -15 bars (May 29 to June 4); T2 = -19 bars (June 10 to 18); T3 = -23 bars (June 25 to 28)



ACALA 1st IRRIGATION STUDIES (*Hutmacher)* drip versus furrow T1 = -13.5 to –14.5 bars ; T2 = -16 to -17 bars; T3 = -18 to -19 bars; T4 =-21 to –23 bars



PIMA 1st IRRIGATION STUDIES – years 1 & 2 (*Hutmacher)* drip versus furrow T1 = -13.5 to –14.5 bars ; T2 = -16 to -17 bars; T3 = -19 to -20.5 bars; T4 =-22 to –23 bars

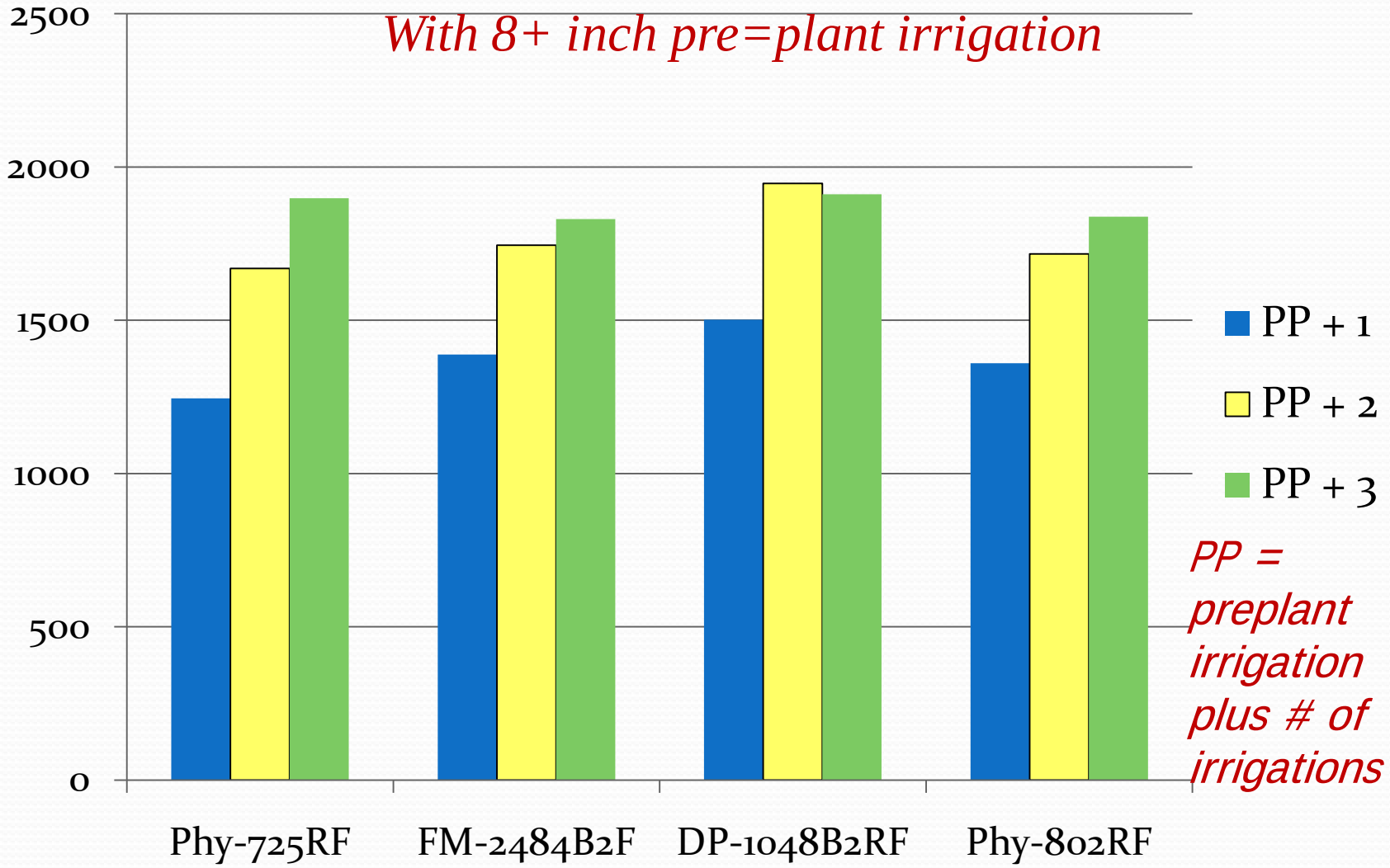


Impacts of delayed 1st irrigations

Some generalizations across studies

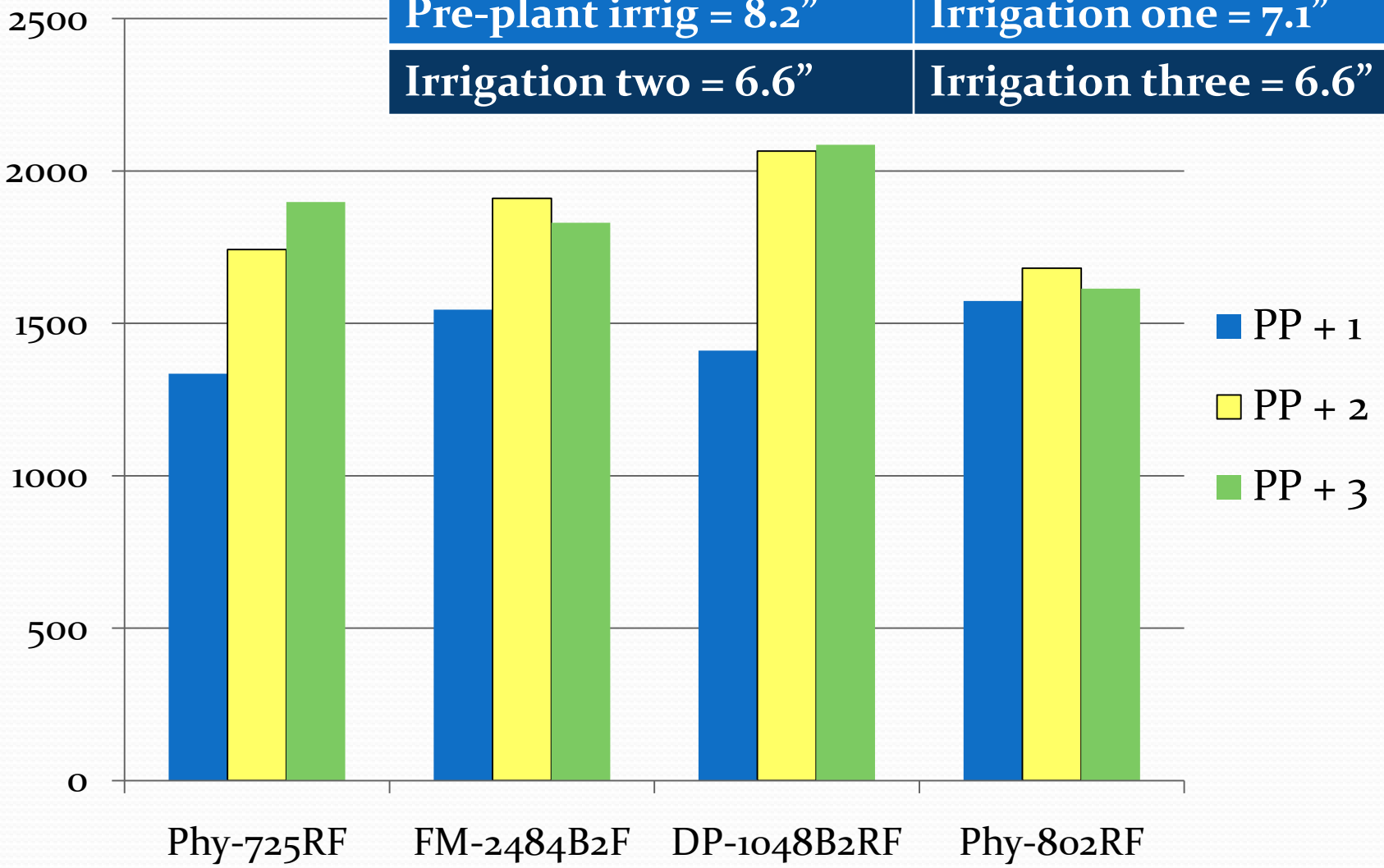
- Sometimes hard to translate delayed 1st irrig into water savings (fewer irrigations per season) but in some soils and years the potential may be there
- Plant growth components most affected by 1st irrigations initiated at closer to -20 bars LWP were: (1) reduced plant size & vigor (seen as lower NAWF at peak bloom); (2) delays in reaching closed canopy; (3) crop maturity timing (affected less in AZ, more in SJV studies)
- Supports concept that don't want to irrigate too early unless root system weak, but don't stress too much or can impact yields
- HOWEVER, yield sensitivity to LWP in range of –15 to –18 bars not too great in these studies

Deficit Furrow Irrigation Study – WSREC- 2011



Deficit Furrow Irrigation Study – WSREC- 2012

Pre-plant irrig = 8.2”	Irrigation one = 7.1”
Irrigation two = 6.6”	Irrigation three = 6.6”



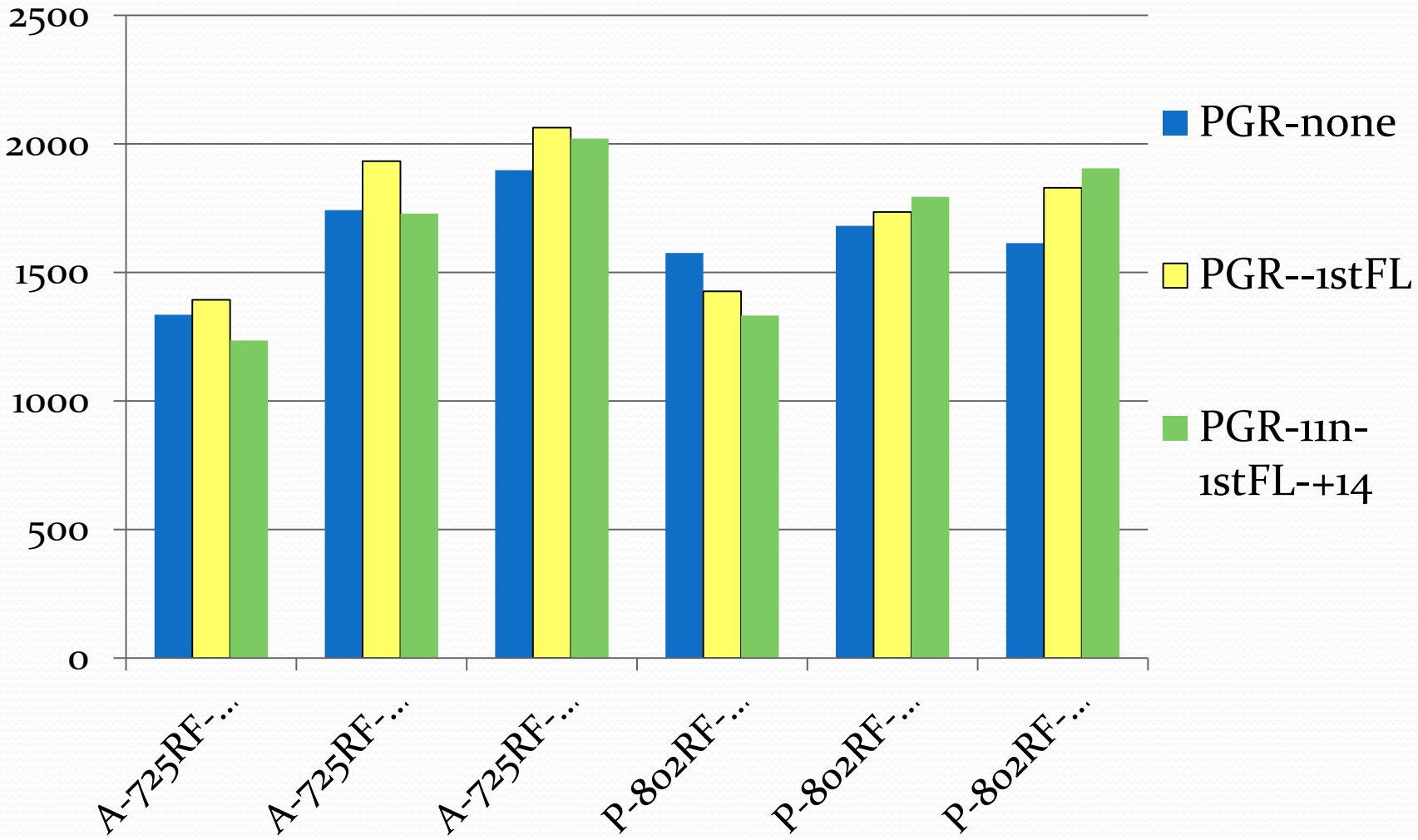
Applied, Soil Water Use, Etc – 2012 study

WSREC Furrow

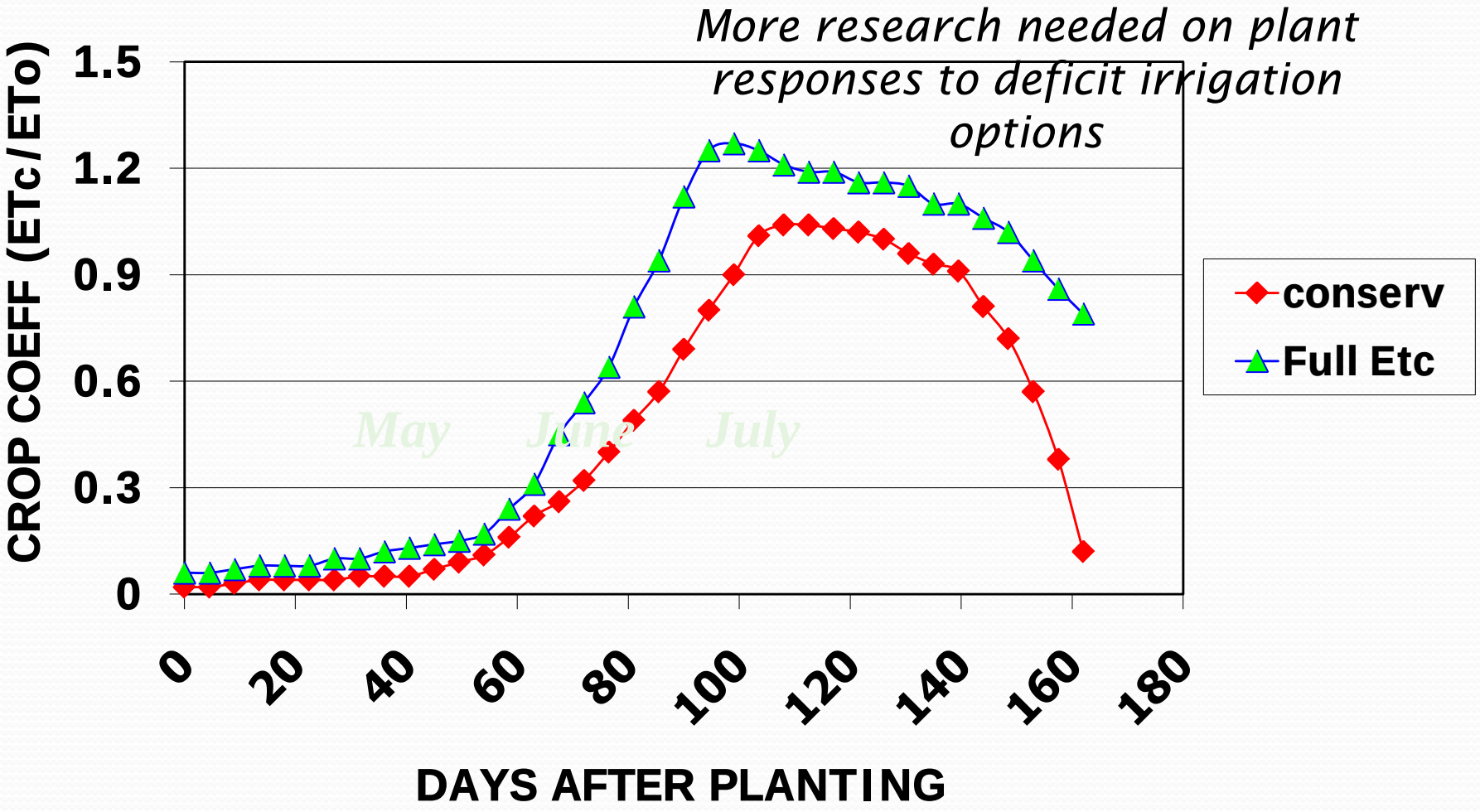
TYPE OF COTTON	PRE-PLANT IRRIG (in)	TOTAL IN-SEASON IRRIG (in)	AVERAGE SOIL WATER DEPLETED (in) – 8 ft	TOTAL ESTIMATE Etc (in)
Acala Phy-725RF				
PRE-PLANT + ONE	8.2	7.1	-14.7	**21.8**
PRE-PLANT + TWO	8.2	13.7	-10.1	**23.8**
PRE-PLANT + THREE	8.2	20.3	-6.4	**26.7**
Pima Phy-802RF				
PRE-PLANT + ONE	8.2	7.1	-14.5	**21.6**
PRE-PLANT + TWO	8.2	13.7	-11.4	**25.1**
PRE-PLANT + THREE	8.2	20.3	-7.9	**28.2**

Deficit Furrow Irrigation Study – WSREC- 2012

Phytogen 725RF and Phytogen 802RF – influence of Plant Growth Regulators at different irrig levels



Comparison of Crop Coefficients for Cotton – under SDI Irrigation - WSREC

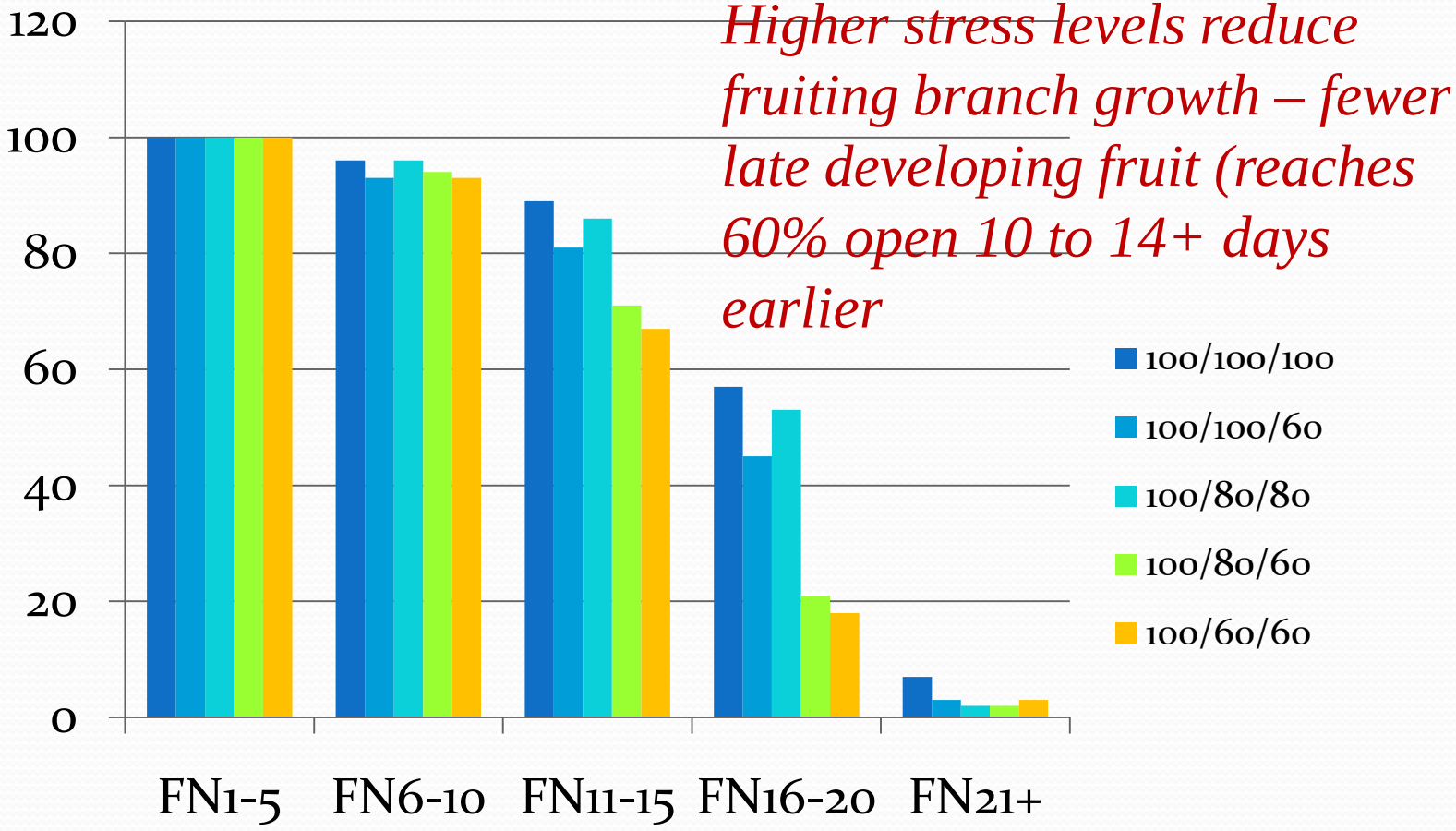


Etc treatments used in SDI Cotton Studies – WSREC

(UC Hutmacher et al) – clay loam soil, deep rooting

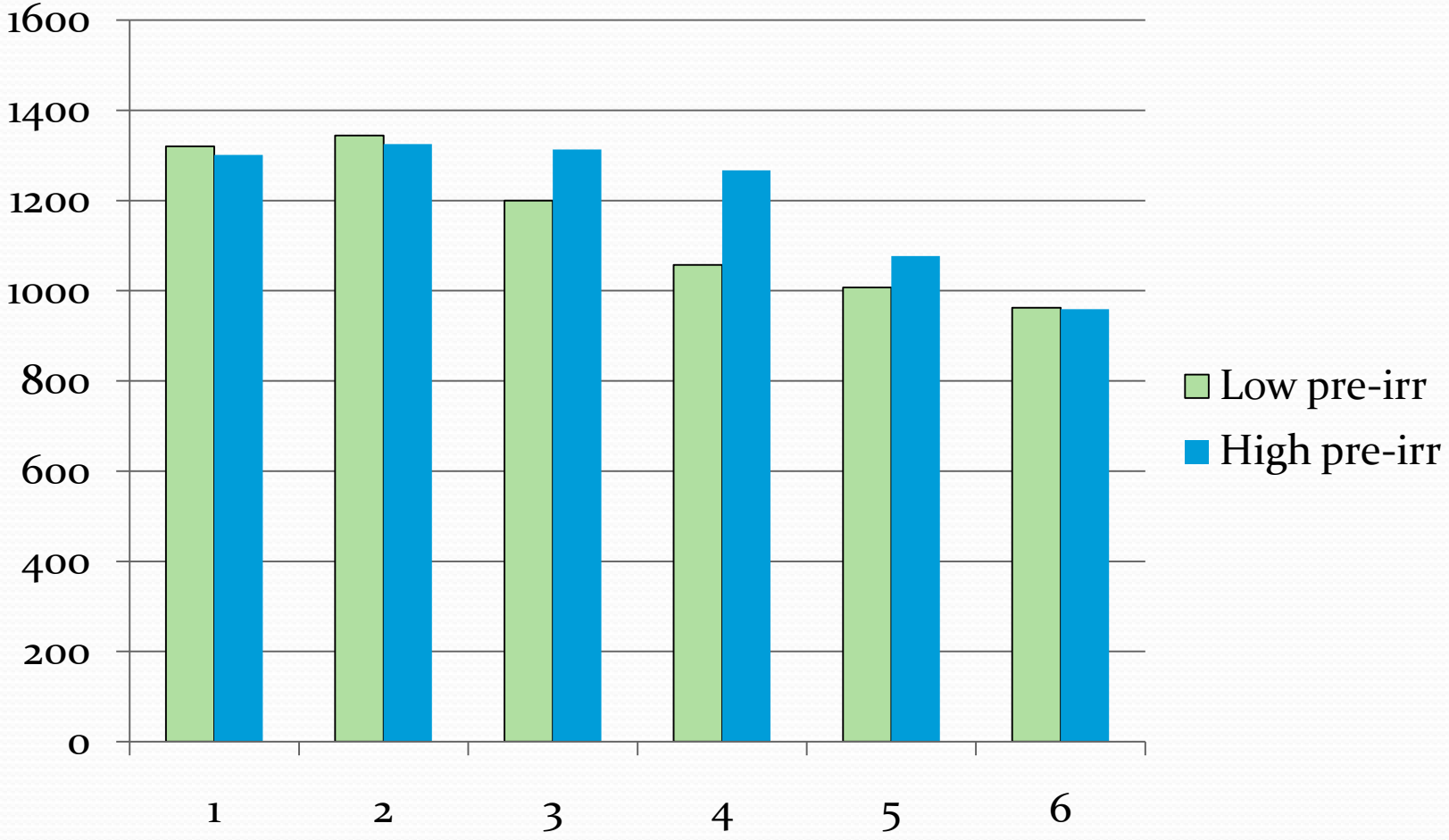
Irrigation Trt #	Irrigation Treatment Code	Irrigation Level (% Etc)		
		June Sq to early bl	July Early bl to pk bl +	August Boll fill to cutout
1	100	100	100	100
2	100/100/80	100	100	80
3	100/100/60	100	100	60
4	100/80/60	100	80	60
5	100/80/80	100	80	80
6	100/60/60	100	60	60

% of Potential Positions within Fruiting node (FN) range shown that have **FP-2 sites** – Pima SDI treatments

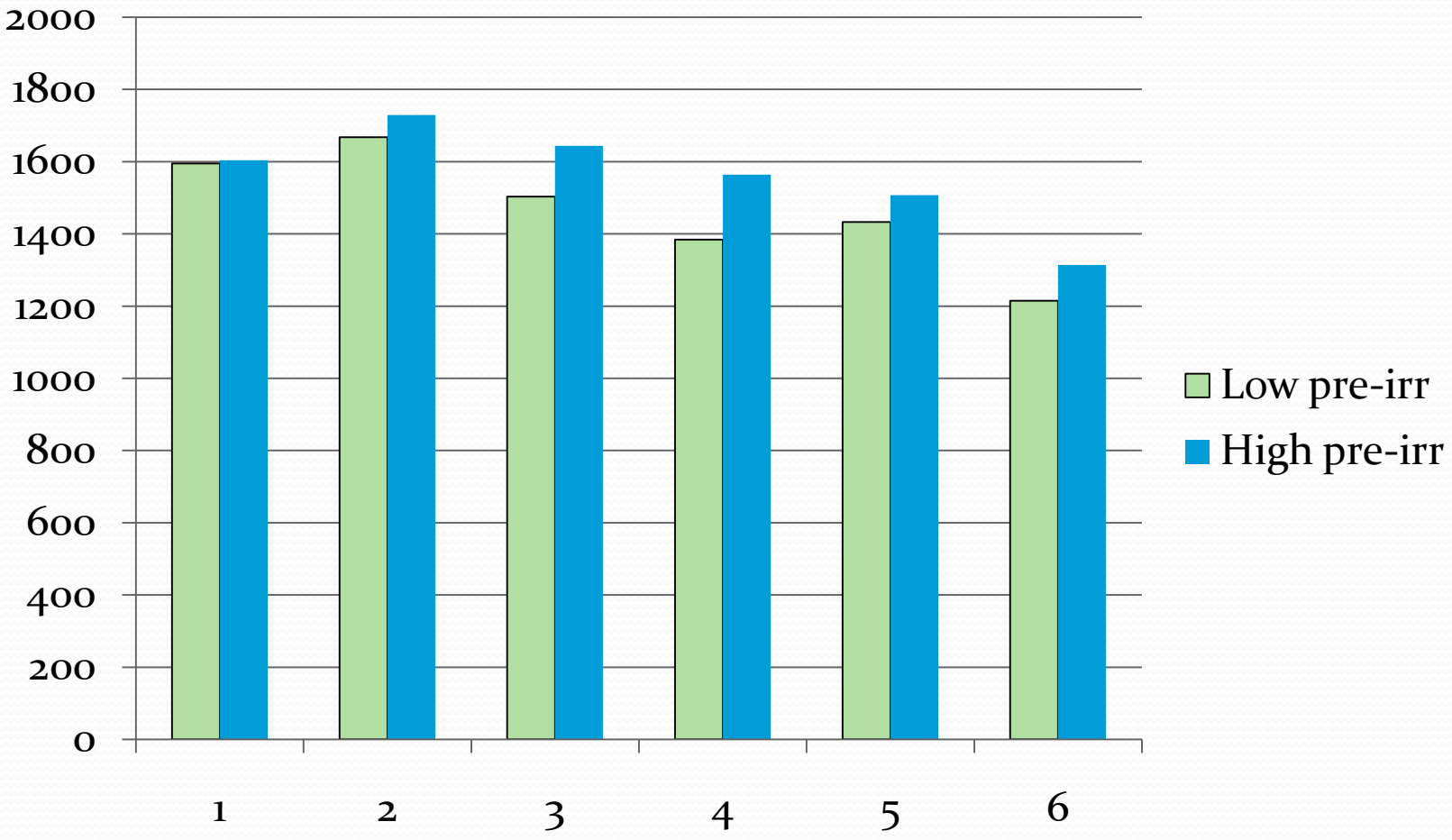


Higher stress levels reduce fruiting branch growth – fewer late developing fruit (reaches 60% open 10 to 14+ days earlier

Drip irrigation treatment responses of **Pima (Phy-805RF)** cotton – **YIELD (lbs/acre)** 2010 trial results – West Side location



Drip irrigation treatment responses of **Acala (Phy-725RF)** cotton – **YIELD (lbs/acre)** 2010 trial results – West Side REC location



Water stress impacts on fruit retention & yield

Deficit SDI Studies Summary

- Impacts on retention patterns and yield influenced by timing and duration of water stress
- high temperatures or interrupted water supplies can increase stress impacts some stages
- Deficit SDI irrigation practiced as frequent water applications at reduced amounts in our conditions produced:
  - moderate reductions in fruit retention and boll size
  - At higher stress levels, fruiting site # reduced more through impacts on stem and fruiting branch growth
- Some mild to moderate deficit irrigation combinations produce some water savings with limited impacts on yields or quality

*Deficit Drip Irrigation Treatment Effects on select hvi parameters - **ACALA -11***

Pre-Irrig Level	Irrigation Treatment	Average Mike	Average Length	Average Strength
ONE	1	4.67	1.16	33.10
	2	4.67	1.14	32.07
	3	4.60	1.16	32.33
	4	4.50	1.14	32.20
	5	4.6	1.14	31.77
	6	4.63	1.16	32.47
TWO	1	4.63	1.16	32.57
	2	4.57	1.14	32.60
	3	4.53	1.15	33.10
	4	4.47	1.14	33.40
	5	4.57	1.16	32.53
	6	4.57	1.16	33.07

2012 and 2013 SDI trial varieties tested– WSREC

Varieties included in Trials				
ACALA TRIALS	Phy-725 RF		PIMA TRIALS	Phy-802RF
	FM-2484 B2F			DP-360
	FM 1845 LLB2			Phy-PX8262 RF
	DP 1048 B2RF			Bayer T-1000 series Bayer T-9000 series

2012 and 2013 SDI irrigation treatments- WSREC

Growth Period	Trt #1	Trt #2	Trt #3	Trt #4 *(two var. only)*
	Percent of estimated evapotranspiration			
Mid-square to early bloom	80	80	80	100
Mid-bloom to vegetative cutout	100	80	60	100
Cutout to about 20% open boll	60	80	60	80

2013 irrigation treatments- WSREC

Growth Period	Trt #1	Trt #2	Trt #3	Trt #4 *(two var. only)*
	Percent of estimated evapotranspiration			
Mid-square to early bloom	80	80	80	100
Mid-bloom to vegetative cutout	100	80	60	100
Cutout to about 20% open boll	60	80	60	80
	Resulting applied water (inches)			
Mid-sq to early bl	**6.13**	**6.10**	**6.10**	**7.63**
Mid-bl to cutout	**13.44**	**10.78**	**8.10**	**13.51**
Cutout to 20% open	**4.41**	**5.87**	**4.40**	**5.88**
Total Applied	**23.98**	**22.75**	**18.6**	**27.02**

2012 irrigation treatments- WSREC

Growth Period	Trt #1	Trt #2	Trt #3	Trt #4 *(two var. only)*
	Percent of estimated evapotranspiration			
Mid-square to early bloom	80	80	80	100
Mid-bloom to vegetative cutout	100	80	60	100
Cutout to about 20% open boll	60	80	60	80
	Resulting water use by category (inches) – from planting through harvest - TOTAL			
Total drip applied	**23.1**	**22.0**	**17.9**	**26.0**
Soil water use in 8 foot profile	**4.6**	**3.9**	**5.6**	**3.5**
Total (AW + SWD)	**27.7**	**25.9**	**23.5**	**29.5**

2012 yield response to irrigation treatments- PIMA

Growth Period	Trt #1	Trt #2	Trt #3	Trt #4 *(two var.)*
	Percent of estimated evapotranspiration			
Mid-sq to early bl	80	80	80	100
Mid-bloom to vegetative cutout	100	80	60	100
Cutout to about 20% open boll	60	80	60	80
Variety	seedcotton yield (lbs/acre)			
Phy 802 RF	**5560**	**5583**	**4945**	**5640**
DP-360	**5459**	**5800**	**5431**	**-**
Phy-811 RF (8262)	**5875**	**5562**	**5354**	**-**
T1000 **T9000**	**5612** **5096**	**5461** **5422**	**4784** **4836**	**-**

2012 yield response to irrigation treatments- ACALA

Growth Period	Trt #1	Trt #2	Trt #3	Trt #4 *(two var. only)*
	Percent of estimated evapotranspiration			
Mid-sq to early bl	80	80	80	100
Mid-bloom to vegetative cutout	100	80	60	100
Cutout to about 20% open boll	60	80	60	80
Variety	seedcotton yield (lbs/acre)			
Phy-725 RF	**6296**	**5908**	**5454**	**6145**
FM-2484 B2F	**6012**	**5959**	**5305**	**-**
FM-1845 LLB2	**6225**	**6057**	**5731**	**-**
Phy 499 WRF	**6399**	**5768**	**5017**	**-**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