Irrigation Management of Lettuce: Large Scale Studies

Michael Cahn and Richard Smith
UC Cooperative Extension, Monterey Co

Saving Water and Nitrogen Fertilizer

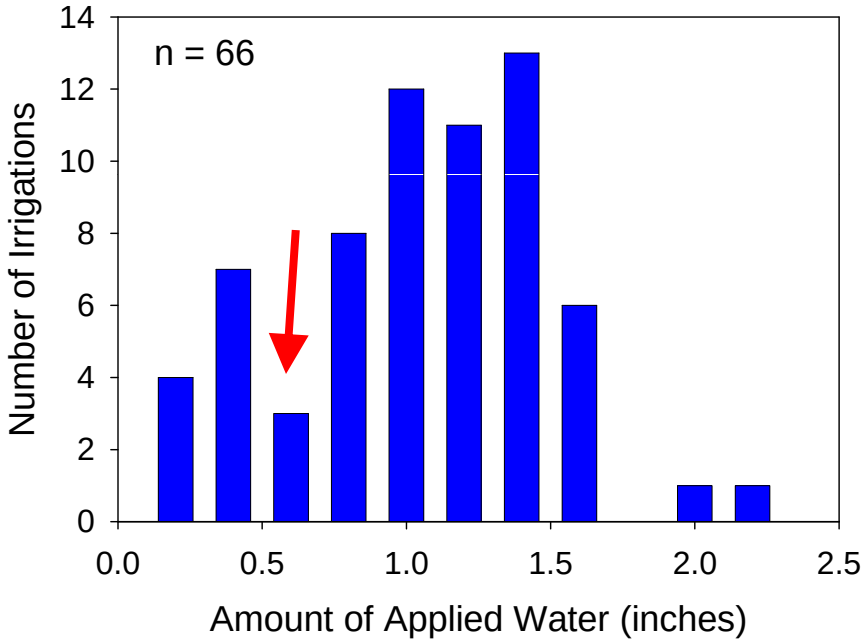
- Water and nitrogen are the 2 main inputs that affect lettuce production
- Water supplies are becoming scarce
- Nitrogen fertilizer and energy prices have been increasing
- Good water management is required to keep nitrogen in the root zone
- Water quality regulators are focusing on vegetable producers

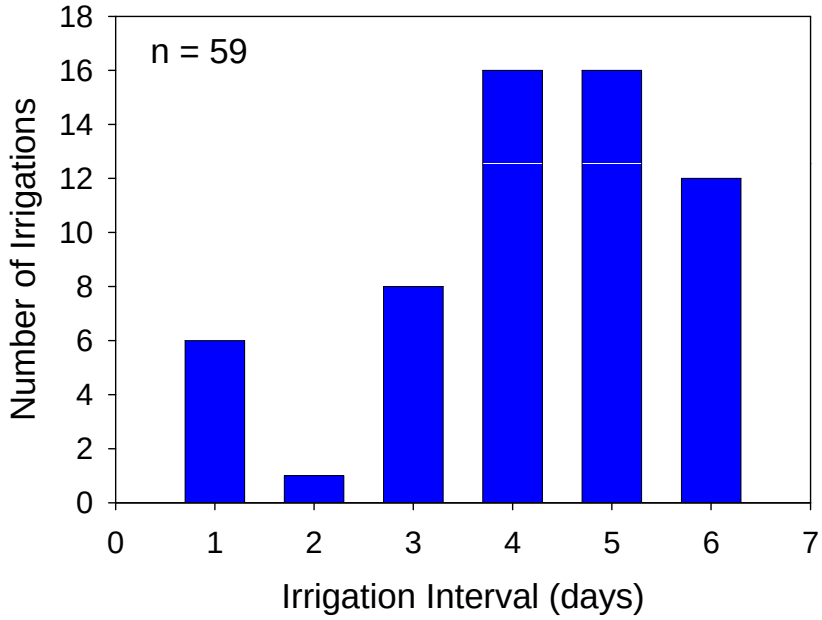
Opportunities to Save Water and Nitrogen Fertilizer

2007 Monitored 8 Romaine Fields Sprinkler + Surface Drip

Lettuce Water Use	Average	Maximum	Minimum
	---------- inches ----------		
Total Evapotranspiration requirement	6.4	8.3	5.5
Consumptive Water Use	8.5	11.1	7.3
Applied Water	17.3	24.4	11.2

Management of Drip in Romaine





Tools for Managing Water and Nitrogen Fertilizer in Lettuce

- Quick nitrate soil test
- Weather-based irrigation scheduling

Welcome Back MIKE

- My Reports
- My Station Lists
- My Preferences

Account Management

- Log Off
- Edit Registration
- Change Password

My Reports

The **My Reports** allows you to perform single-click reporting, select report preferences, and prepare custom reports. There are three station lists (List 1, List 2, and List 3) and each list can hold up to a maximum of 10 stations. A list must contain at least one station before executing reports from this page. You can add and remove station(s) from the list by clicking on Create/Change Station Lists and clicking on Remove. Once a list has been created, clicking on a station number will provide detailed information about the station.

After specifying Station Lists, you can generate a report in any one of the report options listed under Quick Reports by clicking on the list number to the right (list 1, list 2, or list 3). These reports are generated using the Preferences listed at the bottom of the Station Lists. Preferences for Quick Reports can be changed by clicking on Change Preferences at the bottom of the Station Lists. Custom reports allows the user to select the options (climatic parameters), to be reported.

Quick Reports

Report Options	
Standard Hourly (using prefs)	list 1 | list 2 | list 3
Standard Daily (using prefs)	list 1 | list 2 | list 3
Standard Daily ETo Variance (using prefs)	list 1 | list 2 | list 3
Standard Monthly (using prefs)	list 1 | list 2 | list 3
Standard Monthly Average ETo (using prefs)	list 1 | list 2 | list 3

My Custom Reports

Report Options	
pajaro	list 1 | list 2 | list 3 | customize
salinas	list 1 | list 2 | list 3 | customize
undefined	| customize
undefined	| customize

Tip: When specifying the stations for station-lists, group stations by geographic proximity. You can then report by geographic region. Reports based on stations in close proximity can be a useful tool for understanding data patterns in and around the area of interest.

My Station Lists

List 1	List 2	List 3
037	111	019
129	129	028
177		053
--	--	089
--	--	116
--	--	--
--	--	--
--	--	--
--	--	--
--	--	--

Create/Change Station Lists

My Preferences

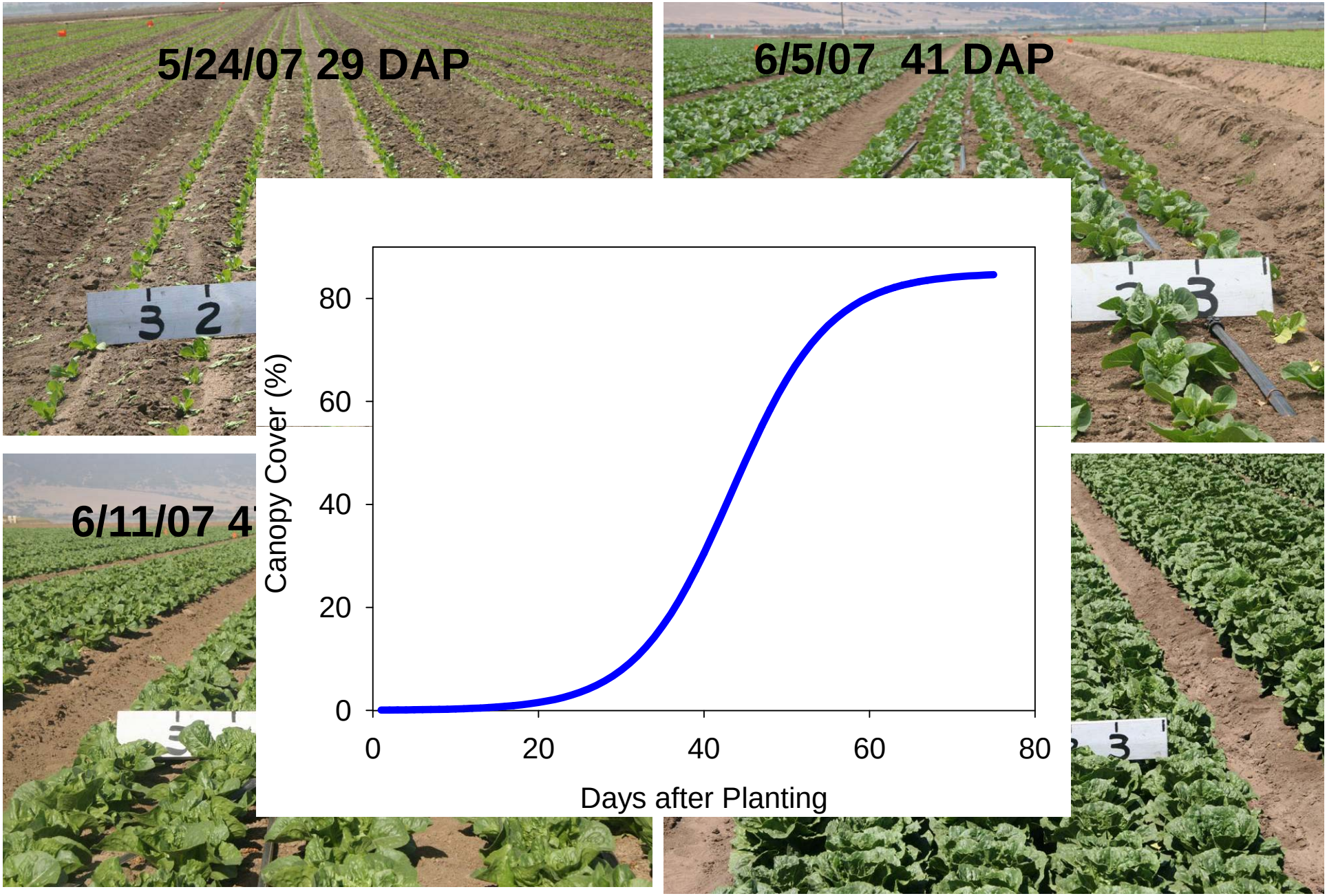
Name	Value
Zip Codes	
Units	English
Output	WEB Report
Hourly Report	7 Days
Daily Report	7 Days
Monthly Report	12 Months

Change Preferences

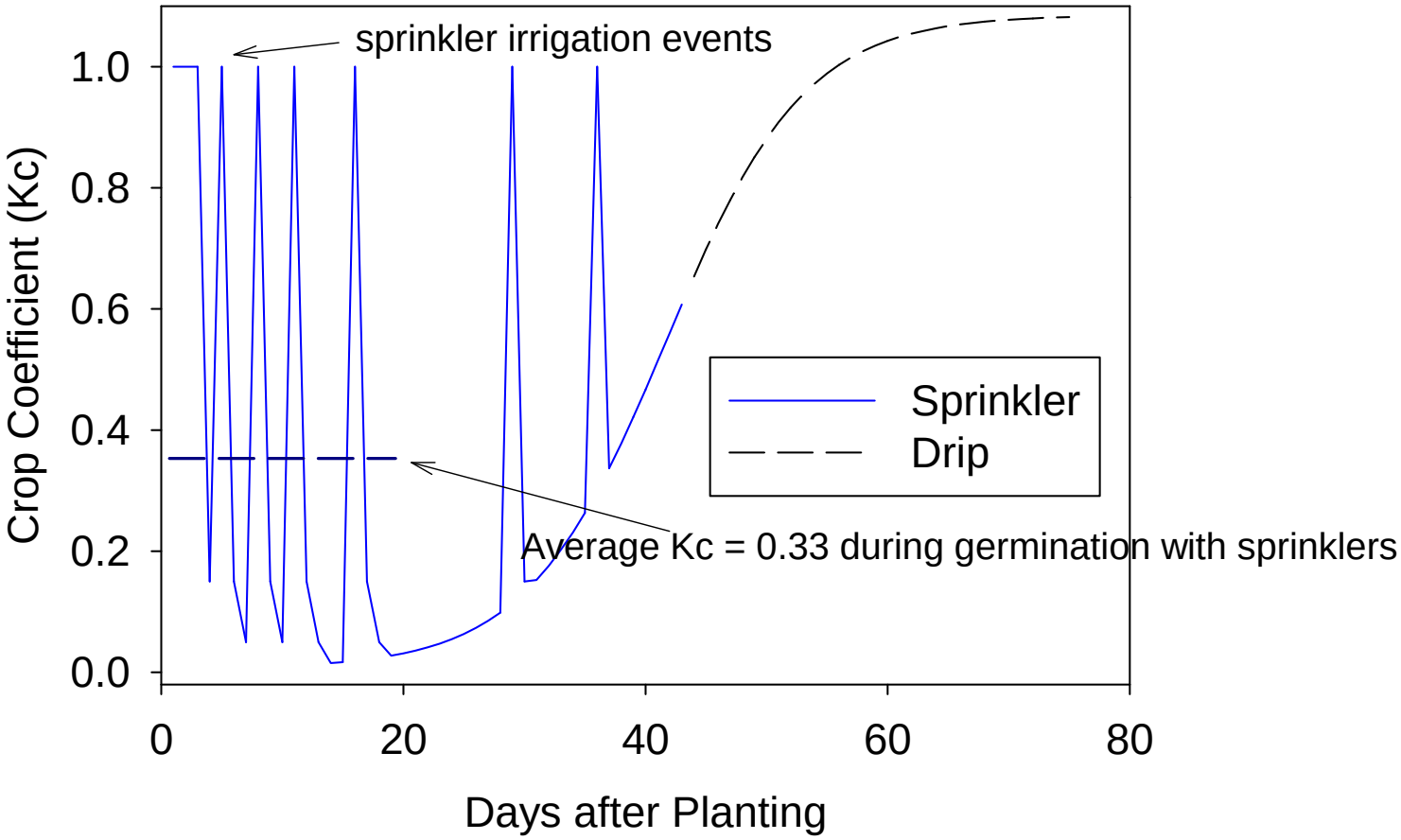
Converting Reference ET to Crop ET:

$$ET_{crop} = ET_{ref} \times K_{crop}$$

K_c can vary from 0.1 to 1.2


5/24/07 29 DAP
6/5/07 41 DAP
6/11/07 4
Canopy Cover (%)
0
20
40
60
80
Days after Planting

Estimated Kc of Lettuce



Monitor Soil Moisture Tension to Determine When to Irrigate

Lettuce growth slows at soil moisture tensions above 20 to 30 cbar

Undisturbed Cores for Volumetric Moisture Analysis

Irrigation Scheduling Spreadsheet

		--- crop ---		-- soil --	---- evapotranspiration -----			---CIMIS irrigation schedule ------			
M		B	C	G	K	L		N	O	P	Q
Irrigation Date	Irrigation Method	Rooting Depth (feet)	Kc × 100 or Canopy Cover (%)	Allowable Depletion (in)	Avg Reference Crop ET (in/day)	Avg Crop ET (in/day)	Total Crop ET (inches)	Recom-mended Irrigation Interval (days)	Actual Irrigation Interval (days)	Irrigation Time (hours)	Irrigation Amount (inches)
8/23/2008	sprinkler	0.5	100	0.24	0.21	0.21	0.00	1.1	0	0.0	0.00
8/24/2008	sprinkler	0.5	100	0.24	0.24	0.24	0.24	1.0	1	1.3	0.32
8/25/2008	sprinkler	0.5	100	0.24	0.24	0.24	0.24	1.0	1	1.3	0.32
8/27/2008	sprinkler	0.5	75	0.24	0.24	0.18	0.36	1.3	2	1.9	0.48
8/30/2008	sprinkler	0.5	55	0.24	0.24	0.13	0.40	1.8	3	2.1	0.53
9/3/2008	sprinkler	0.5	55	0.24	0.21	0.12	0.46	2.0	4	2.5	0.62
9/7/2008	sprinkler	0.5	45	0.24	0.24	0.11	0.43	2.2	4	2.3	0.58
9/20/2008	sprinkler	1	16	0.47	0.17	0.03	0.35	17.3	13	1.9	0.47
9/27/2008	sprinkler	1	32	0.47	0.18	0.06	0.40	8.2	7	2.2	0.54
10/5/2008	drip	1.5	44	0.65	0.16	0.07	0.55	9.6	8	5.3	0.64
10/10/2008	drip	1.5	60	0.65	0.16	0.10	0.48	6.8	5	4.7	0.56
10/14/2008	drip	2	80	0.83	0.17	0.14	0.54	6.1	4	5.3	0.64
10/18/2008	drip	2	84	0.83	0.16	0.13	0.54	6.2	4	5.3	0.63
10/22/2008	drip	2	86	0.83	0.14	0.12	0.48	6.9	4	4.7	0.57
10/27/2008	drip	2	86	0.83	0.15	0.12	0.62	6.7	5	6.1	0.73

2008 Demonstration Trials of Irrigation Scheduling and Quick Nitrate Test

- 3 locations (Salinas, King City, San Ardo)
- Commercial Iceberg and Romaine Fields (15 to 27 acres trials)
- Management treatments from wet date to harvest (Grower vs BMP)
- Relied on grower irrigation and fertilizer methods
- 3 replicate strips of each treatment (24 beds wide)
- Commerical and small plot harvests

Additional Challenges

King City (planted June 28th)

- Sprinklers only: Limited ability to change irrigation schedule and no option to fertigate

Salinas (planted July 14th)

- Grower practice was similar to BMP

San Ardo (planted August 23rd)

- Hot weather and irrigation system problems at germination contributed to poor stand establishment
- Drip system installed late and operated at low pressure (no fertigation option)

Applied Water at Trial Sites

Trial Site	Grower Total Applied Water (inches)	BMP Total Applied Water (inches)		Estimated Crop ETc (inches)	Estimated Consumptive Water Use [1] (inches)	Water use reduction (%)
King City	17.7	14.7	**3.0**	10.1	13.4	17
Salinas	9.9	8.7	**1.2**	7.6	8.9	12
San Ardo	19.4	11.9	**7.5**	6.7	8.7	39
Average	15.7	11.8	**3.9**	8.1	10.3	23

[1.] consumptive water use = ETc/DU; DU = distribution uniformity of the irrigation system

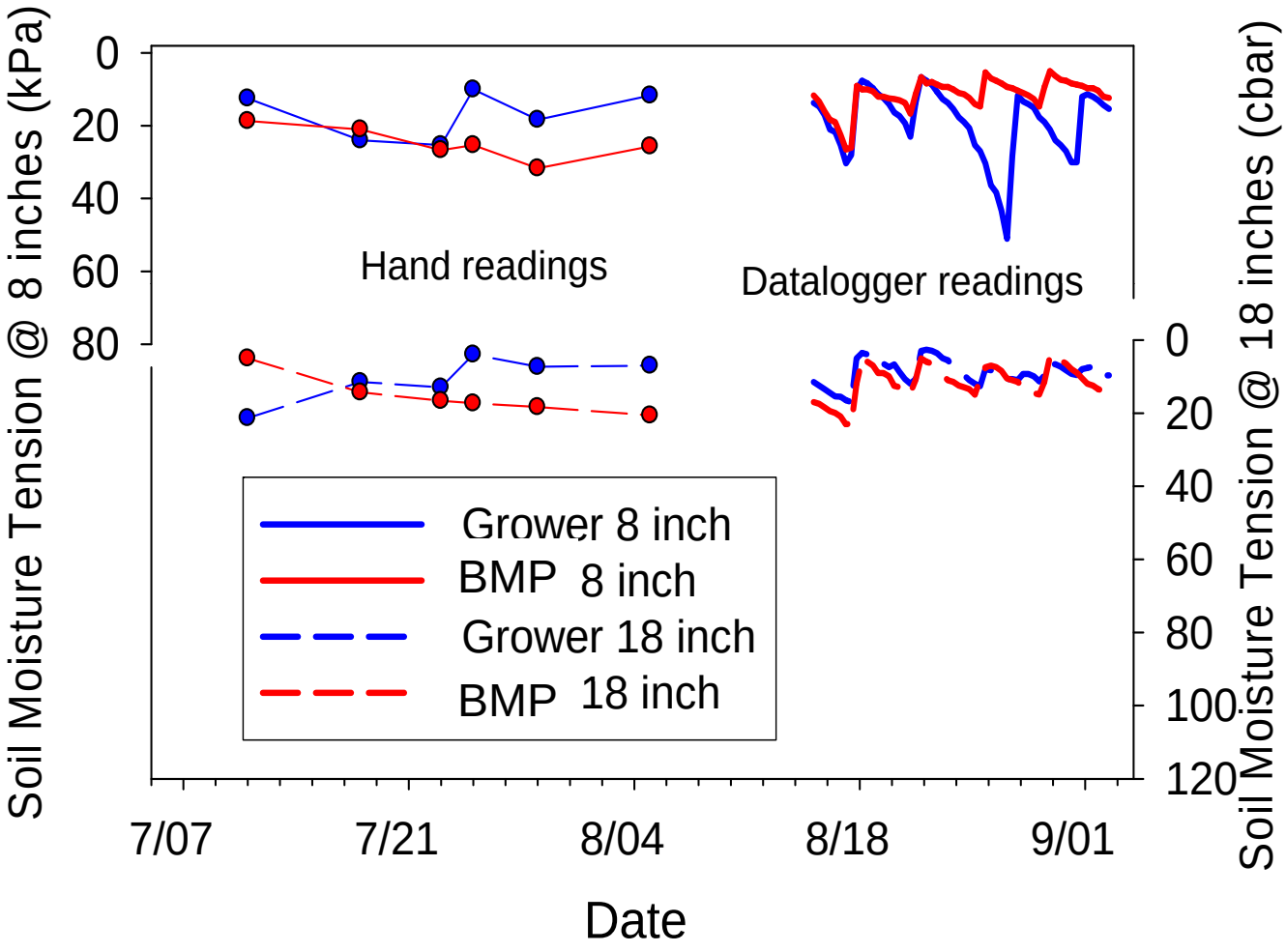
Water Applied for Pre- and Post-Germination

Trial Site	Grower	BMP	Grower	BMP		Grower	BMP	
	Total Applied Water		Germination Water			Post Germ. Water		
King City	17.7	14.7	5.6	4.5	**1.1**	12.1	10.2	**1.9**
Salinas	9.9	8.7	3.5	2.4	**1.1**	6.4	6.3	**0.1**
San Ardo	19.4	11.9	6.0	5.8	**0.2**	13.4	6.1	**7.3**
Average	15.7	11.8	5.0	4.2	**0.8**	10.6	7.5	**3.1**

Irrigation Scheduling Errors

	King City		Salinas		San Ardo	
Scheduling Error	Grower	BMP	Grower	BMP	Grower	BMP
	---------- % ----------					
Average error	5	7	7	11	9	9
Max. over application	8	34	4	14	16	17
Max. under application	-23	-24	-18	-25	-20	-19

Soil Moisture (King City)



Applied Nitrogen Fertilizer

Trial Site	Grower (Total Applied Nitrogen lbs N/acre)	BMP (Total Applied Nitrogen lbs N/acre)	BMP Nitrogen Reduction (lbs N/acre)
King City	248.3	109.7	138.6
Salinas	76.9	64.7	12.2
San Ardo	199.7	153.6	46.1
Average	175.0	109.3	65.6

Average Soil Nitrate levels (1 foot depth)

	Grower	BMP
Trial Site	Mean Soil Nitrate (over season) (ppm NO3-N)	
King City	33.3	47.0
Salinas	18.3	19.5
San Ardo	19.5	20.4
Average	23.7	29.0

Did the BMP water management reduce nitrate losses?

Estimated Nitrogen Losses due to Leaching (King City July 25-July 29)

Management Treatment	Applied Water[1]	Crop ET	Soil Moisture Storage	Percolation	NO3-N concentration in leachate	Nitrogen loss by leaching
	---------- inches ----------				ppm	lb/acre
BMP	0.8	0.6	0.0	0.3	173.9	11.2
Grower	1.4	0.6	-0.1	0.9	178.4	37.3

Estimated Nitrogen Losses due to Leaching (Salinas July 10-July 24)

Management Treatment	Applied Water[1]	Crop ET	Soil Moisture Storage	Percolation	NO3-N concentration in leachate	Nitrogen loss by leaching
	---------- inches ----------				ppm	lb/acre
BMP	2.4	1.2	0.0	1.2	116.4	31.4
Grower	3.5	1.2	0.3	2.1	104.9	49.5

Summary

- Met target of using an average of 1 foot of water (11.8 inches) to produce lettuce
- Grower water and nitrogen amounts were generally average
- Yield loss only at San Ardo trial (-14%); however, quality was improved at this site.
- Average yield of BMP practice was within 92% of grower treatment
- Irrigation scheduling and operation errors could be significant limitations to using the BMP approach