University of California
Agriculture and Natural Resources

Nutrient Uptake In Pima and Upland Cotton:
High Yield Conditions, Irrigation Method Impacts

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- Steve Wright; Dan Munk; Brian Marsh; Bill Weir, (UCCE Tulare and Kings, Fresno, Kern, Merced Counties
- Bruce Roberts (formerly UCCE, Kings Co.– CSU Fresno)

- **CA Dept. of Food & Agriculture – FREP program**
- **Cotton Incorporated**
- **CA Cotton Alliance**

- ✓ In California, with a long tradition of growing world-class, high-quality Acala/Upland (*Gossypium hirsutum)* cotton for decades, we have shifted to growing Pima cotton (*G. barbadense)* on over 80% of our cotton acreage

- ✓ Most prior UC research experience with nitrogen management has been with Acala varieties. In the past decade, however, we have at least started to look into Pima cotton responses to N management, mostly as side-projects within trials directed toward evaluating cultivar differences or irrigation responses.

- ✓ With increasing concerns regarding efficiency in use of Nitrogen in crop production, it will become more important to better understand if Pima and Upland cotton differ in N management responses.

Over multiple years, we conducted irrigation trials with different varieties/ types of cotton (Pima and Upland/Acala types) **and used these same studies to begin to evaluate N uptake** (also P and K to a limited degree, but not discussed here)

Some studies done at West Side REC (clay loam) in Fresno Co.

- have done series of deficit and fully irrigated cotton trials with a few Pima and Upland/Acala varieties to compare responses

- the deficit treatments have been produced by reducing amounts of applied water in mid and late season (drip) or by delaying irrigations and eliminating the final irrigation in furrow plots

- all have been what we considered adequately fertilized, with about 145 to 170 lbs N/acre applied (split application in furrow plots, injected in drip plots)

- applied fertilizer amounts have been adjusted for residual soil NO3-N in the upper 2 feet of soil

Fertilizer application patterns used – furrow versus SDI

All plots (furrow and SDI irrigated) received a 200 lbs/ac application of 11-52-0 (for startup N, non-limiting P levels); adjusting for pre-plant soil residual NO3-N in the upper 2 feet

FURROW IRRIGATED PLOTS:

- N fertilizer split into two applications: (1st) applied prior to planting at rate of 50-60 lbs N/ac; and (2nd) applied at rate of 90-110 lbs/ac prior to the first or second within-season irrigation during late squaring (between about 65-80 days after emergence)

SDI IRRIGATED PLOTS:

- applications started early-squaring stage (about 40 dae), increased each week so that 85% of full 140-170 lb/ac target was applied by 100-110 dae (corresponds with peak bloom period). Remainder applied prior to 130 dae (close to vegetative cutout)

Many efforts nationwide over the years (including in CA) have evaluated the utility of cotton petiole NO3-N or leaf blade total N content as predictors of plant nutrient status, and likelihood of responses to supplemental N

Petiole NO3-N Evaluations in CA
can be a useful part of feed-back information for management

Most consistent data:
typically has been between late squaring & 4 weeks after 1st bloom

- With residual soil NO3-N of >60-70 lbs N/acre top 2 ft, petiole NO3 data had little sensitivity when lint yields <1200 lbs/acre

- At lower residual soil N or with yields > 1400 lbs per acre, utility of petiole data improves

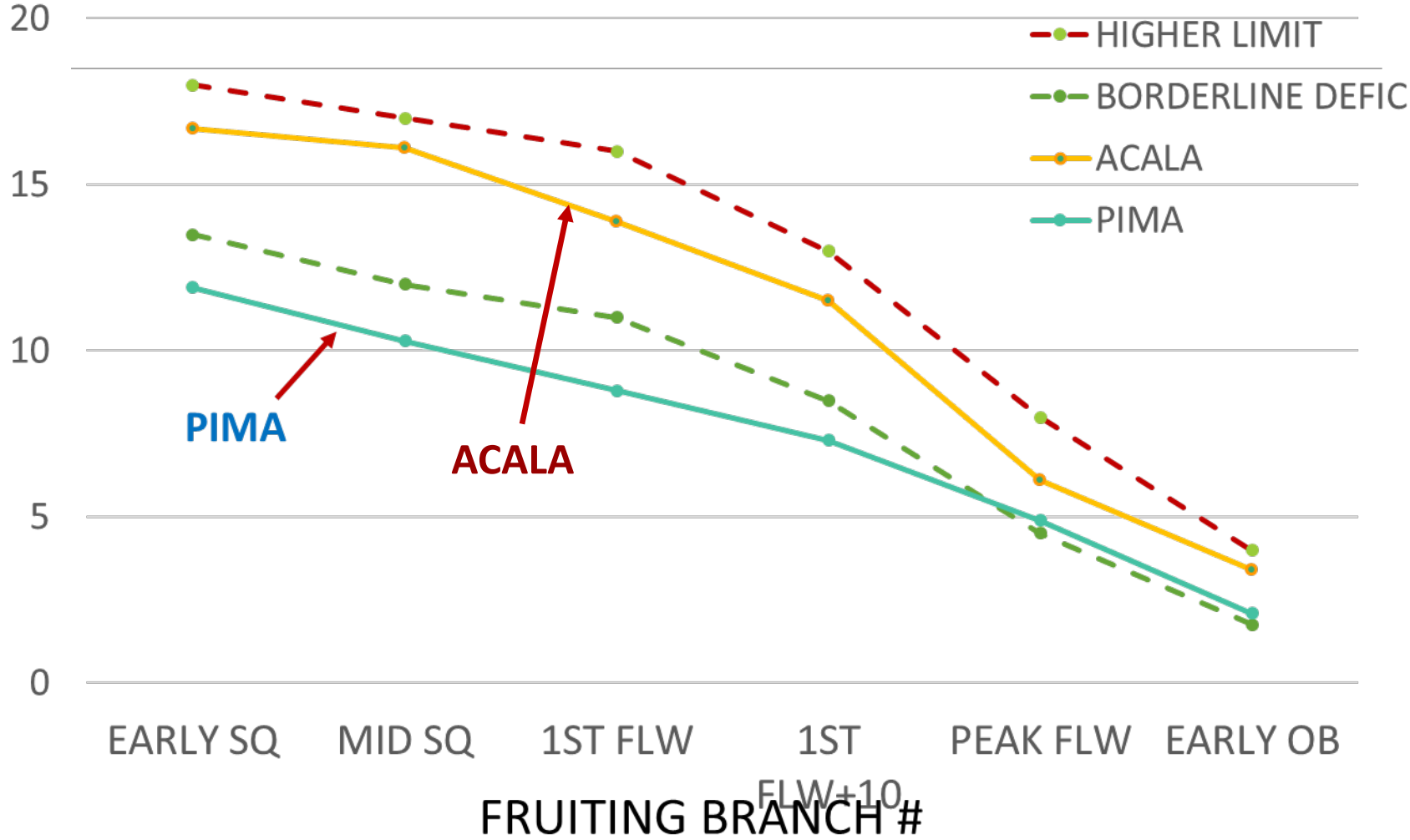
***Observation:**

- with split applications or low-rate frequent nutrient applications, particularly with SDI irrigation, lower early bloom petiole NO3-N numbers can still be ok

Cotton – WSREC - *53 lbs N/ac top 3 ft of soil, 40 lbs pre-plant fertilizer*

Pima Yields (Furrow = 1840 lbs/acre)

Acala Yields (Furrow = 2011 lbs/acre)



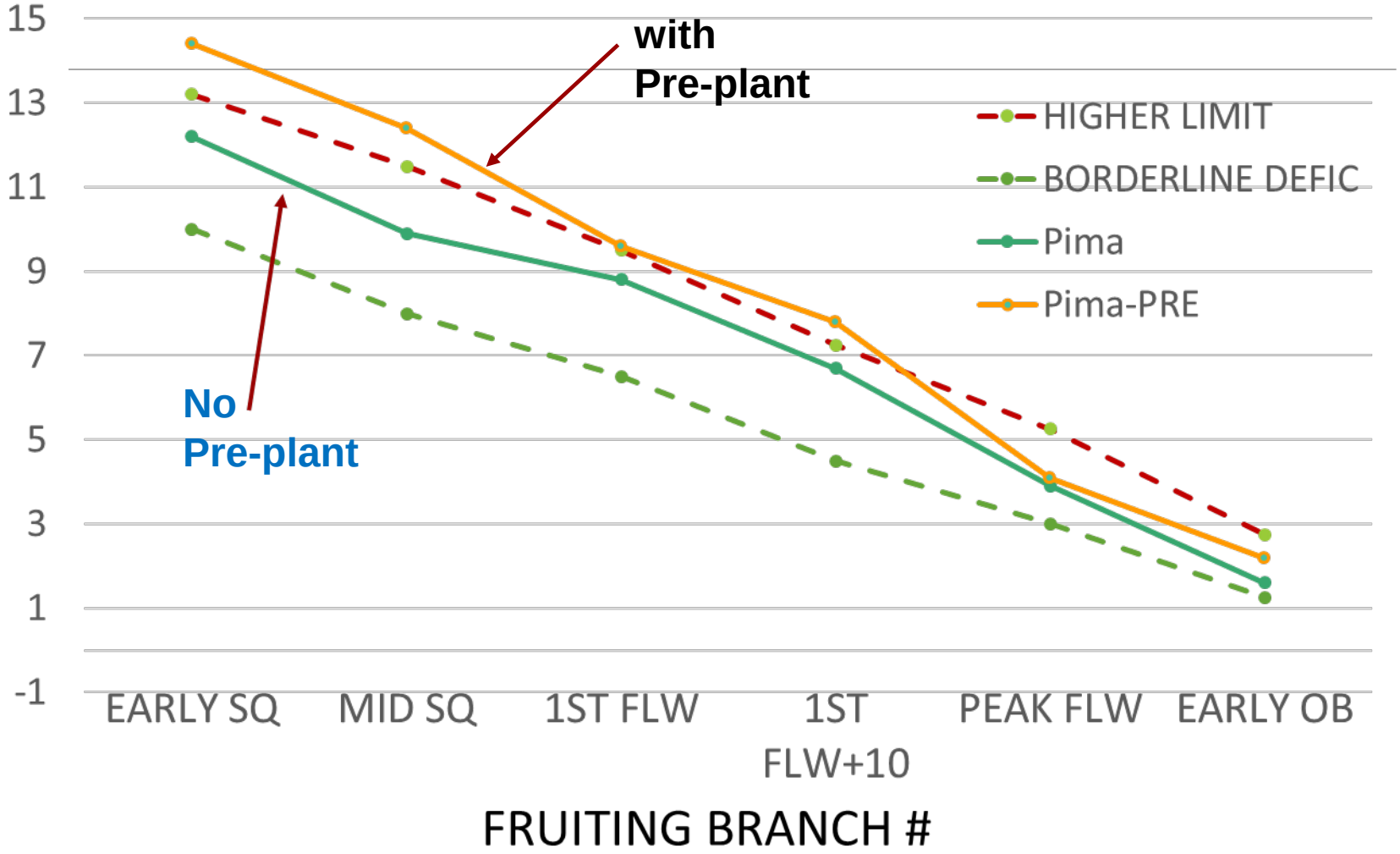
Nitrate (NO3-N) petiole guidelines *(UCCE – Hutmacher) /University of CA (2016 version)*

Petiole Nitrate (NO3-N) – in ppm				
	Upland Cotton		**Pima Cotton**	
Growth Stage	*Borderline to Deficient*	*Sufficient Upper Level*	*Borderline to Deficient*	*Sufficient Upper Level*
Early square	<13-14,000	>17-20,000	<10,000	>12-14,000
1st flower	<10-12,000	14-18,000	<6-7,000	>8-10,000
1st flower + 10 days	<7000-10,000	12,000-14,000	<4,000-5,000	>6,500-8,000
Peak bloom	<3,500-5,500	>7,000-9,000	<2,500-3,500	>4,500-6,000
Early open boll	<1,500-2,000	>3,500-4,500	<1,000-1,500	>2,500-3,000
10-15 days after cutout	<750-1,200	>1,500-2,000	<750-1,000	>1,250-1,500

Cotton – WSREC - *37 lbs N/ac top 3 ft of soil;* ***150 lbs total fertilizer N***

Pima Yield (SDI = 1848 lbs/acre); 150 lbs N/ac fertigated

Pima Yield (SDI with 60 lbs/ac pre-plant, 90 lbs in-season = 1870 lbs/acre)



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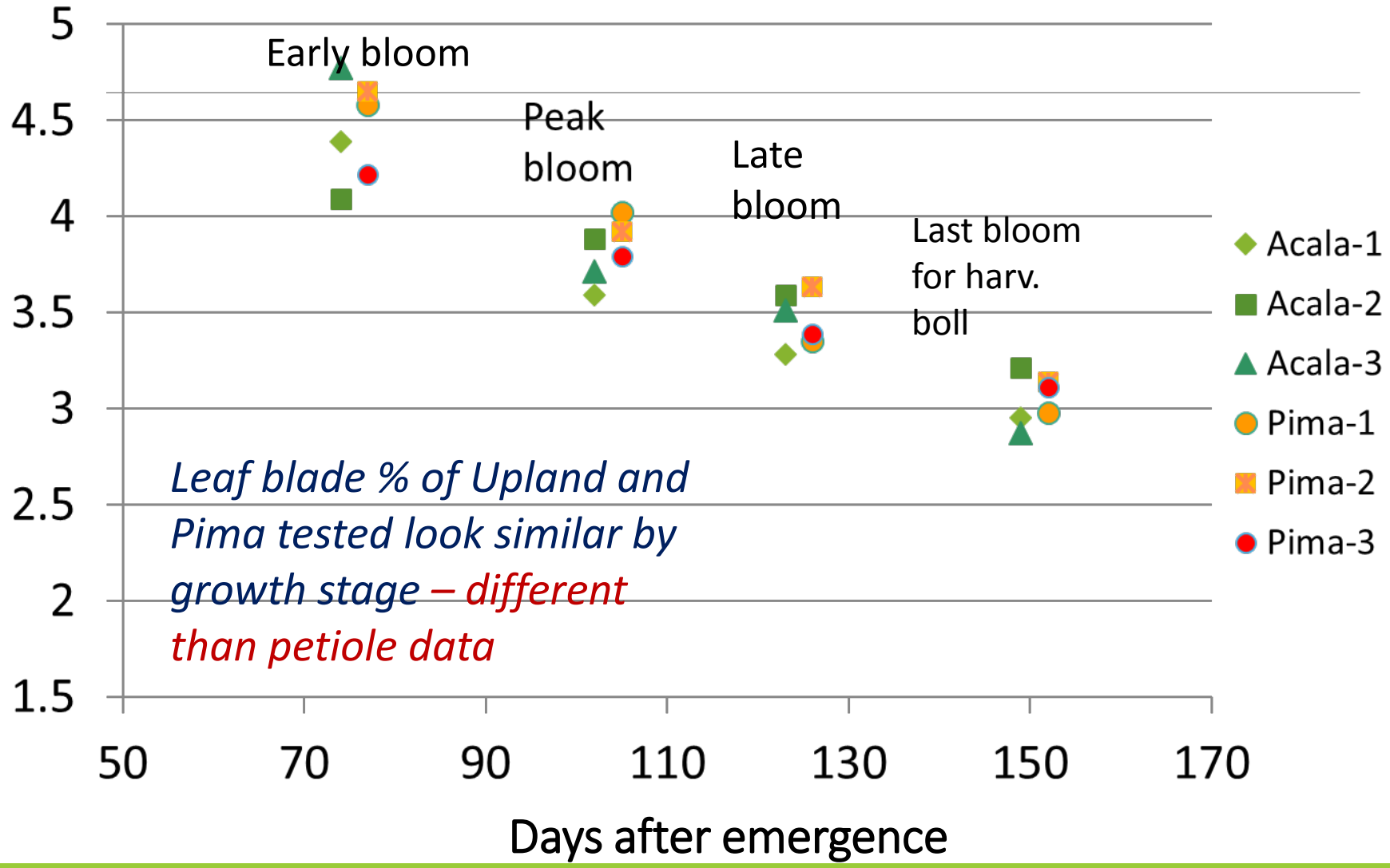
** Experiences with fertigated SDI (drip) cotton are that lower end of ranges shown are adequate & higher values in ranges are more typical for split-fertilized furrow irrig cotton*

Leaf N conc (%) as affected by 3 irrigation trts and DAE (average across three expts each Acala and Pima)



Additional questions relate to **total plant N uptake?** (total above-ground plant uptake) and **N removal with harvest** (what is taken off the field with harvest?)

Components of Nitrogen Management Plans required at the field level / management unit level

Components of nitrogen management plans include:

- planting dates, yield goals and attained yield

- estimate of residual N

- estimate of N likely to be available from irrigation water, N released from organic matter or manure applications

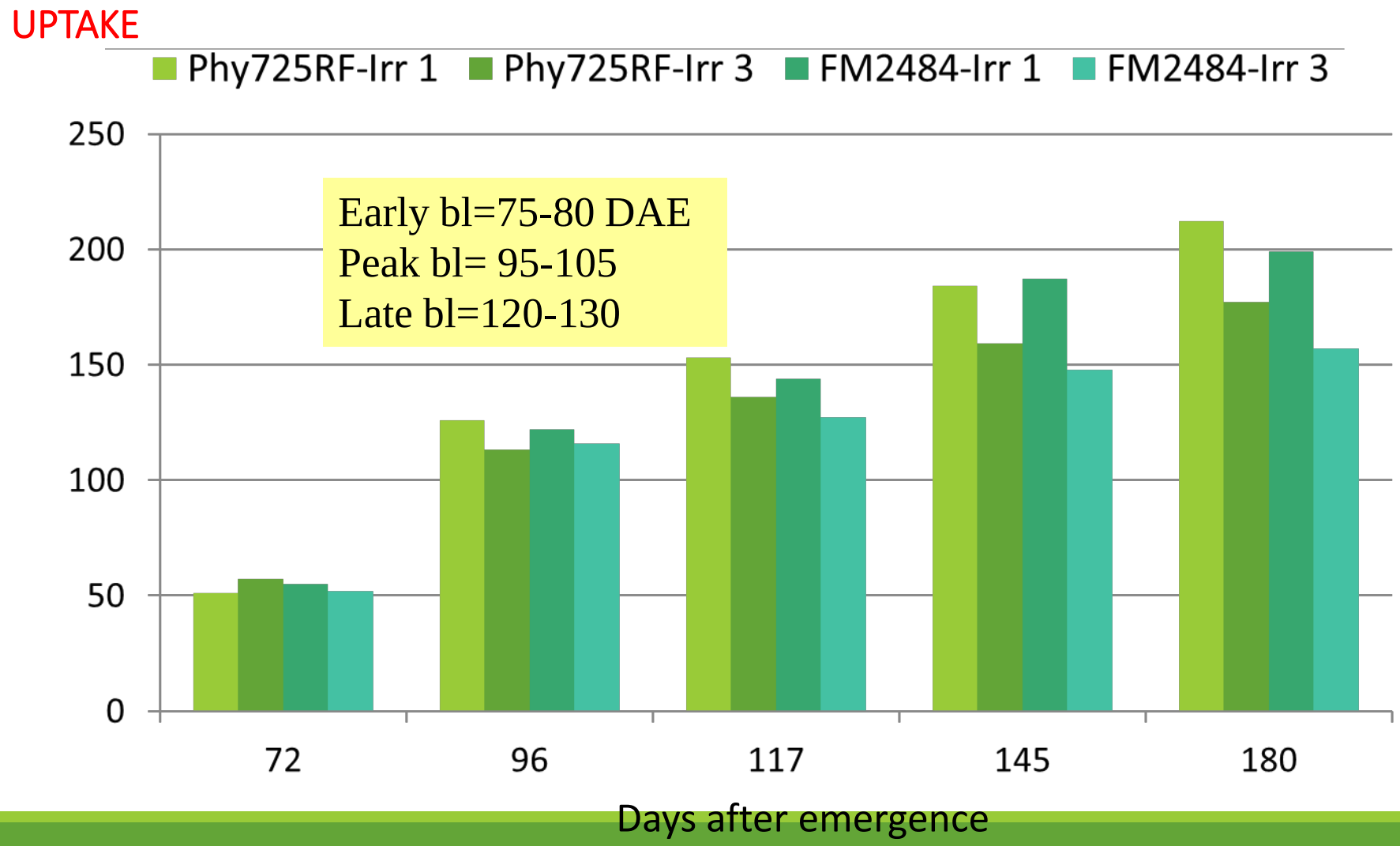
-One of the potential issues and difficulties with the N Mgmt Plan requirements is to provide sound estimates of

-**Nitrogen removed with harvested crop**

* *As stated …. we have not run N management studies yet directly to estimate N removal, but have some limited data from other trials*

NITROGEN UPTAKE above-ground plant parts (lbs/ac) as a function of days after planting – Drip Irrigated UPLAND varieties – 2013 DEFICIT IRRIGATION TRTS

Yields Irrig Trt 1 = 2141, 2051 lbs/ac Irrig Trt 3 = 1502, 1678 lbs/ac



NITROGEN UPTAKE PER 100 lb/ac of LINT YIELD

above-ground plant parts (lb/ac) per 100 lb/ac lint yield –

Drip Irrigated UPLAND varieties – 2013 FULL & DEFICIT IRRIGATION TREATMENTS

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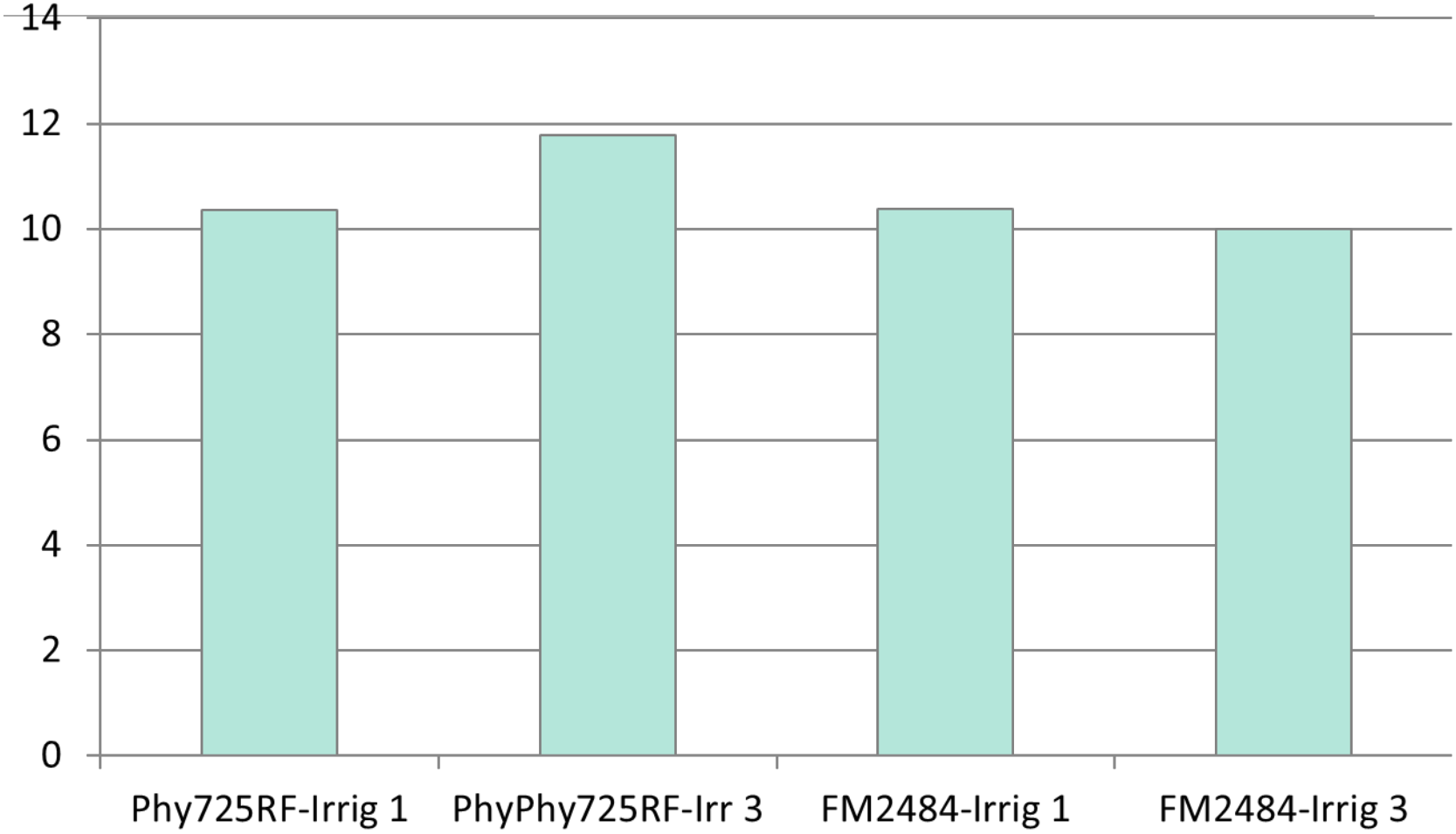
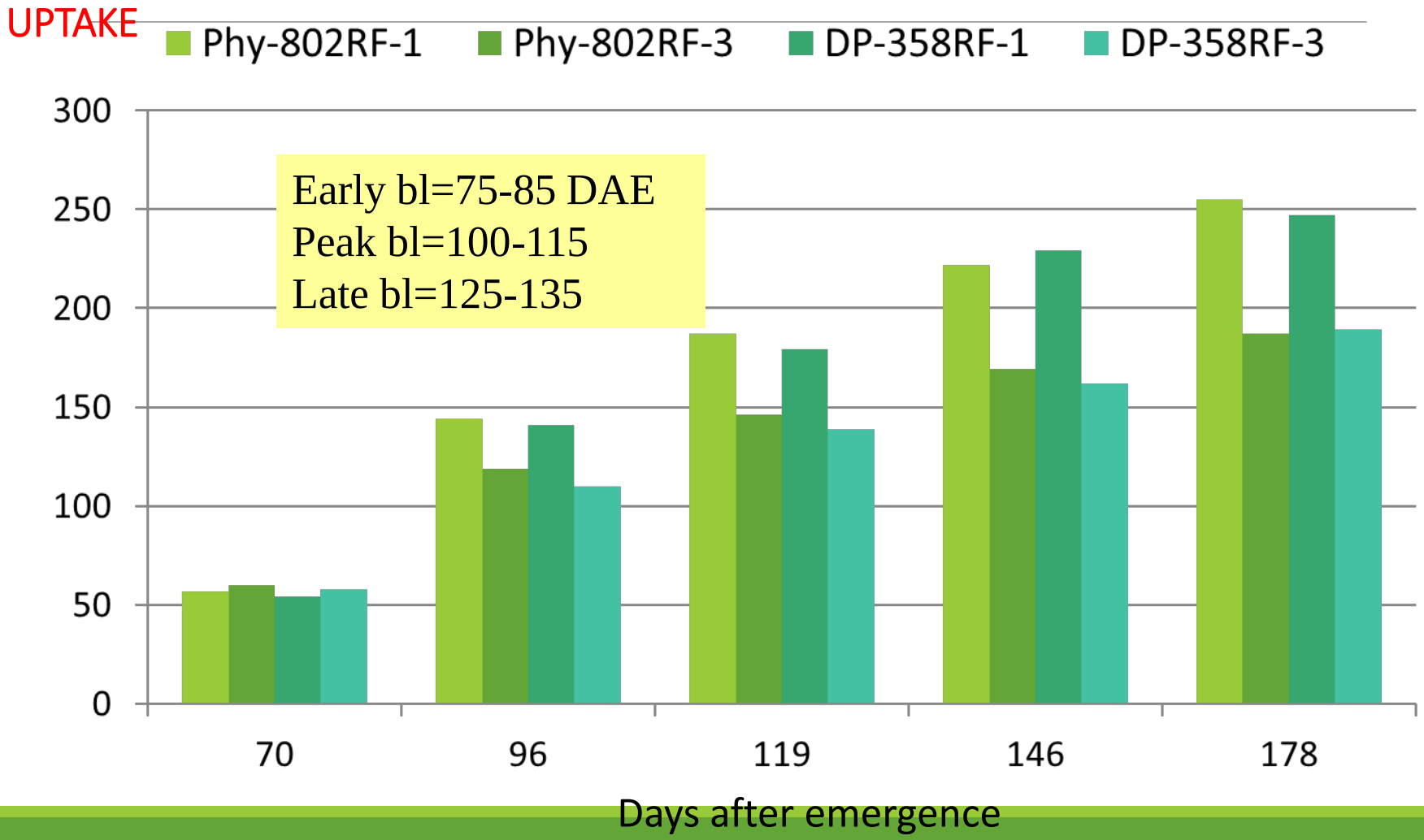


NITROGEN UPTAKE above-ground plant parts (lbs/ac) as a function of days after planting – Drip Irrigated PIMA varieties – 2014 DEFICIT IRRIGATION TREATMENTS

Yields Irrig Trt 1 = 1944, 2031 lbs/ac Irrig Trt 3 = 1660, 1619 lbs/ac

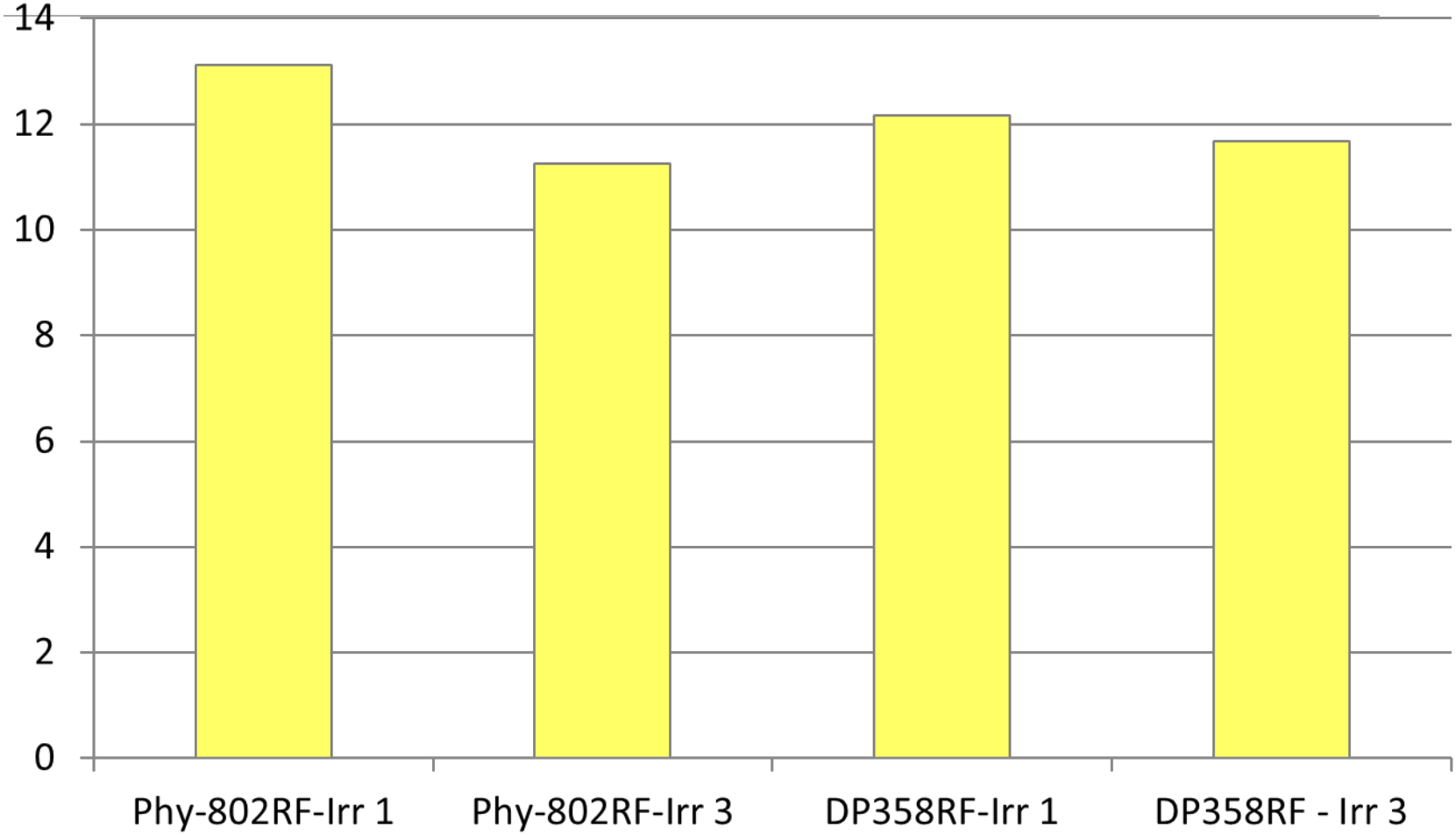


NITROGEN UPTAKE PER 100 lb/ac of LINT YIELD

above-ground plant parts (lb/ac) per 100 lb/ac lint yield –

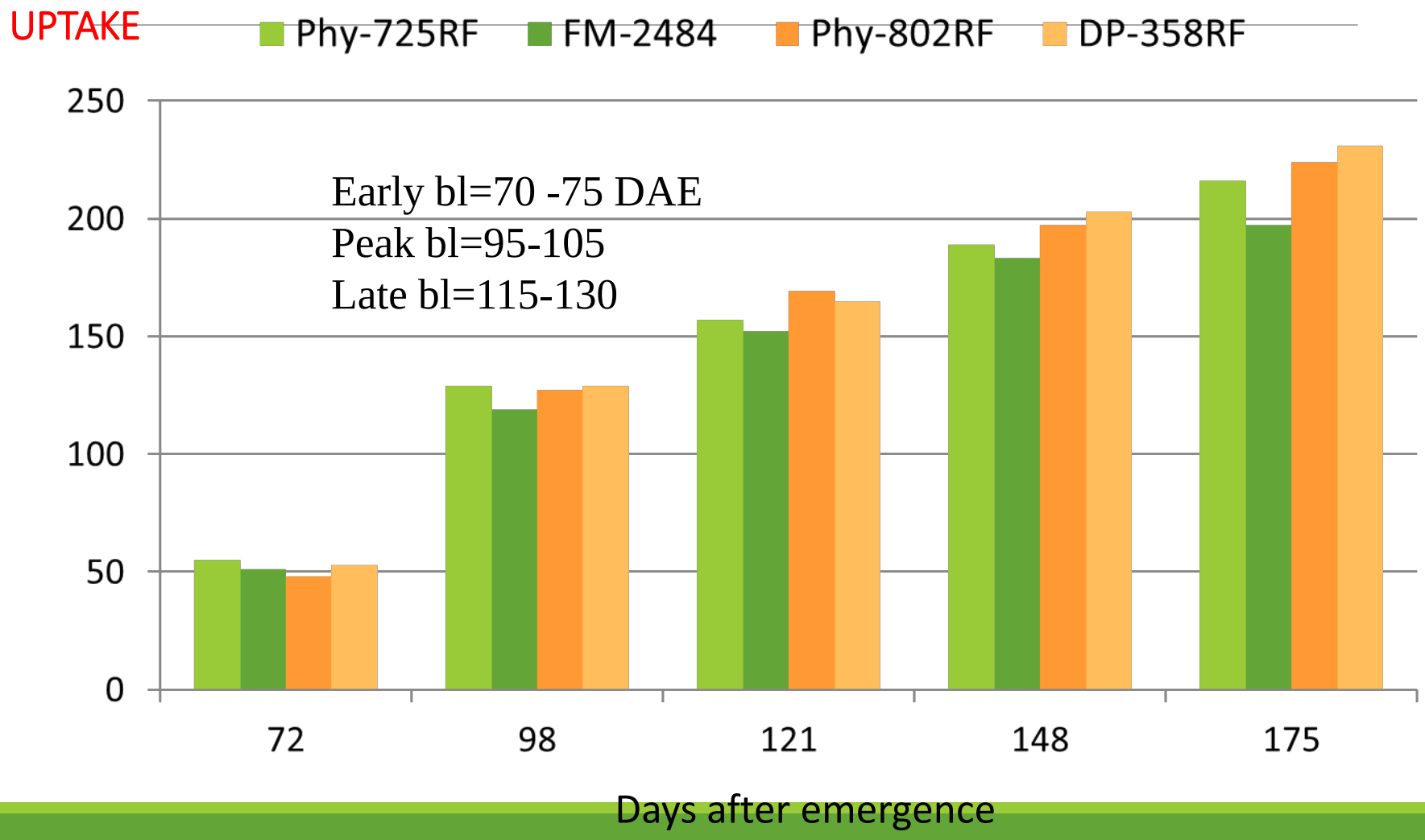
Drip Irrigated PIMA varieties – 2014 FULL & DEFICIT IRRIGATION TREATMENTS

Yields Irrig Trt 1 = 1887, 1940 lbs/ac Irrig Trt 3 = 1710, 1679 lbs/ac



NITROGEN UPTAKE – above ground plant parts (lbs/ac) as a function of days after planting – Furrow-Irrigated ACALA and PIMA – 2015

Yields Acala = 1956, 2158 lbs/ac Pima = 1972, 1839 lbs/ac

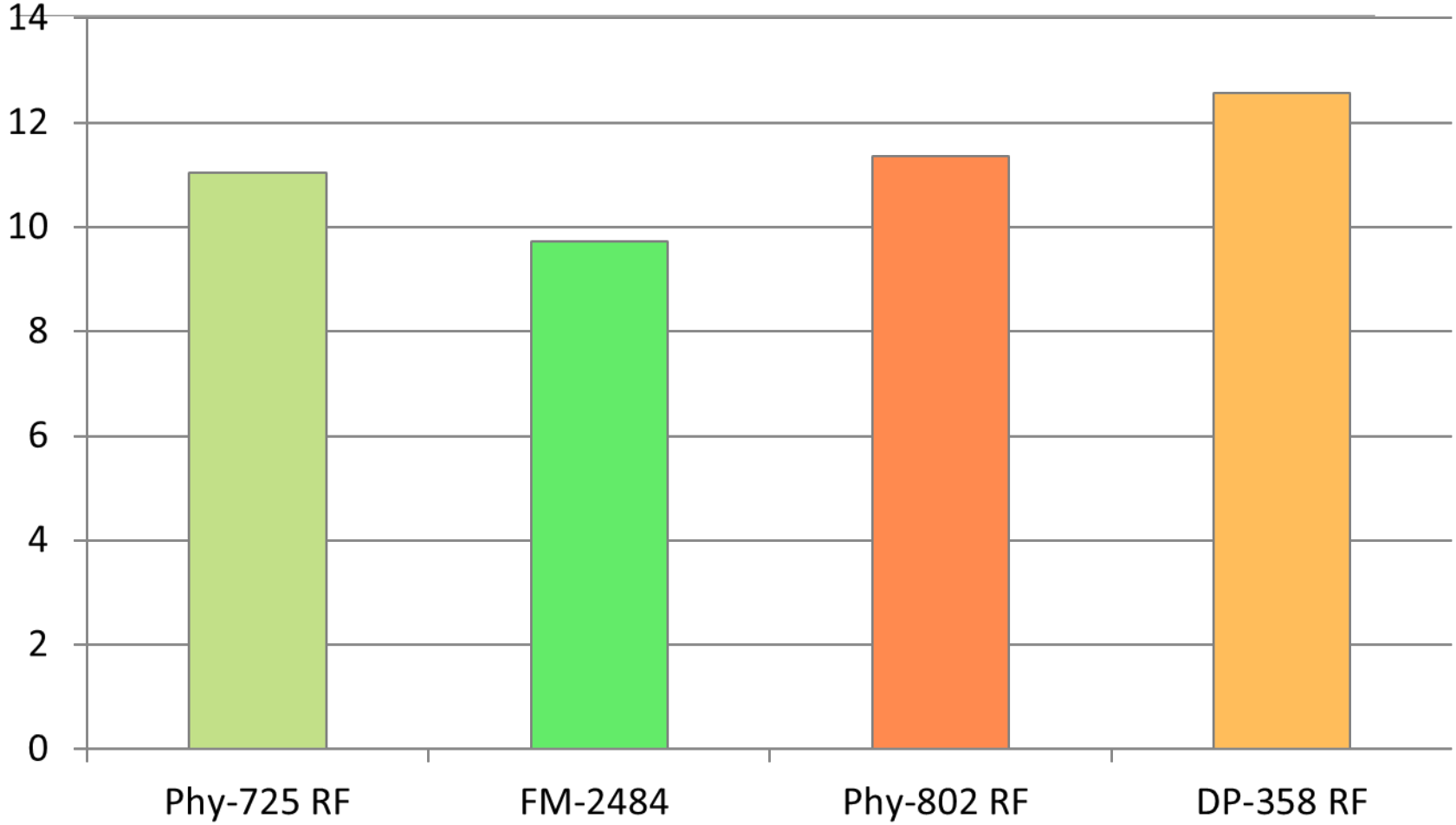


NITROGEN UPTAKE PER 100 lb/ac of LINT YIELD

above-ground plant parts (lb/ac) per 100 lb/ac lint yield –

Furrow Irrigated UPLAND AND PIMA varieties – 2014 FULL IRRIGATION TRTS

Yields Acala / Uplands = 2158, 1956 lbs/ac Pima = 1972, 1839 lbs/ac



Above Ground Plant Nitrogen Uptake (lb/ac)

Cultivar / Type	Irrigation Level	Irrigation Method	Lint Yield (lb/ac)	N uptake (lb) per 100 lb/ac yield
Phy-802 Pima	Deficit (60%)	Drip	1386	13.0
		Furrow	1323	12.5
	Full	Drip	1874	14.2
		Furrow	1762	13.4
Phy-725 Acala	Deficit	Drip	1507	12.4
		Furrow	1386	11.8
	Full	Drip	1772	13.2
		Furrow	2121	12.7
FM-1830 Upl	Deficit	Drip	1501	11.8
		Furrow	1416	11.4
	Full	Drip	2012	12.5
		Furrow	1818	12.8

DRIP Uplands NS vs Stress

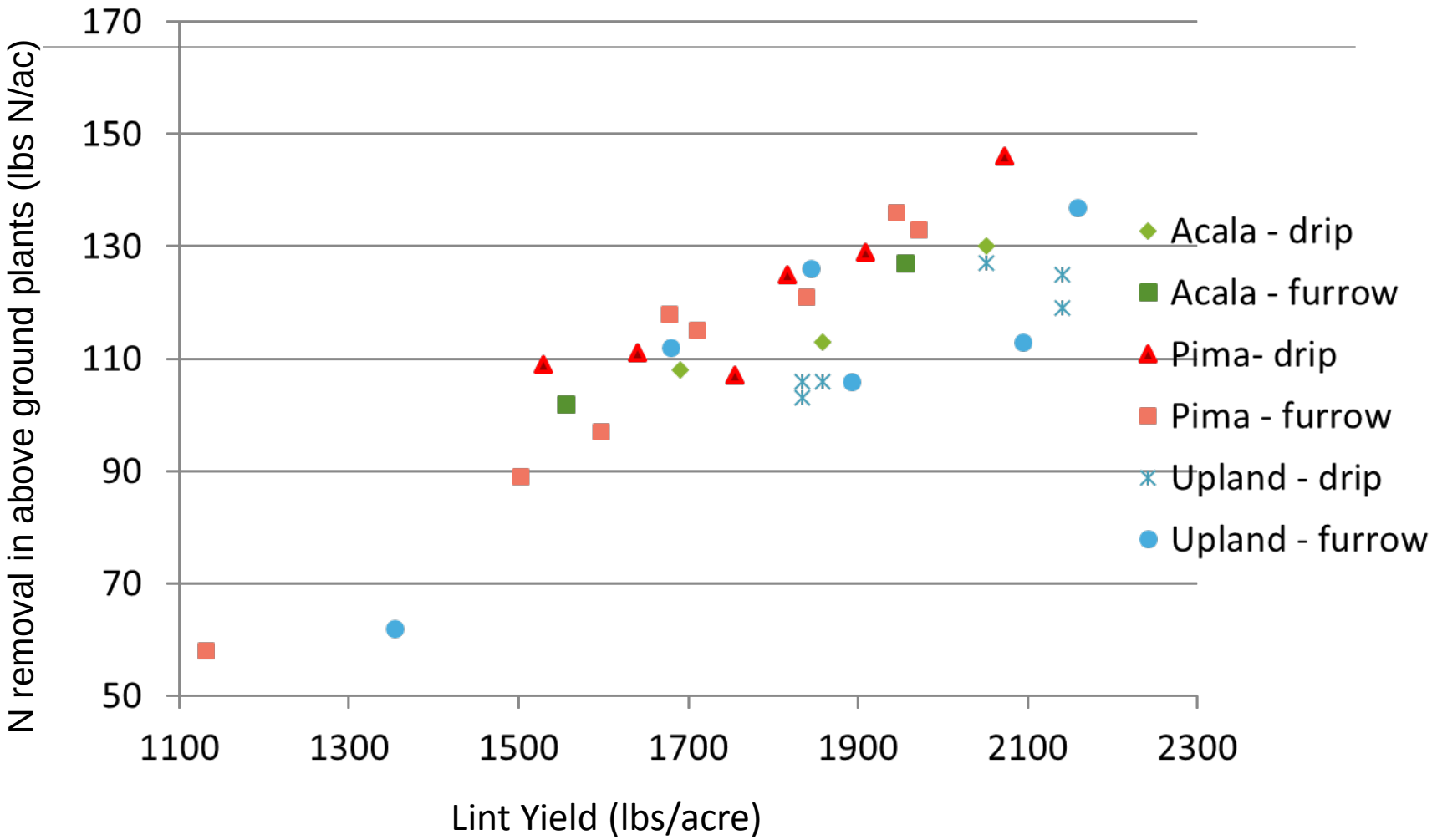
ENTRY	DRIP IRRIG TRTS (2013)	YIELD (lbs/acre)	190 DA Emerge HARVEST REMOVAL (lbs Nitrogen/acre)
Phy-725RF	Trt 1 (well watered) – non stressed	2051 (37 lint % crop)	**127** **3.6% N in seed** **46 lb N/T sc** **31 lbs N/bale**
Phy-725 RF	Trt 3 (mid-late season delays)	1858 (39 lint % crop)	**106** **3.65% N in seed** **44 lbs N/T sc** **29 lbs N/bale**
FM 2484 B2F	Trt 1 (well watered) – non stressed	2141 (38 lint % crop)	**119** **3.41% N in seed** **42 lbs N/T sc** **28 lbs N/bale**
FM 2484 B2F	Trt 3 (mid-late delays)	1834 (40 lint % crop)	**103** **3.74% N in seed** **41 lbs N/T sc** **28 lbs N/bale**

Furrow
Uplands & Pima – NS vs Stress

ENTRY	FURROW IRRIG TRTS (2016)	YIELD (lbs/acre)	190 DA Emerge HARVEST REMOVAL (lbs N/acre)
Phy-764WRF *Acala*	Trt 1 (well watered)	2094 (41 lint % crop)	**113** **3.74% N in seed** **44 lb-N/T sc 27lbs/bale**
Phy-764WRF *Acala*	Trt 2 (late stress)	1892 (39 lint % crop)	**106** **3.59% N in seed** **43 lb N/T sc 28 lbs/bale**
Phy-764WRF *Acala*	Trt 3 (mid-late stress)	1354 (42 lint % crop)	**67** **3.82% N in seed** **41 lb N/T sc 25 lbs/bale**
Phy-802RF Pima	Trt 1 (well watered)	1597 (39 lint % crop)	**97** **3.88% N in seed** **47 lb N/T sc 30 lbs/bale**
Phy-802RF Pima	Trt 2 (late stress)	1502 (39 lint % crop)	**89** **3.79% N in seed** **46 lb N/T sc 30 lbs/bale**
Phy-802 RF Pima	Trt 3(mid-late stress)	1131 (41 lint % crop)	**58** **3.55% N in seed** **42 lb N/T sc 26 lbs/bale**

Cotton – UC WSREC studies

N Removal (lbs N/acre) as a function of lint yield, cotton type and irrigation method



SUMMARY:
Similarities and Differences Pima versus Uplands

Petiole NO3-N levels for sufficiency and borderline deficiency differ markedly between Pima and Uplands (Pima levels about 30-40% lower under same conditions as Uplands)

Leaf blade total N concentration ranges of non-stressed, moderate to higher fertility cotton very similar in Pima and Upland cottons

Under mild deficit irrigation and about 3 bale/ac yields, average per-harvest **above-ground N uptake** totaled about 160-185 lbs N/acre

At yield levels about 4 bales+/acre under full irrigation, **average above ground N uptake** totaled about 195-260 lbs/acre, with some tendency toward 5-15% higher uptake in Pima at similar yields

SUMMARY:
Similarities and Differences Pima versus Uplands

N uptake per 100 lbs/ac of lint yield is one way to look at the relationship of N to one measure of yield

- In evaluations to date, the ratio was generally a little higher with Pima (about 11.5 -13 vs. 10 – 12.3 for Upland), and generally a little higher with full irrigation than with deficit (11.4 to 13 vs. 12.5 to 14)

N removal with harvest estimates in this limited data set ranged from about 25 lbs/bale to 31 lbs/bale, with no clear differences between Upland and Pima types of cotton in this data.

*Speculation might be that lint percent & seed size differences between cultivars may be greater determinants of N removal per bale of lint than type of cotton alone??

Studies will continue … goal is to measure a range of field-determined values for plant N uptake and N per unit yield … in part to deal with the idea that there is one value that can be applied to all cotton production situations (PIMA versus UPLANDS)

Even with this approach … consider that there will be …

CONDITIONS WHERE N MANAGEMENT BECOMES MORE DIFFICULT *including :*

1. poor fruit retention / particularly if combined with vigorous vegetative growth
2. late-planted, re-planted cotton fields with a tendency toward vegetative growth
3. previous crops heavily fertilized, with high residual N
4. high irrigation water NO3-N
5. Reduced early fertilizer N application with subsequent very good fruit set
6. *All these situations promote need for more feedback info to do good N mgmt … <u>not less feedback</u>*

Thank you

Support for Cotton N Studies was from:

1) CA State Support Committee, Cotton incorporated
2) CDFA Fertilizer Research and Education Program (FREP)
3) CA Cotton Growers and Ginners
4) CA Cotton Alliance
5) University of CA West Side REC / UC Davis Plant Sci Dept