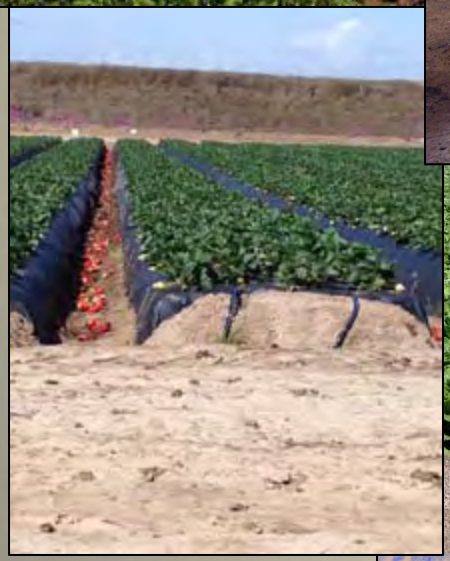
Water and Nitrogen Management:

Adapting to Field Level Conditions and Constraints



Water and Nitrogen Management

Regional issues and regulatory environment

Focus increasing on GW and identification of GW 'risk' areas due to farm production practices

Increasing attention to drinking water quality and landowner-grower actions

Required calculation and reporting of nitrogen (N) applications from irrigation water

For some growers, requirements for submission of water and N fertilizer applications, and toxicity, salinity, and N monitoring of surface discharges to impaired water bodies

Emphasis on grower reporting of Management Practice Implementation, Assessment, and Outcomes

What Type of Monitoring and Assessment is Most Relevant to Growers?

What Type of Monitoring is Most Relevant to Growers?

OPTIMAL Nitrogen Fertilizer and Irrigation Management = HIGH Production Efficiency

- Improved crop yields and quality? ($$)
- Reduced costs ($$) for water and fertilizers
- Less energy consumption ($$)
- Reduced potential for surface and groundwater contamination

Demonstration and Evaluation of Soil Nitrate Quick Test (2001)

FREP-funded project with 8 cooperating growers

Demonstration was part of a water district mobile lab program

Included cool and warm season crops, both sprinkler and drip irrigated

Integrated soil nitrate results with petiole nitrate and leaf N analysis

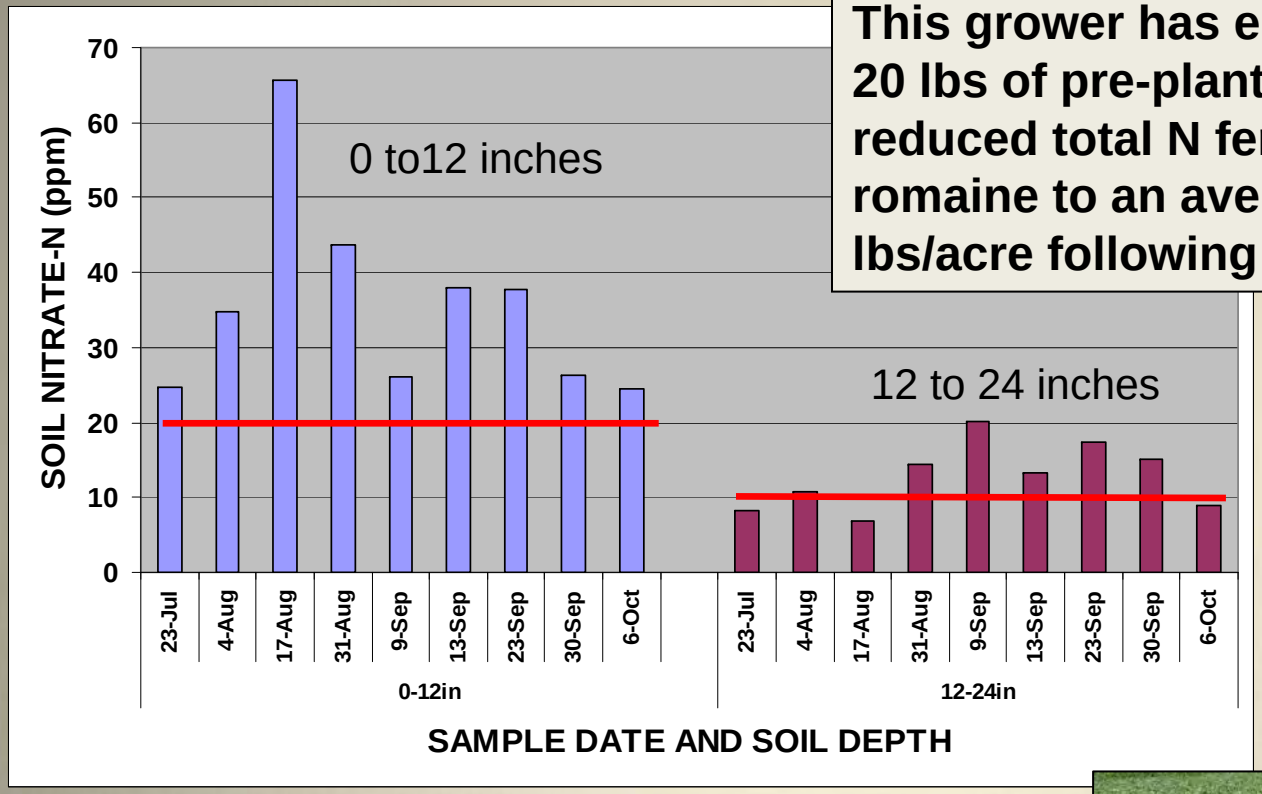
<u>Outcomes</u>

Three growers made changes to fertilization programs, citing significant cost savings

While growers found value in the information, most indicated that **logistical issues** were a challenge

- Time and oversight required ($$)
- Lack of educated or trained personnel
- Driving distance and coordination challenges between fields or ranches
- Conflicts with fertilizer applicator

Matching N Application to Crop Need



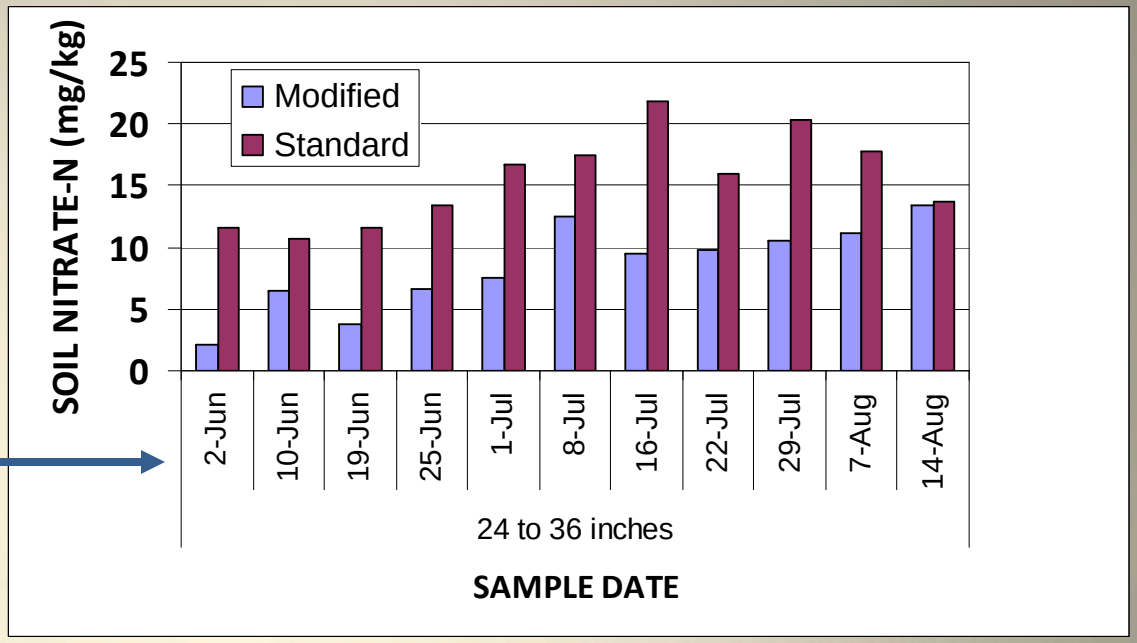
This grower has eliminated the 20 lbs of pre-plant N and reduced total N fertilizer for romaine to an average of 85 lbs/acre following 1st crop

Grower adapted the soil nitrate quick test method, trained irrigation foreman, and maintains field records

Grower Practice Evaluation

Adaptation and full implementation required a slow incremental process

Grower was interested to assess the potential impact on nitrate dynamics below crop root zone

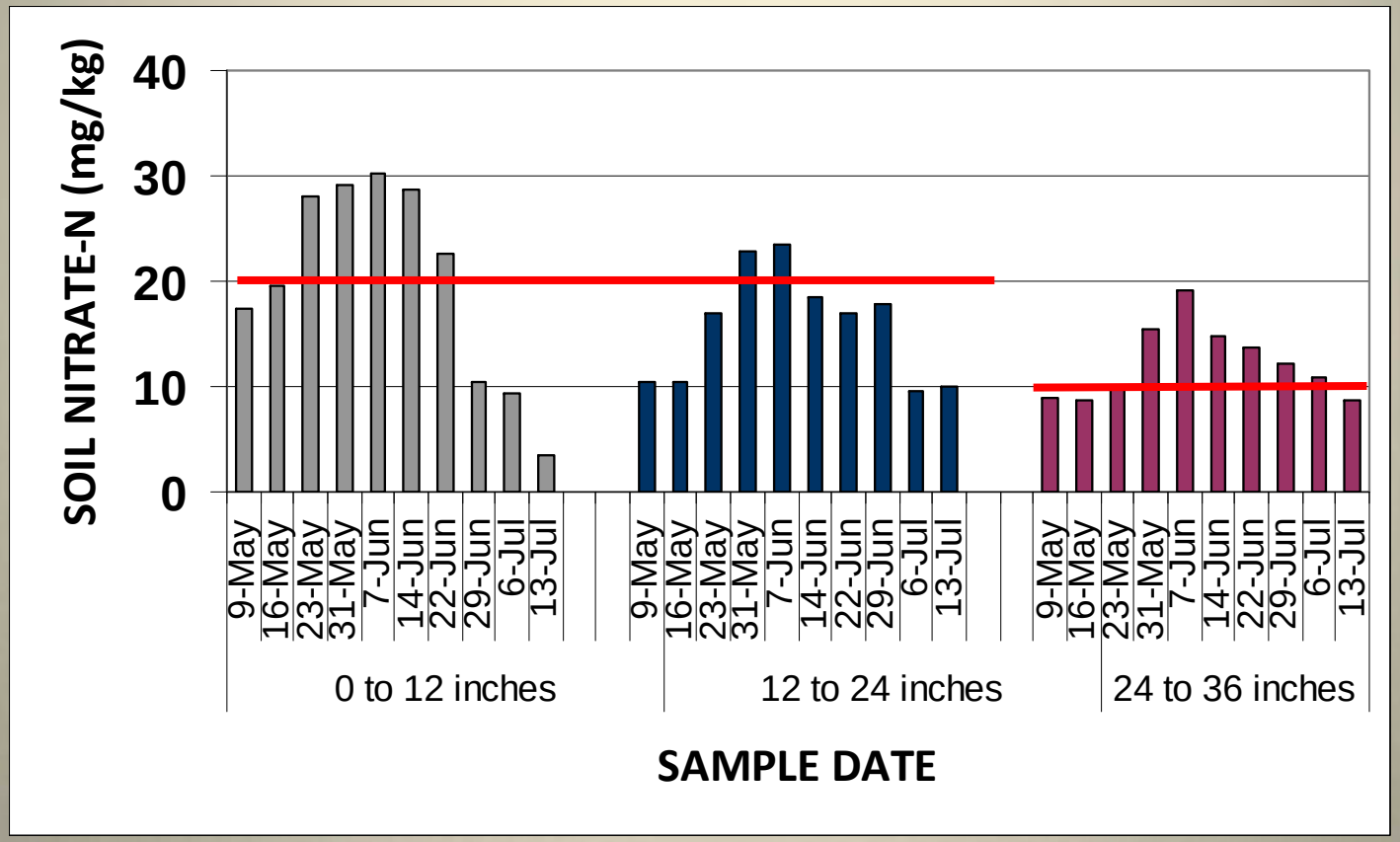


Average Nitrate-N Release Rate	[lbs N/day in 14 days]	
Clay loam	0.5	1.6
Sandy clay loam	0.4	2.1

Estimation of soil and N release from first crop residues also confirmed that pre-plant N could be eliminated

Grower Practice Confirmation

Application of a grower modified soil nitrate quick test has allowed for elimination of an average of 55 lbs of fertilizer N for the second crop of romaine



Production Practice Monitoring and Evaluation

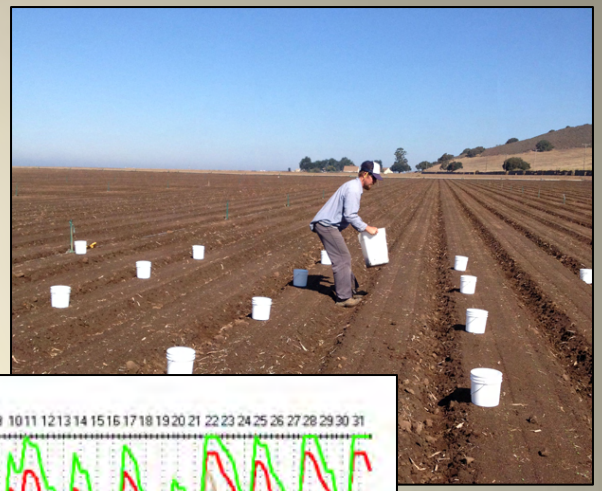
Irrigation System Evaluation

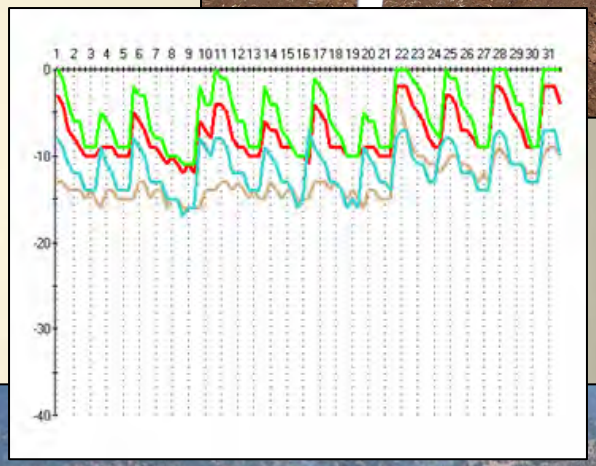
- Distribution Uniformity
- Confirm system application rate

Field Monitoring

- Irrigation, Tail water, Tile Drain Flow
- Soil Moisture (tension)
- Soil Nitrate Dynamics
- Crop Nutrition (when applicable)

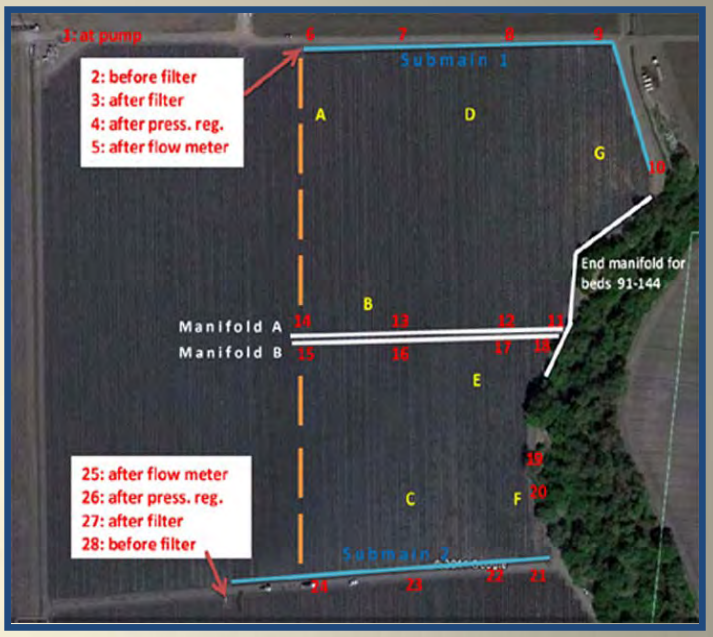
Irrigation Efficiency Evaluation





Irrigation System Evaluations

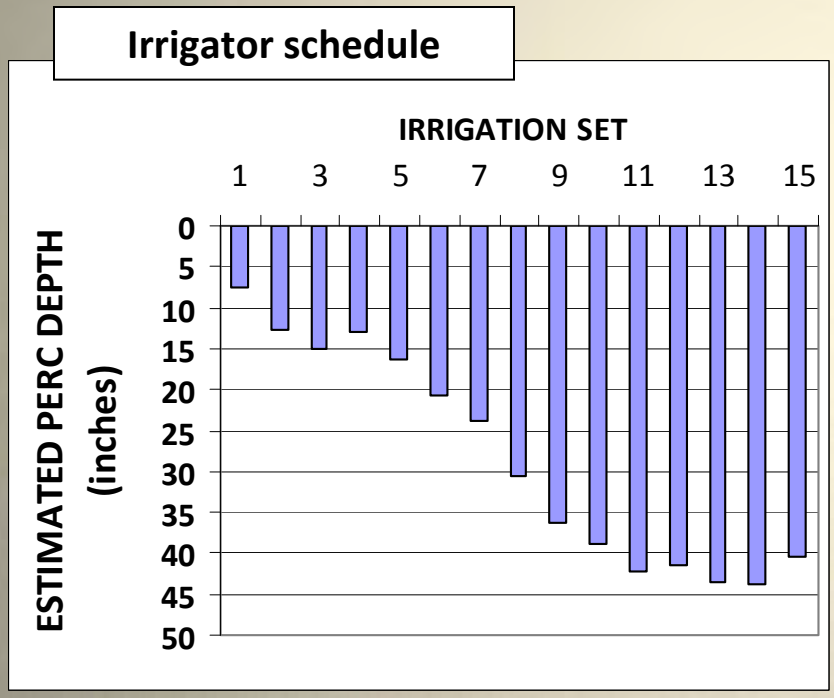
Location	DUlq	Tape Discharge rate	Field application rate
	%	gpm/100 ft	inches/hour
Area A	87.6	0.52	0.25
Area B	88.2	0.48	0.23
Area C	88.6	0.44	0.21
Area D	56.3	0.38	0.18
Area E	87.2	0.45	0.21
Area F	74.7	0.40	0.19
Overall	**76.9**	**0.44**	**0.21**

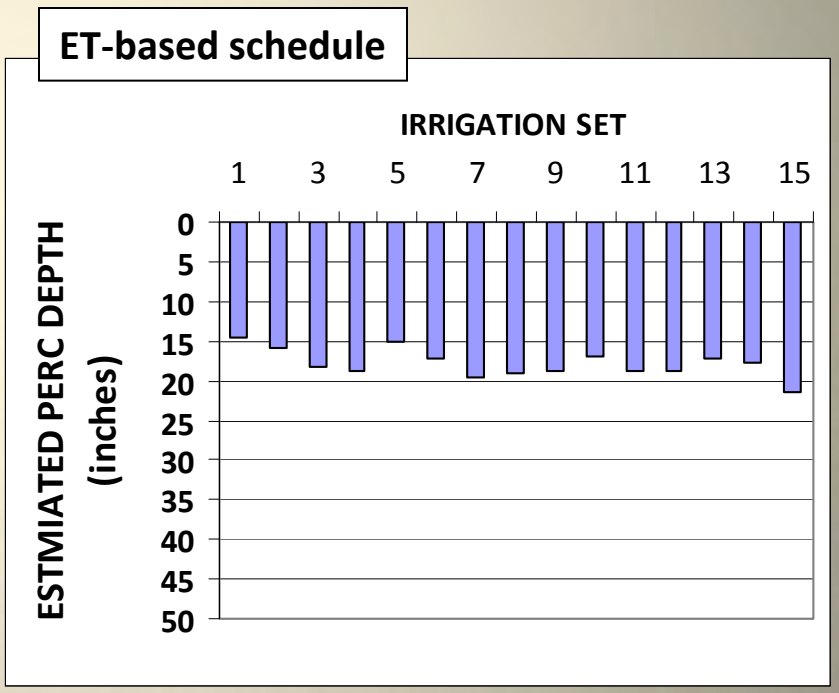


Irrigation System	DUlq		
	Poor	Good	Excellent
Drip	≤ 80	81 - 89	≥ 90
Microsprinkler	≤ 75	76 - 84	≥ 85
Sprinkler	≤ 70	71 - 79	≥ 80
Furrow/Flood	≤ 40	41 - 59	≥ 60

Minimize Deep Percolation

Perhaps the most important management factor for maximizing the use of water and N is irrigation scheduling and efficiency

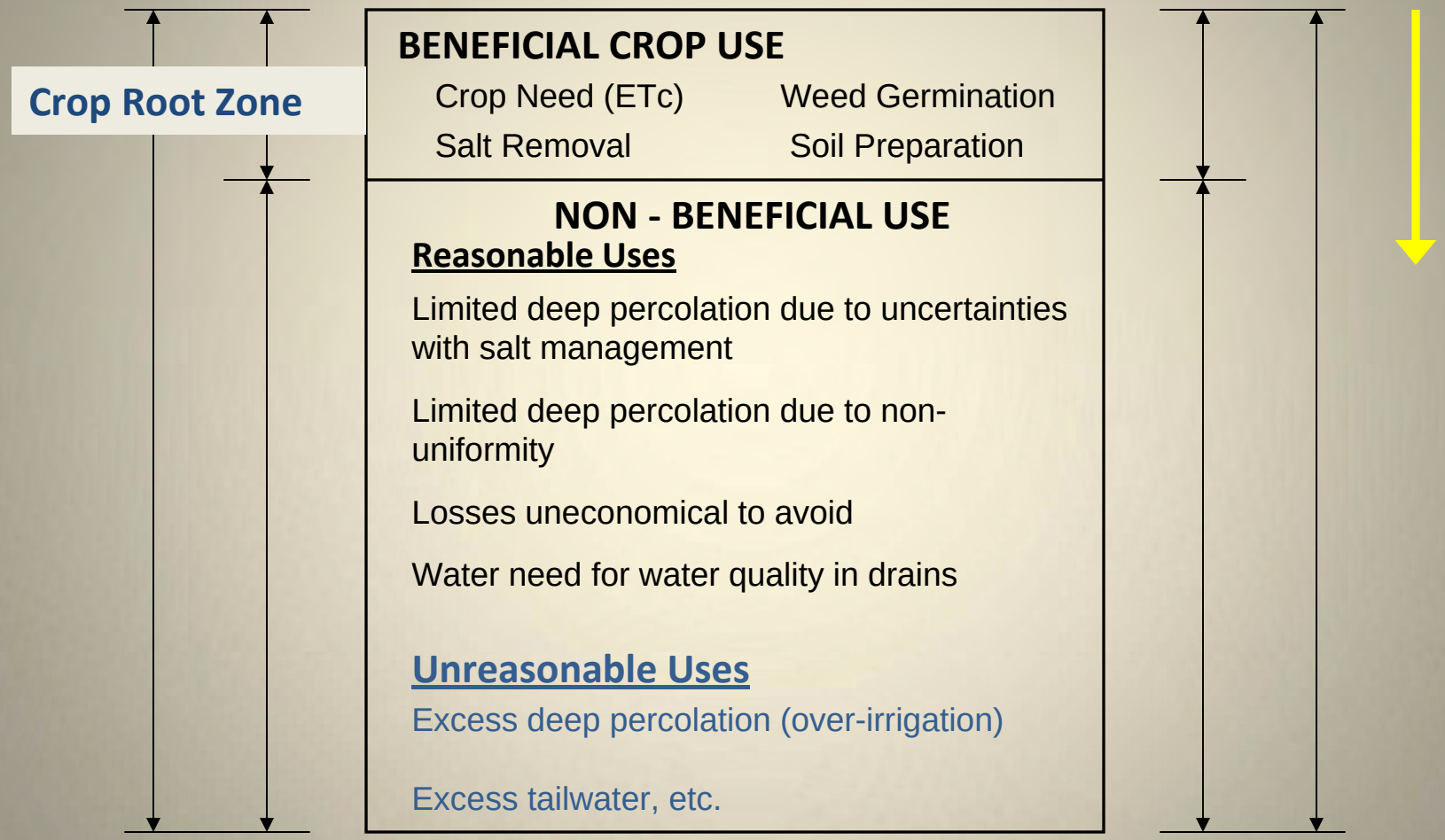




Set interval and set length affect potential percolation depth

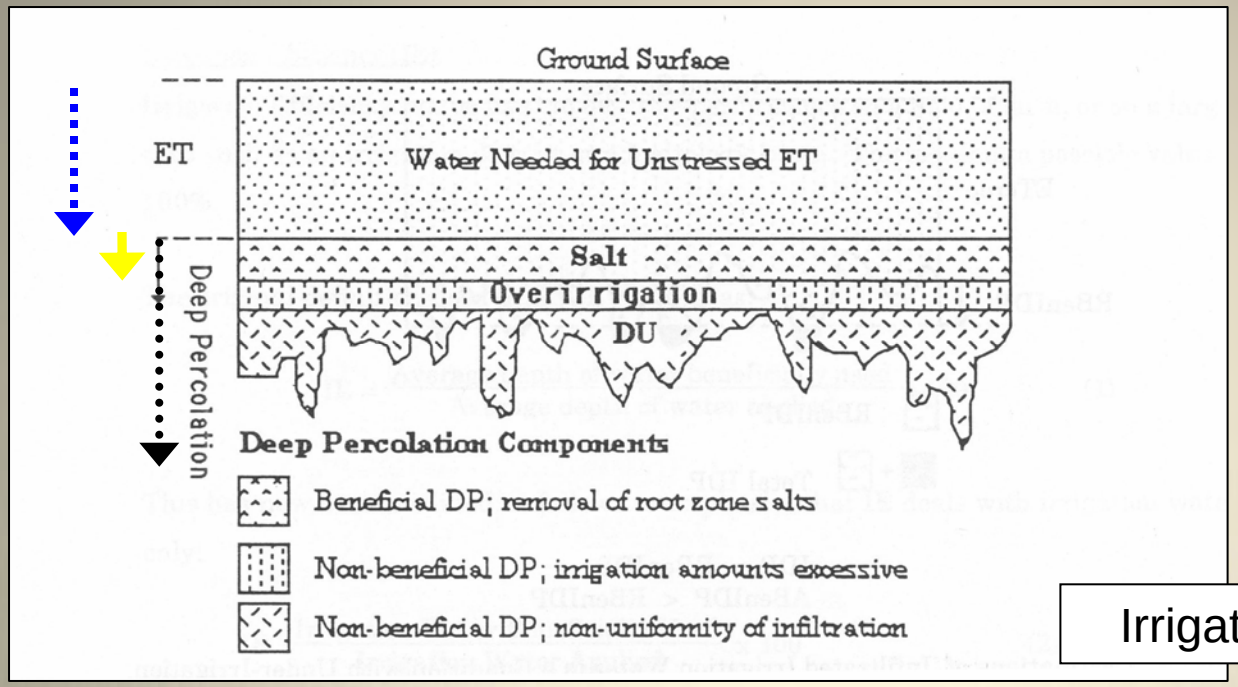
Irrigation Efficiency

Irrigation should meet Beneficial Crop Uses



$$IE = \frac{\text{Irrigation Water Beneficially Used}}{\text{Irrigation Water Applied} - \Delta\text{Storage}} \times 100$$

Irrigation Efficiency



Irrigation Efficiency = IE

HIGH Irrigation Efficiency is achieved when uniformity is optimized and water applications match crop need… AND **deep percolation** of irrigation water is minimized.

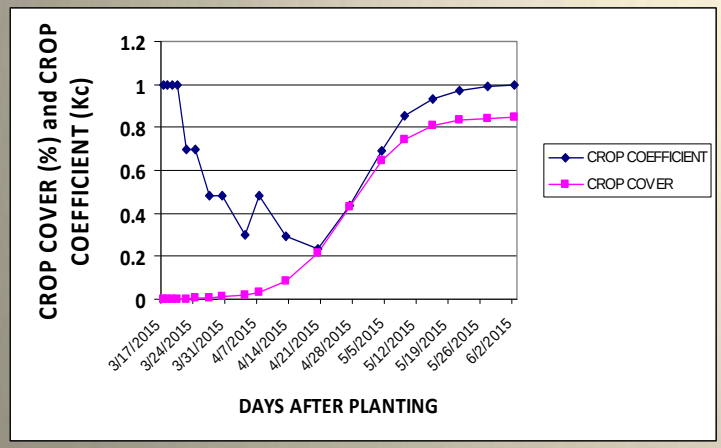
An IE greater than 90% is considered excellent, while an IE less than 60% is considered poor

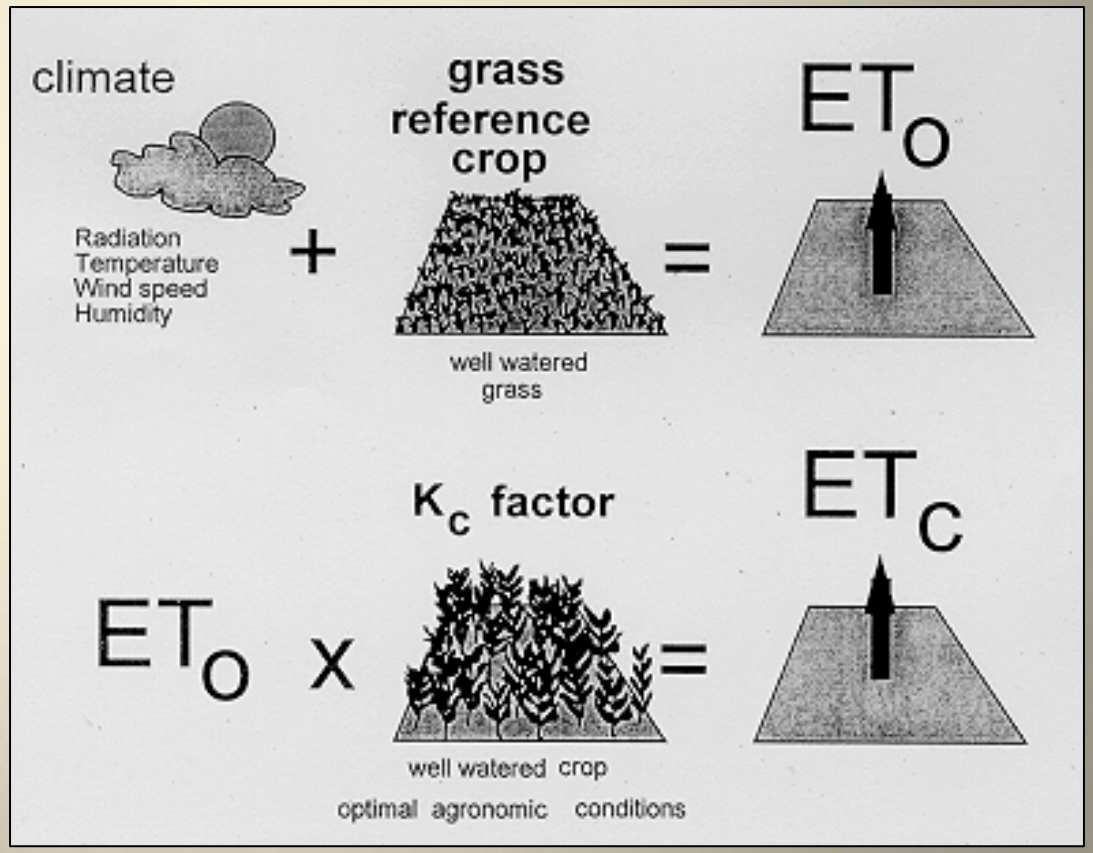
Estimating Crop Water Need

Crop ETc (inches) = Crop Coeff. x ETo

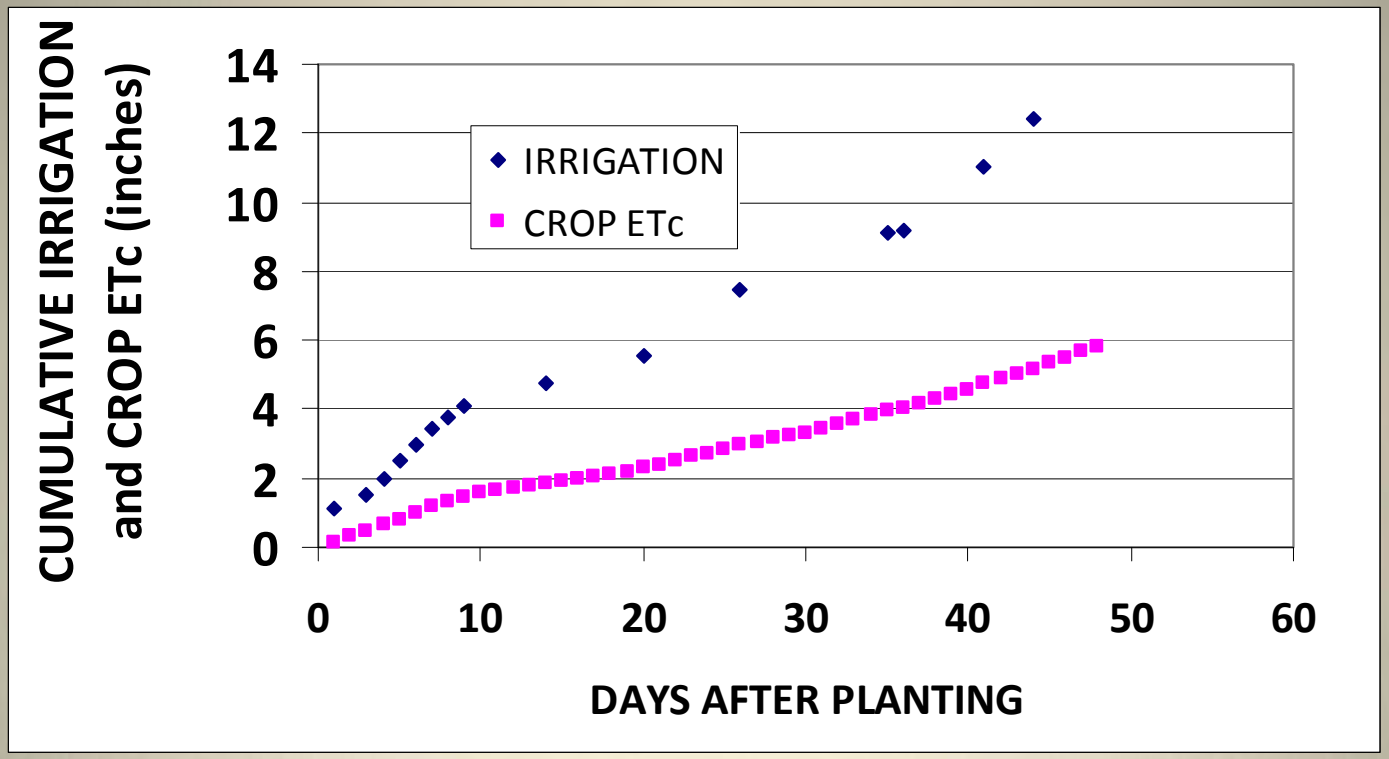
For scheduling purposes crop water need can be estimated on a daily or weekly basis

The canopy cover or crop coefficient increases as a crop develops





Irrigation Efficiency Evaluation



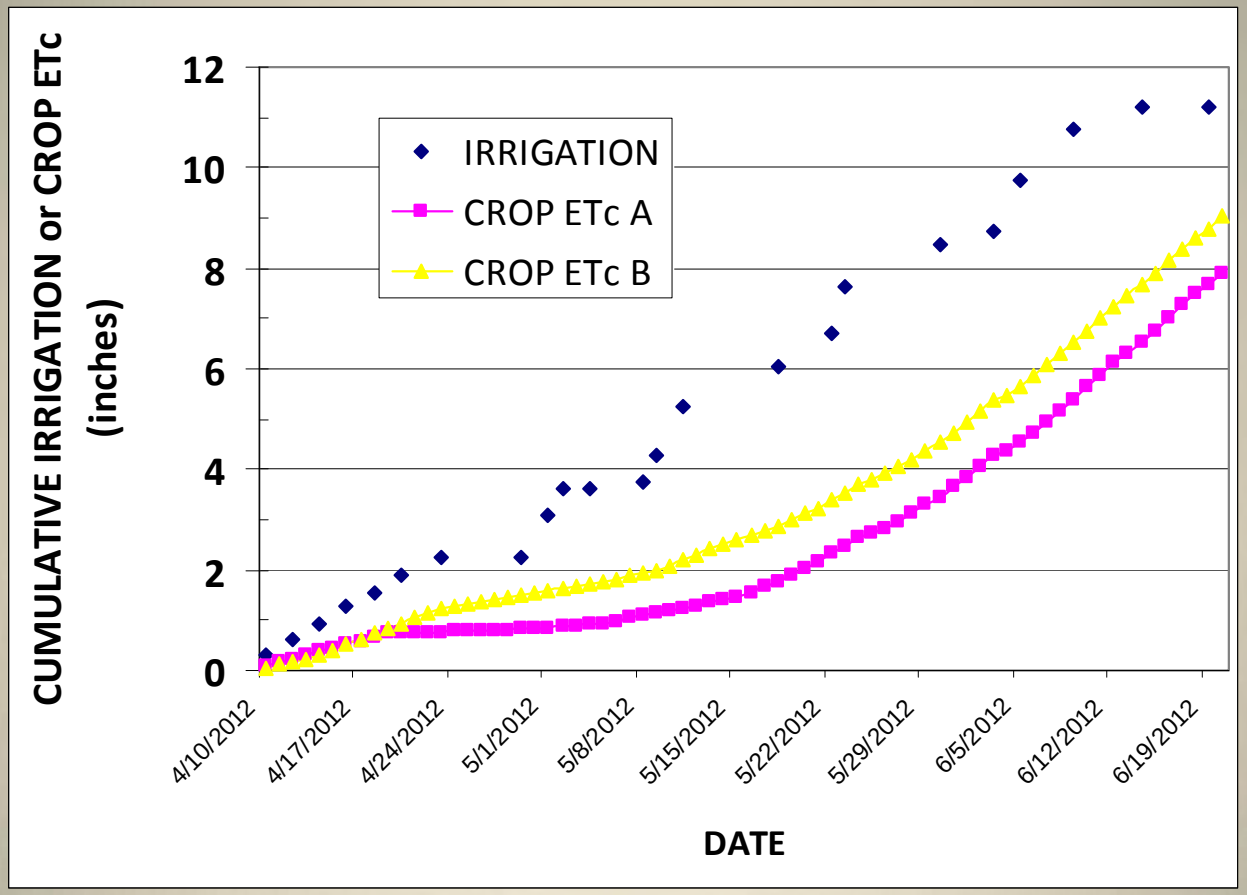
Blue line shows each irrigation set

Pink line shows estimated daily crop water use

Crop ETc = Crop Coefficient x ETo

IE = 47%

Irrigation Efficiency Evaluation

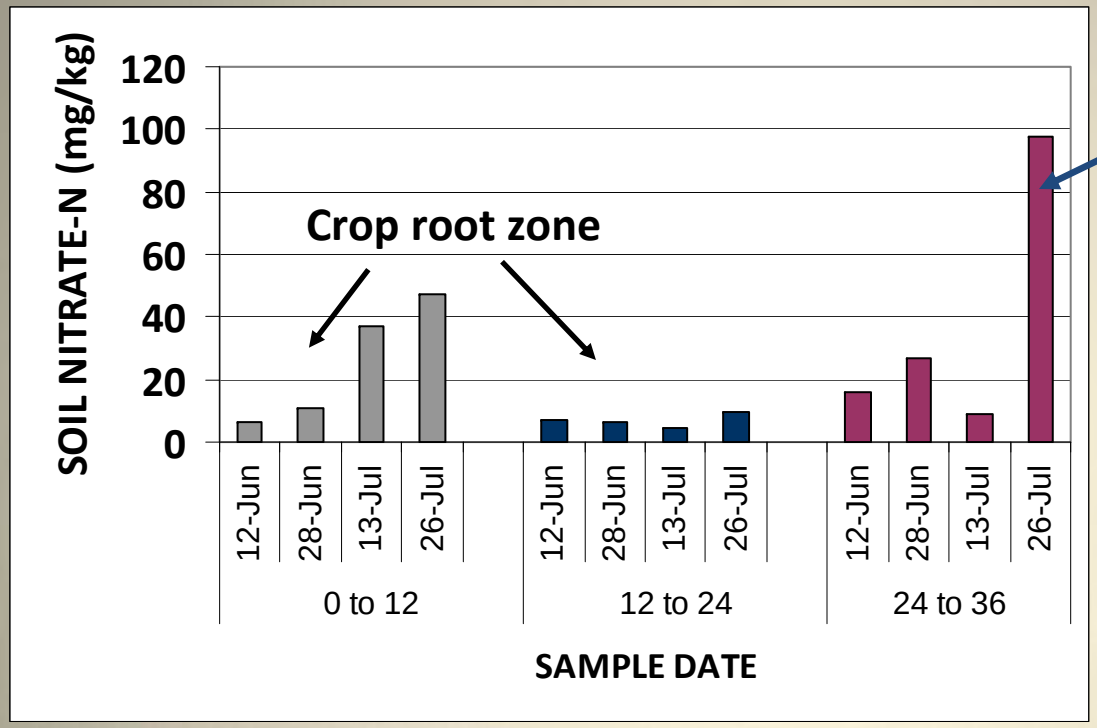


Blue line shows each irrigation set

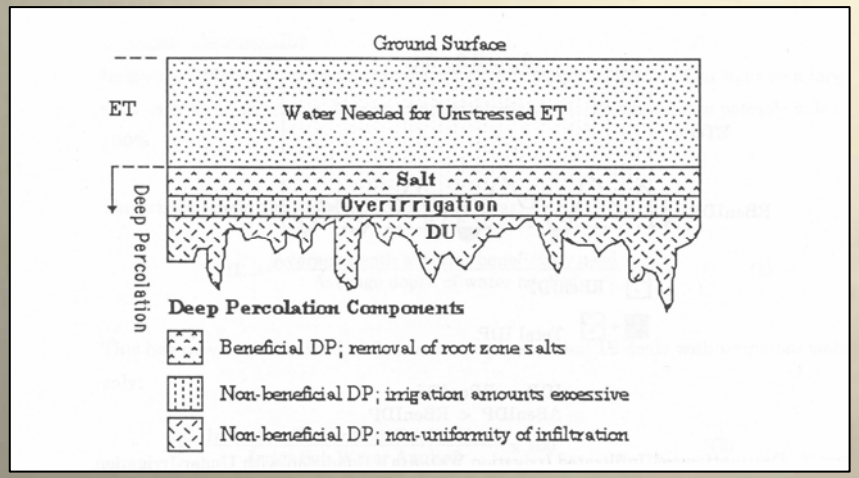
Pink and yellow line show range of estimated daily crop water use

IE = 78.2%

Confirm Potential Deep Percolation Events



Nitrogen lost to crop



July 13 to 26	inches
IRRIGATION	3.44
ETo	2.96
CROP ETc	2.14
PERCOLATION?	1.31

Optimizing Drip Irrigation Management

The grower is an 'early adopter' of buried drip irrigation for the crop, realizing improved yields and quality, in part due to lower disease incidence and better weed control

Grower and Irrigation Foreman experienced problems on certain soil types and as a result over-irrigation and excessive N applications often occurred

Two seasons of practice evaluation on four ranches would provide an average baseline

<u>Establishing a Baseline</u>

- Evaluate irrigation system uniformity
- Monitor irrigation flows
- Assess canopy development for estimation of crop ET
- Monitor soil moisture and nitrate dynamics

Baseline - Field 1

Evaluate irrigation system (mid-season) distribution uniformity

System uniformity poor (**DU = 4.6%**)

Installation (tape stretching and leaks), clogged emitters

Application rate = 0.05 in/hr

Action – System replaced (**DU > 90%)**

Irrigation Volume

Prior to system replacement as much as 2.7 inches (45 hr set) was applied in a single set.

Total applied water was over 3 times greater than crop requirement

Irrigation Efficiency = 33%

Baseline – Field 2

Evaluate irrigation distribution uniformity

System uniformity (**DU = 82%**),

Application rate = **0.12 in/hr**

Irrigation Volume

As much as 4.6 inches (47 hr set) was applied in a single set.

Total applied water was about 3 times greater than crop requirement

Irrigation Efficiency = 28%

Baseline Averages

IRRIGATION	
DU%	Efficiency
(%)	
59.4	30.4

Second season

Evaluate irrigation distribution uniformity

System uniformity (**DU =69% and 86%**)

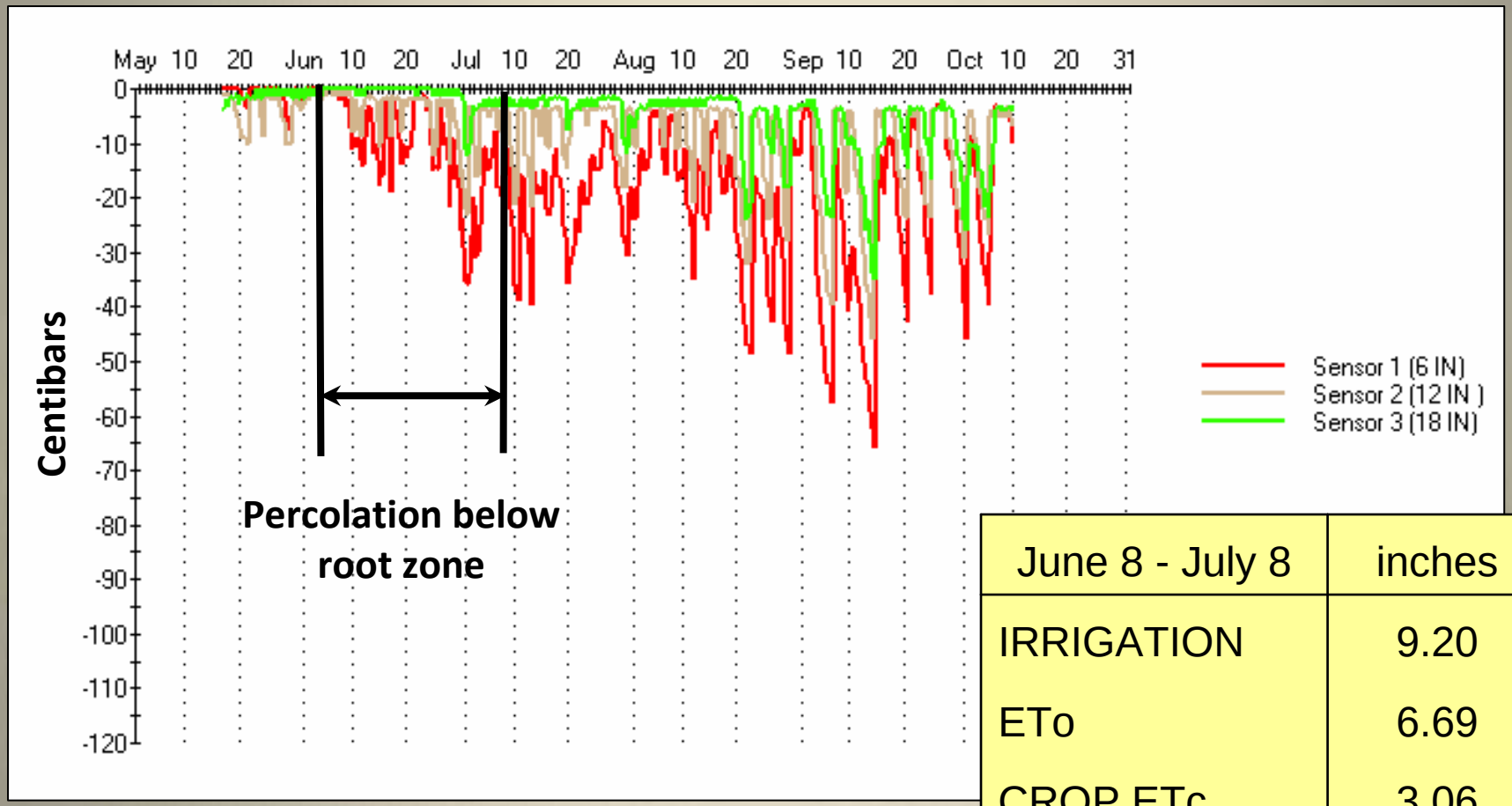
Application rate = **.07 and .08 in/hr**

Irrigation Efficiency

Total applied water was 3 times greater (Field 1) and 2.25 times greater (Field 2) than crop requirement

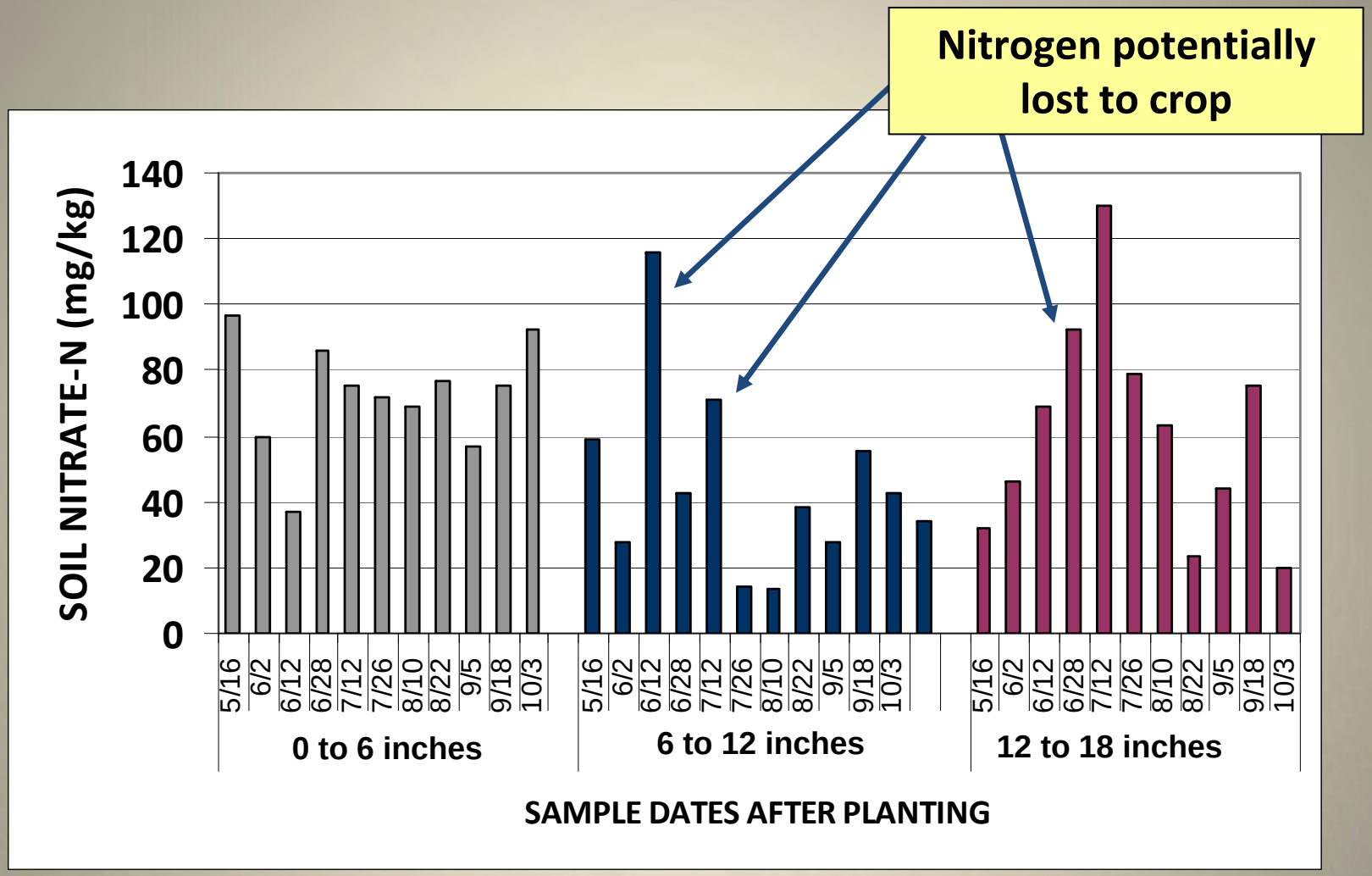
	Irrigation Efficiency (%)	
	Field 1	Field 2
No DU Adjustment	**30.4**	**44.3**
DU Adjusted	**44.0**	**51.5**

Water use efficiency was reduced in early crop stage



June 8 - July 8	inches
IRRIGATION	9.20
ETo	6.69
CROP ETc	3.06
EXCESS	6.14

N fertilizer efficiency was reduced as a result



Percolation of excess irrigation carried nitrate below root zone

Post-season Discussion and Decisions

The results of field monitoring indicated that while system DU was improved, there were still challenges due to inconsistent installation and maintenance to prevent emitter clogging

Despite improved DU, irrigation scheduling resulted in excessive over-irrigation of the crop, reduced N fertilizer efficiency, and likely some deep percolation losses of nitrate-N

Based on field evaluations, the company decided to trial an ET-based irrigation scheduling method in following season

The company desired to have it's Irrigation Foreman directly involved in implementing and evaluating the efficacy of this practice

Third Season

Implement ET-based irrigation scheduling

- On a weekly basis the Irrigation Foreman was given guidelines for the two fields
- Early on the Foreman indicated concerns about guidelines and provided suggestions for improvement based on field conditions
- Field meetings revealed a number of field level constraints
  Drip tape installation, poor soil water conductivity and limited capillary movement, drip flow rate too low, lack of pump timers

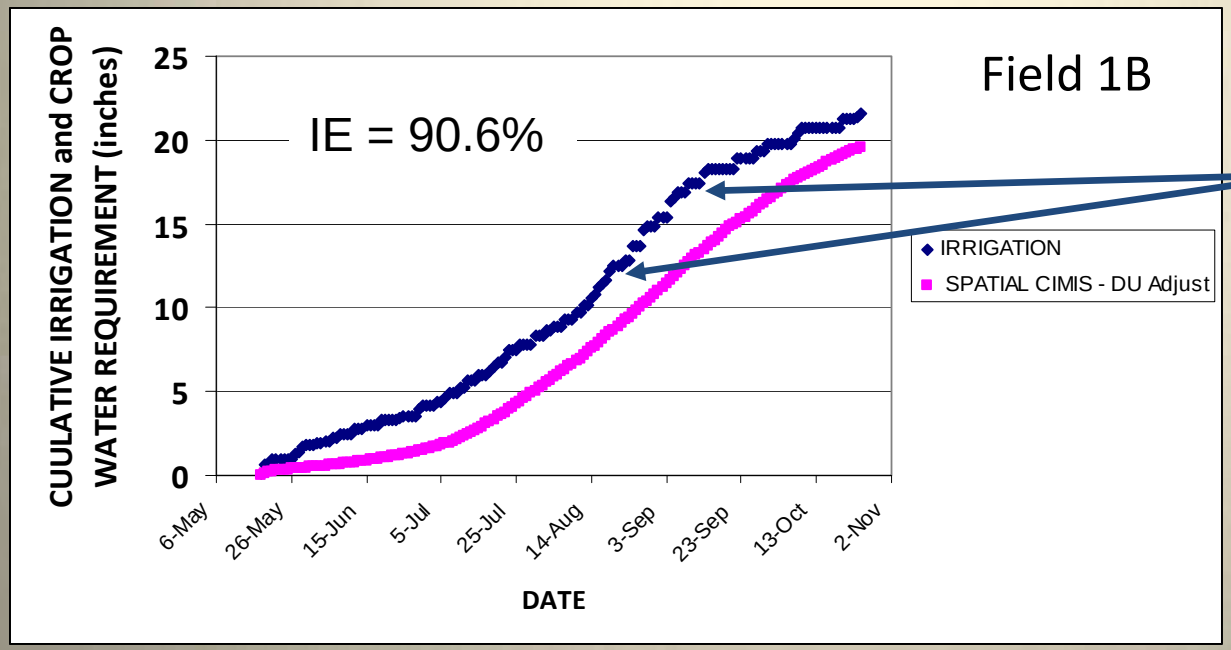
Evaluate irrigation distribution uniformity

System uniformity high (**DU =96% and 90.5%**),

Application rate = **.075 and .07 in/hr**

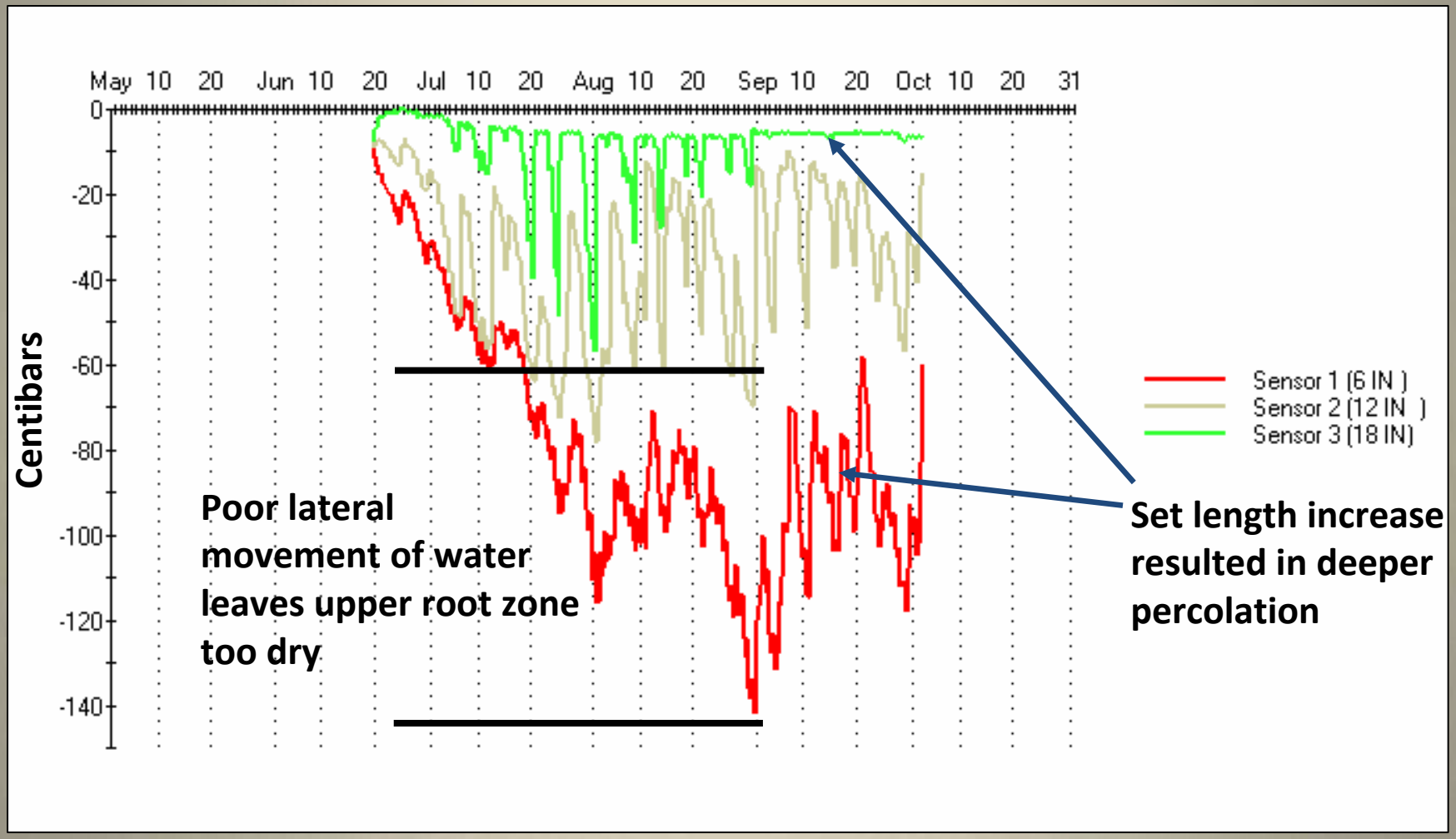
	Irrigation Efficiency (%)	
	Block A	Block B
Field 1	**81.9**	**90.6**
Field 2	**67.2**	**69.7**

Irrigation Efficiency at Field 2 was negatively impacted by tape installation and poor water conductivity in soil

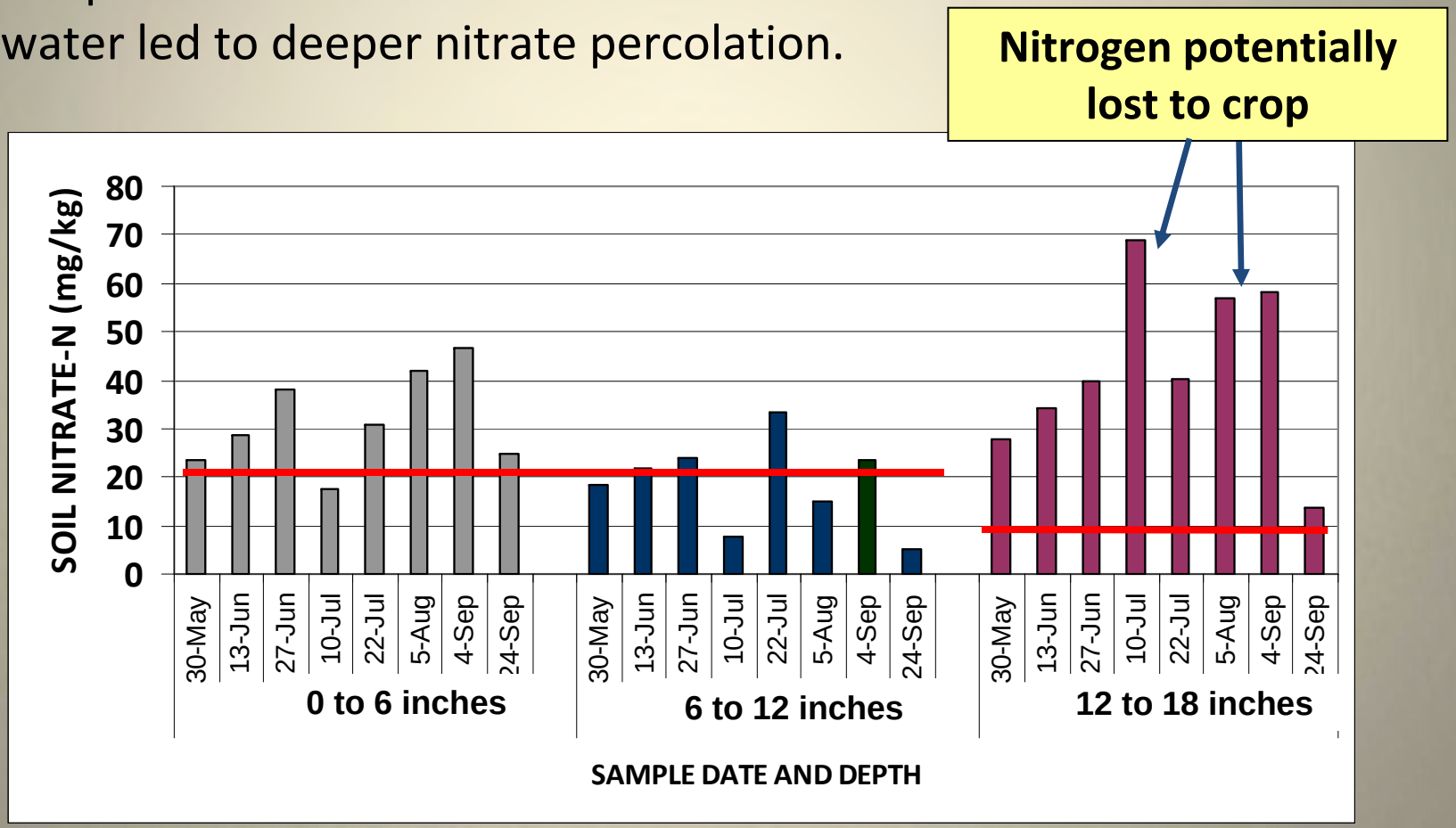


Deep percolation events were minimized in Field 1B with higher apparent crop N use efficiency

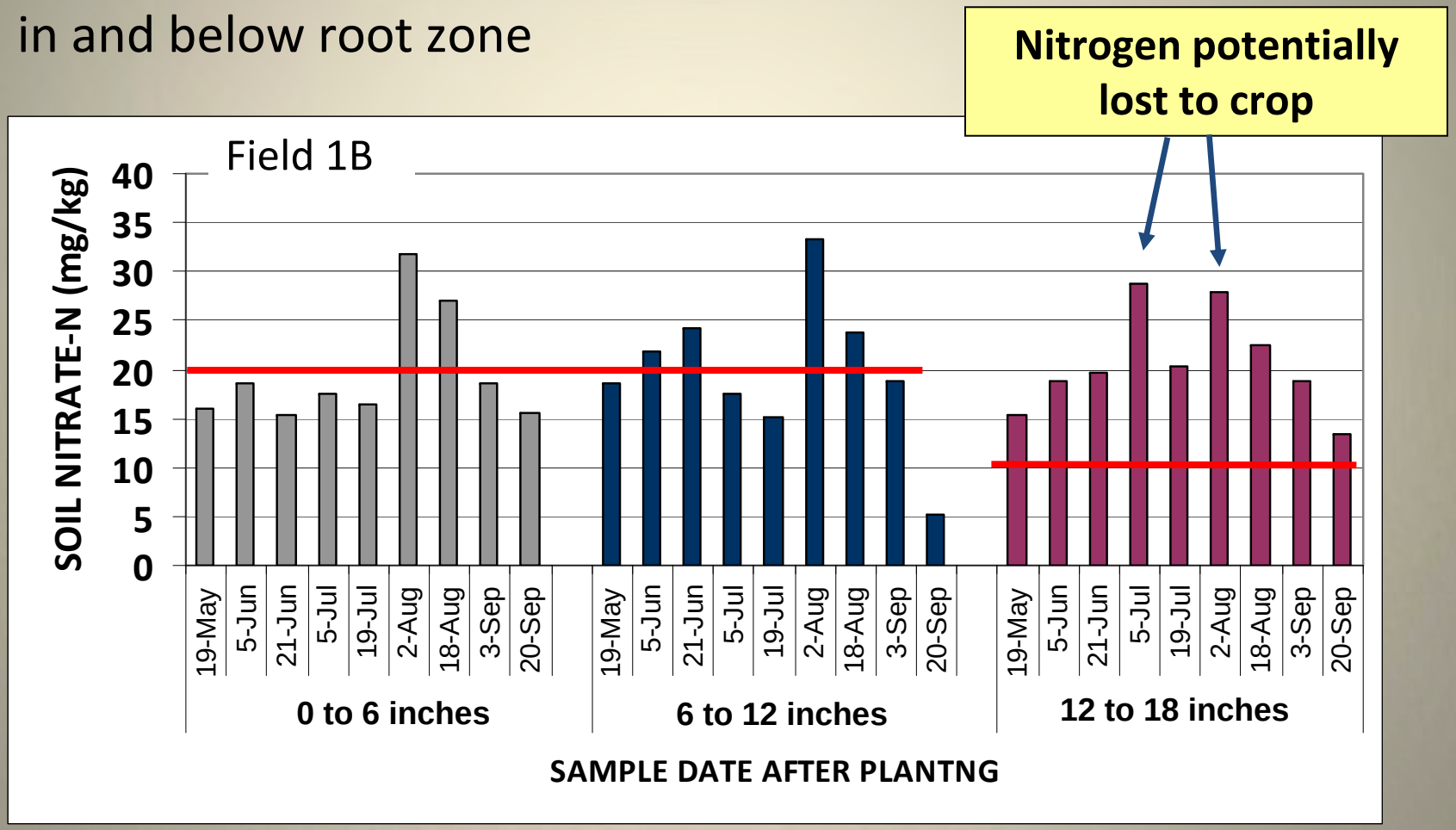
Water use efficiency in Field 2 was reduced as drip tape was installed too deep



In order to overcome the limitations of a small wetted zone, the irrigator chose to increase average set length higher than the ET guideline. Irrigating more frequently was not possible. Poor lateral movement of water led to deeper nitrate percolation.



Field 1B - Changes in irrigation and fertigation scheduling allowed for lower fertilization levels and reduced nitrate-N in and below root zone



Fourth season

Implement ET-based irrigation scheduling

The Foreman indicates more confidence with the weekly guidelines. Replacement drip tape w/ greater thickness is installed 2 inches higher in soil. Most pumps have timers installed. Irrigation scheduling is adjusted on problem soil type by increasing set frequency, while reducing set length.

The Foreman takes primary responsibility for irrigation management of one field and plans to give weekly guidelines to another irrigator

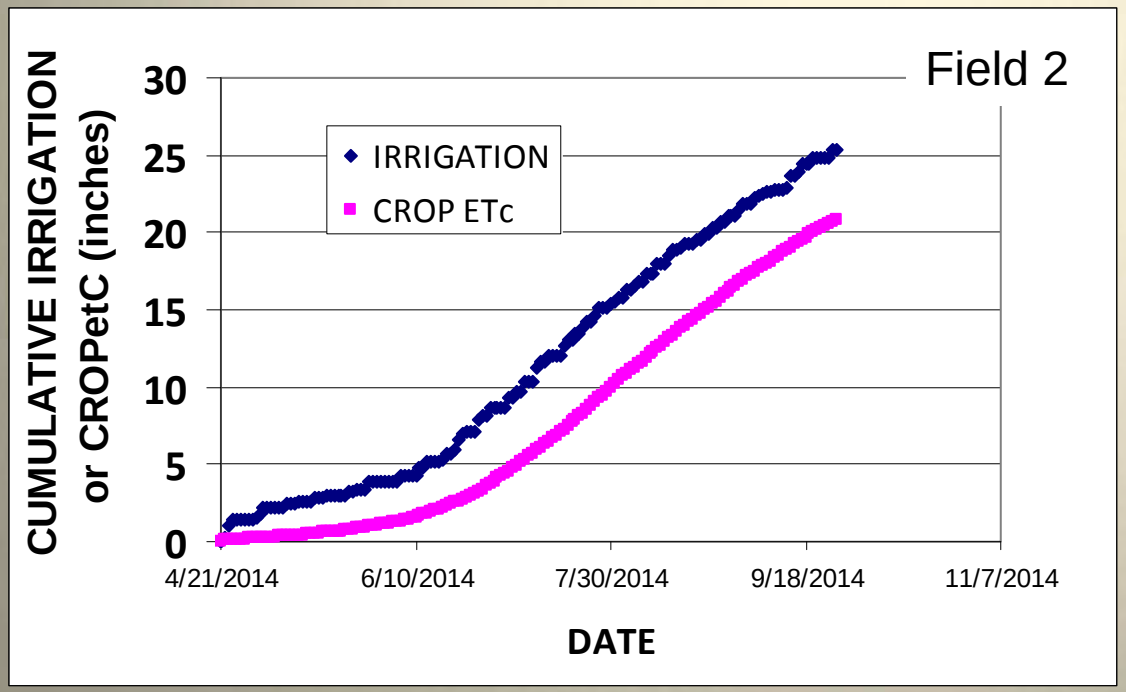
Evaluate irrigation distribution uniformity

System uniformity high (**DU =94.7% and 87.2%**)

Application rate = **.011 and 0.10 in/hr**

Fourth season

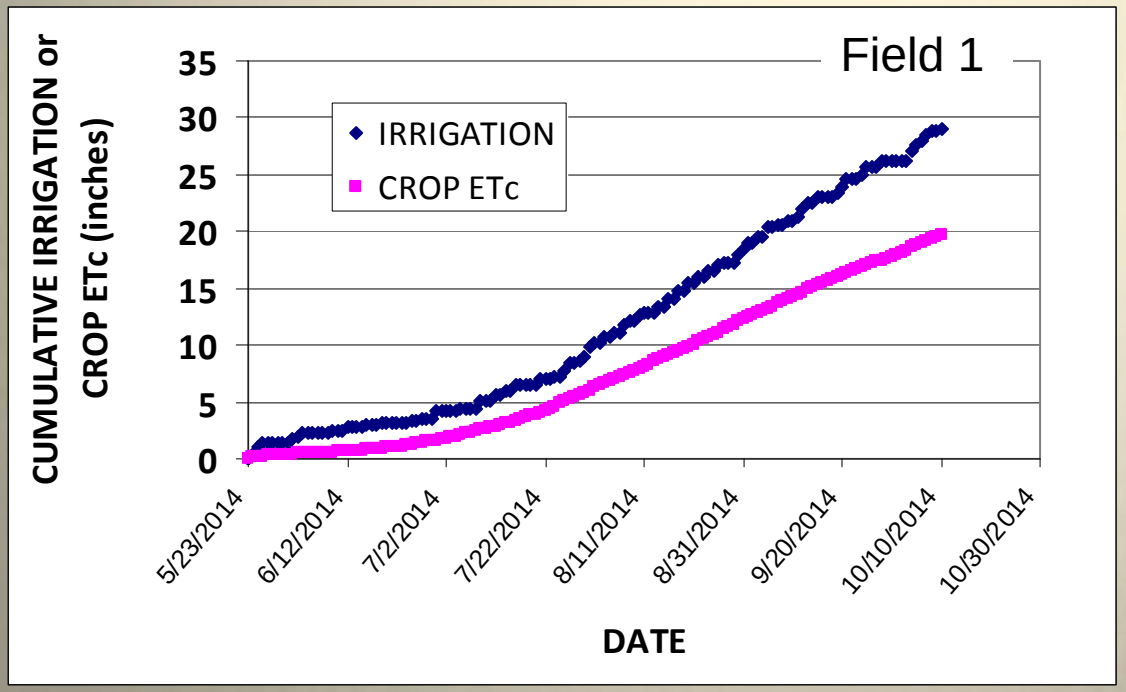
	Irrigation Efficiency (%)	
	Field 1	Field 2
No DU Adjustment	**62.7**	**77.6**
DU Adjusted	**71.4**	**82.0**



July 24 - Oct 10	inches
IRRIGATION	3.69
ETo	4.49
CROP ETc	3.89
EXCESS	**-0.2**

Fourth season

	Irrigation Efficiency (%)	
	Field 1	Field 2
No DU Adjustment	**62.7**	**77.6**
DU Adjusted	**71.4**	**82.0**



July 24 - Oct 10	inches
IRRIGATION	9.26
ETo	4.81
CROP ETc	4.3
EXCESS	**4.96**

Increased Efficiency = Water Savings

Grower evaluation and annual monitoring of representative fields has provided documentation of improving practice effectiveness for protection of water resources, while meeting yield and quality goals

	IRRIGATION		Estimated Range of Water Savings	
YEARS	DU%	Efficiency		
	(%)		AF/year	
Baseline Average	59.4	30.4		
SEASON 1 Avg.	77.5	47.4	**182.8**	**207.7**
SEASON 2 Avg.	93.4	72.5	**368.5**	**390.7**
SEASON 3 Avg.	91.0	76.7	**295.1**	**349.0**

Thank You!