SALINITY MANAGEMENT IN PROCESSING TOMATOES

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WHERE DO SALTS COME FROM?

- Irrigation water is the primary source of salts in agricultural systems
- Also from fertilizers, manures, composts
- Shallow saline water tables

- Salts can accumulate in the root zone and damage crops

WHAT SALTS ARE IN THE WATER?

- Sodium (Na^+)
- Calcium (Ca^{2+})
- Magnesium (Mg^{2+})

Cations

- Chloride (Cl^-)
- Sulfate (SO_4^{2-})
- Bicarbonate (HCO_3^-)

Anions

Boron (B), Carbonate (CO_3^{2-}), Nitrate (NO_3^-), Potassium (K^+)

HOW IS SALINITY MEASURED?

Electrical Conductivity (EC)

EC_w = salinity of the water

EC_e = salinity of the soil

Total Dissolved Solids (TDS)

mg/L = ppm

Exchangeable Sodium Percentage (ESP): % of soil cation exchange sites occupied by sodium

Sodium adsorption ratio (SAR): a ratio of Na, Ca and Mg concentrations

HOW DOES SALT EFFECT PLANTS?

Overall salinity causes osmotic stress

Specific ion toxicity (Na, Cl, B)

Physical changes to the soil; water infiltration problems

HOW DOES SALT EFFECT PLANTS?

- Overall salinity → Osmotic stress
  - High salt restricts osmotic flow
    - more energy used to exclude salt in the root zone and take in water
  - Water stress symptoms
    - Stunting
    - Reduced yields

SALINITY VS SODICITY

- Salinity is a condition where the salt concentration is sufficiently high to reduce crops yields or quality (Electrical conductivity, EC)

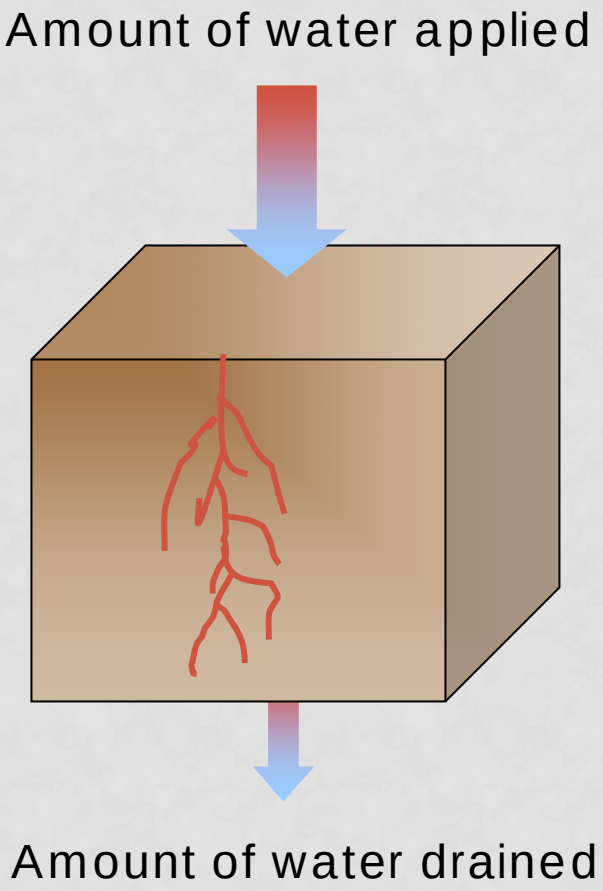
- Sodicity is a condition where the water is dominated by sodium (Na+); affects soil structure; poor aeration; water infiltration; affects plant health (measured as Sodium Adsorption Ratio, SAR; or Exchangeable Sodium Percentage, ESP)

SAR & EC_W TOGETHER AFFECT PERMEABILITY

Permeability	No Problem	Increasing Problem	Severe Problem
SAR = 0-3 & ECw =	> 0.7	0.7 – 0.2	< 0.2
SAR = 3-6 & ECw =	> 1.2	1.2 – 0.3	< 0.3
SAR = 6-12 & ECw =	> 1.9	1.9 – 0.5	< 0.5
SAR = 12-20 & ECw =	> 2.9	2.9 – 1.3	< 1.3
SAR = 20-40 & ECw =	> 5.0	5.0 – 2.9	< 2.9

SALINITY MANAGEMENT

Leaching Fraction (LF) = volume of water that drains below the rootzone / volume of water that infiltrates the ground



Steve Grattan, UCD

Salinity distribution in relation to various leaching fractions

ET

Same irrigation water ECw

Soil Depth

Low LF

High LF

40%

30%

20%

10%

ECe

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AMENDMENTS

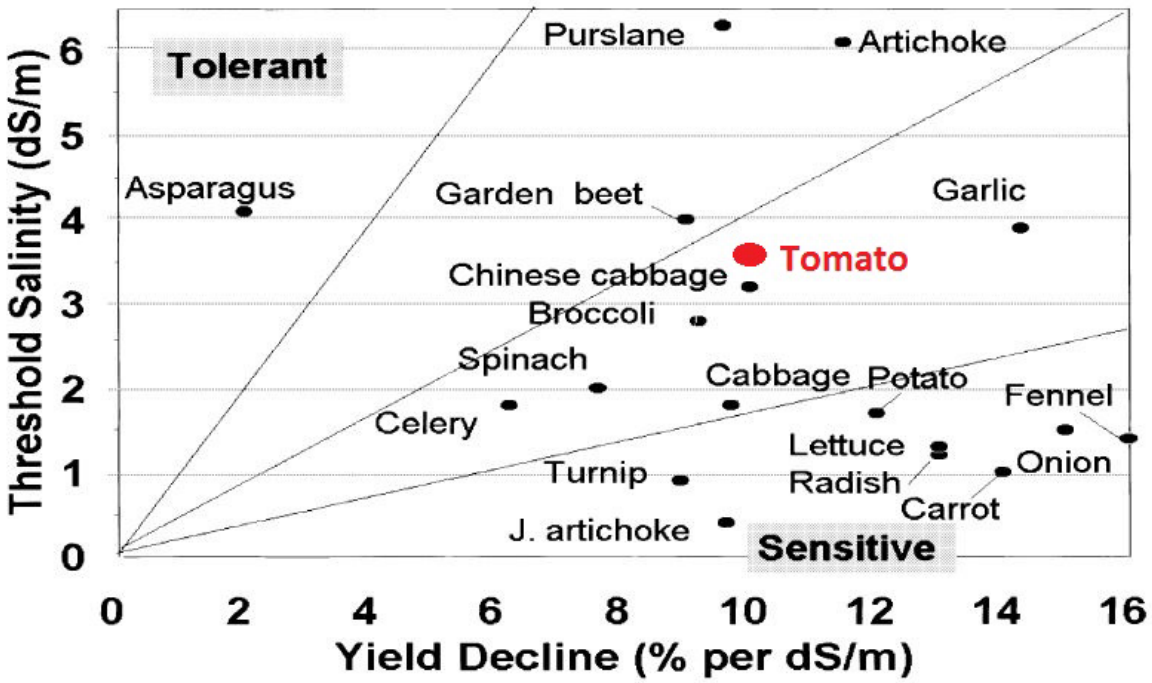
- Gypsum ($CaSO_4$)
- Sulfuric Acid (H_2SO_4)
  - In soils containing lime ($CaCO^3$)

Calcium

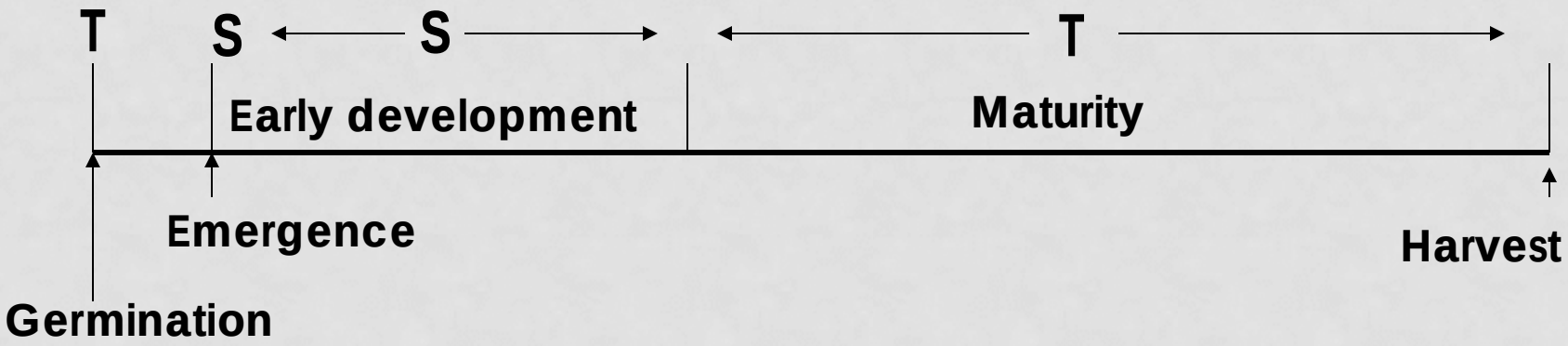
- Improves soil aggregation & structure
- Improves root function & ion transport across membranes
- Plants can tolerate higher ECe (+ 1-3 dS/m) in soils with high levels of gypsum

TOMATOES ARE MODERATELY SENSITIVE TO SALINITY

M.C. Shannon, C.M. Grieve/Scientia Horticulturae 78 (1999) 5–38

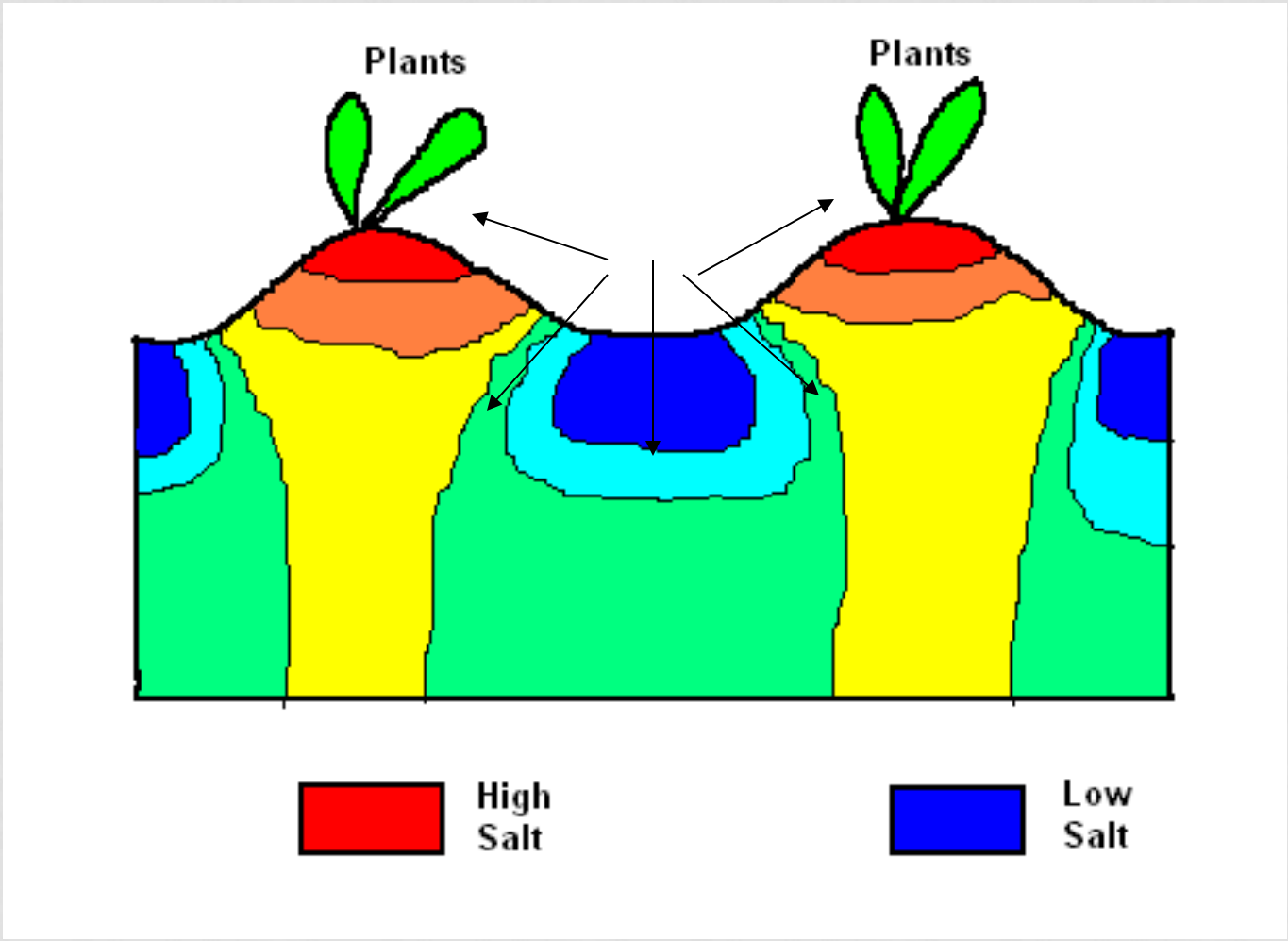


Crop Sensitivity to Salinity in Relation to Stage of Growth



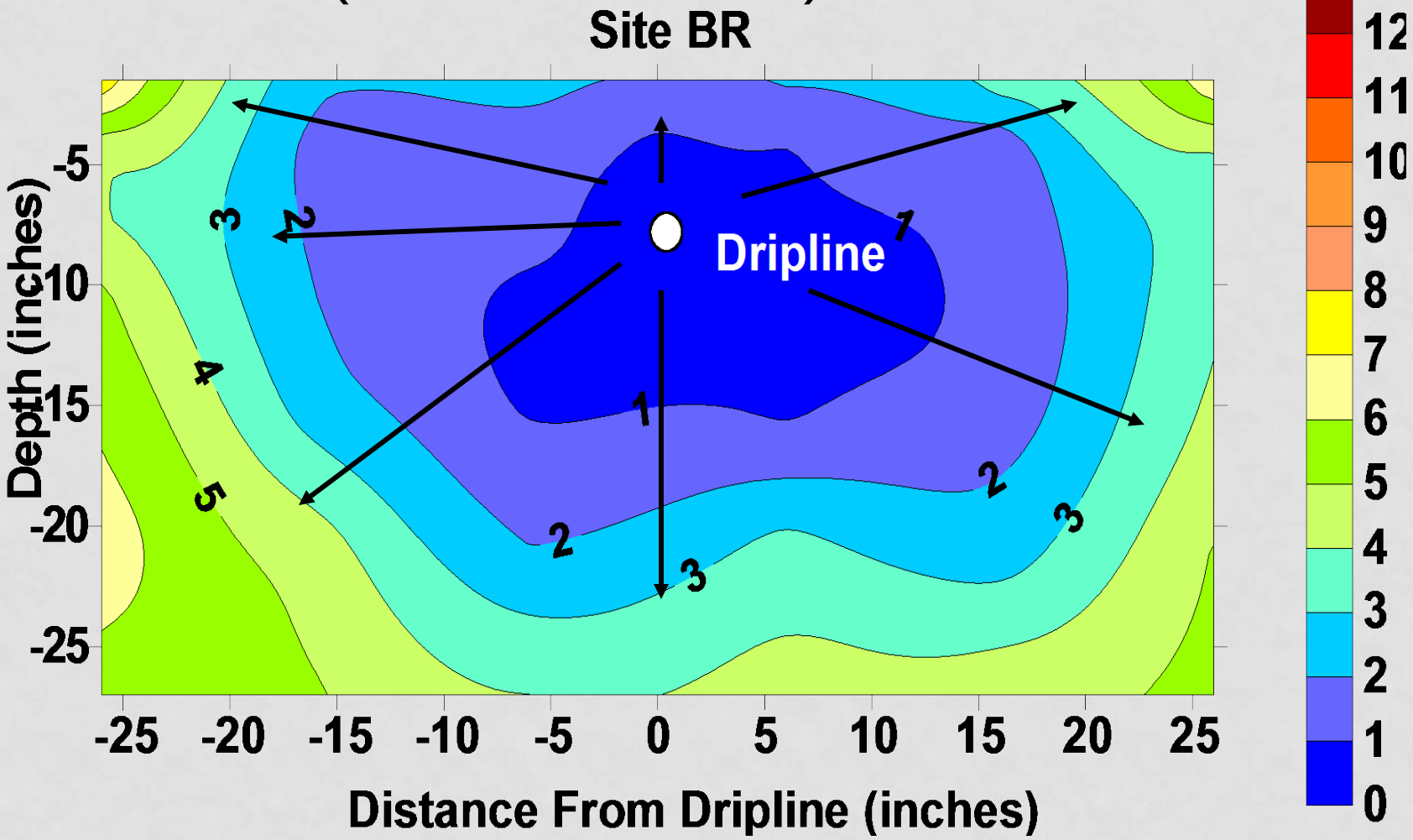
After Maas and Grattan, 1999

FURROW IRRIGATION



B. Hanson, 2005

Salt pattern under drip irrigation (ECw = 0.3 dS/m)



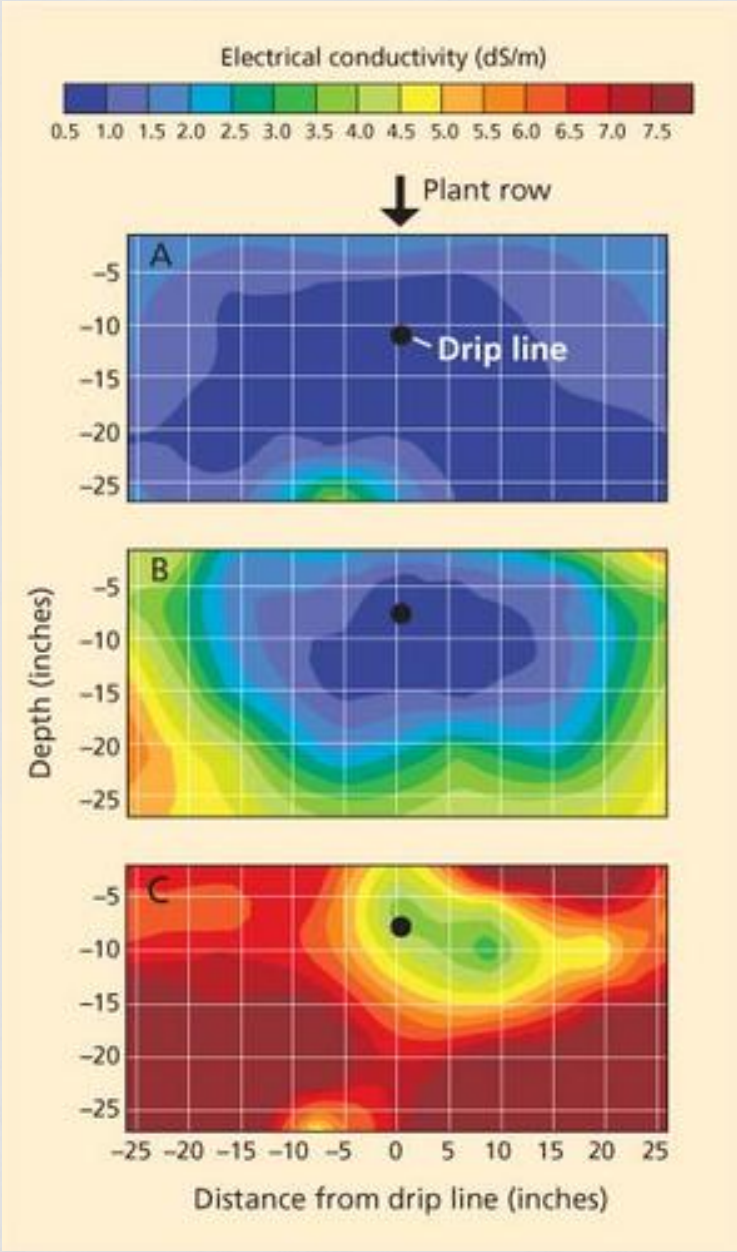
Hanson, 2005

Soil salinity around the drip line for water depth of about

(A) 6 feet, EC_w = 0.3 dS/m, EC groundwater = 8 to 11 dS/m;

(B) 2 to 3 feet, EC_w = 0.3 dS/m, EC groundwater = 5 to 7 dS/m

(C) 2 to 3 feet, EC_w = 1.1 dS/m, EC groundwater = 9 to 16 dS/m



Hanson and May (2009) California Agriculture 63(3):131-136.

PROCEDURES

Two commercial field sites in the Delta region

- Furrow irrigated field
- Drip irrigated field (2014 was second year)
  - Grower's schedule
  - Full irrigation in the early season followed by a deficit irrigation strategy

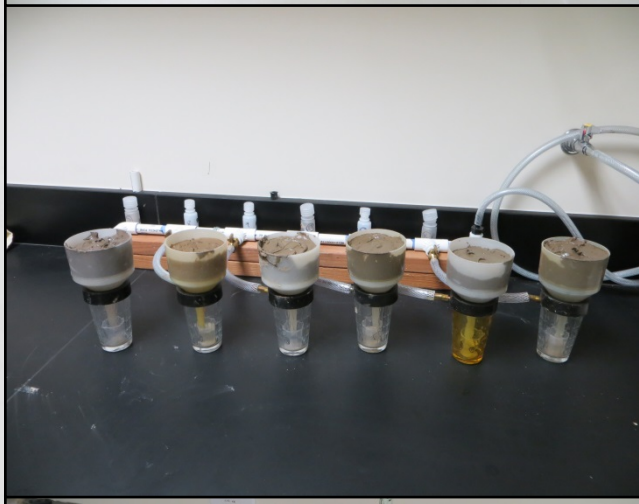
Both sites were transplanted with 60" bed configuration with single plant rows

Both sites sourced water from Middle River near Howard Road bridge, soils of both are categorized as Egbert series

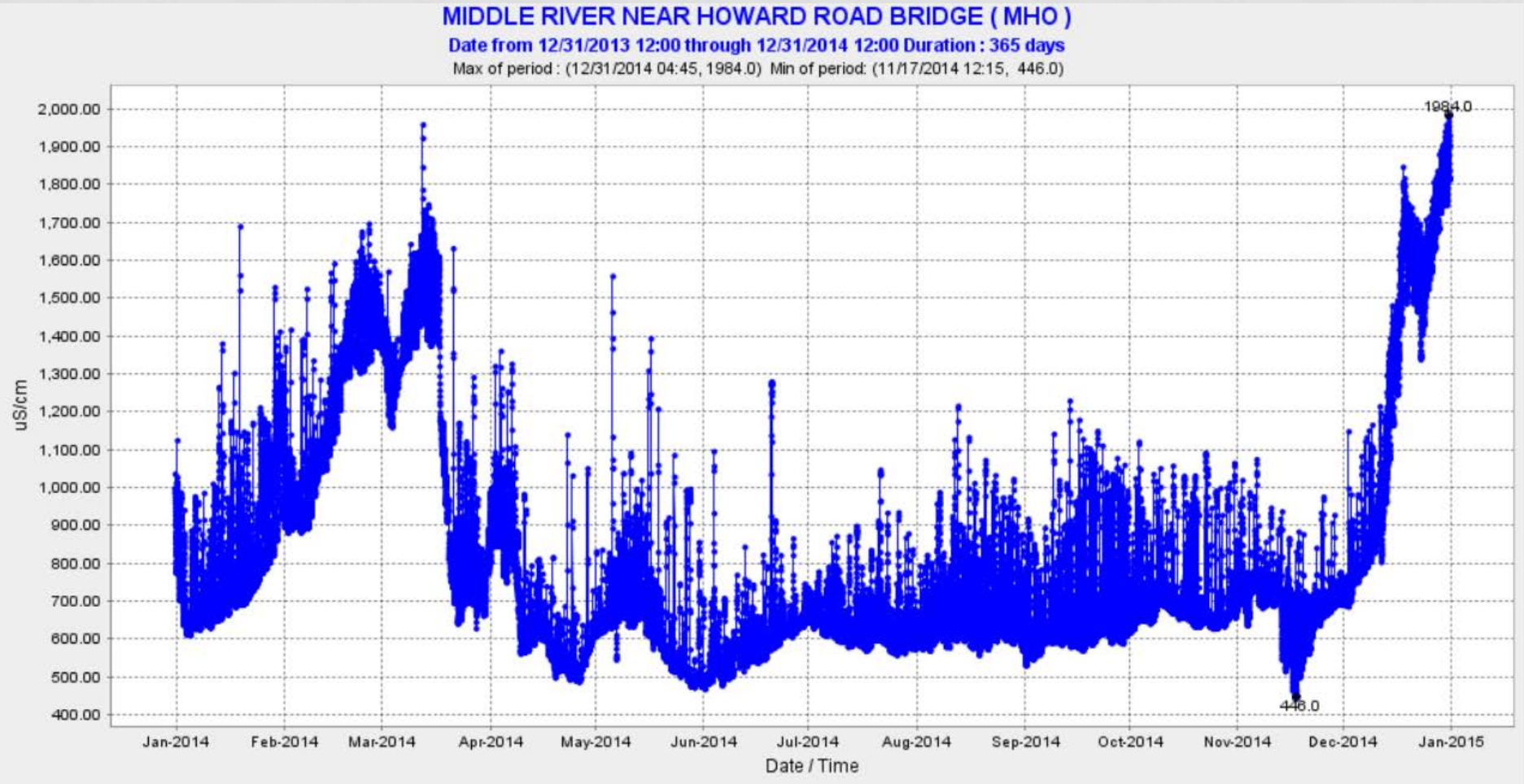
PROCEDURES

Measurements:

- Fruit yield and quality
- Applied water volumes (drip field)
- Groundwater salinity
- Depth to water table
- Irrigation water salinity
- Soil salinity



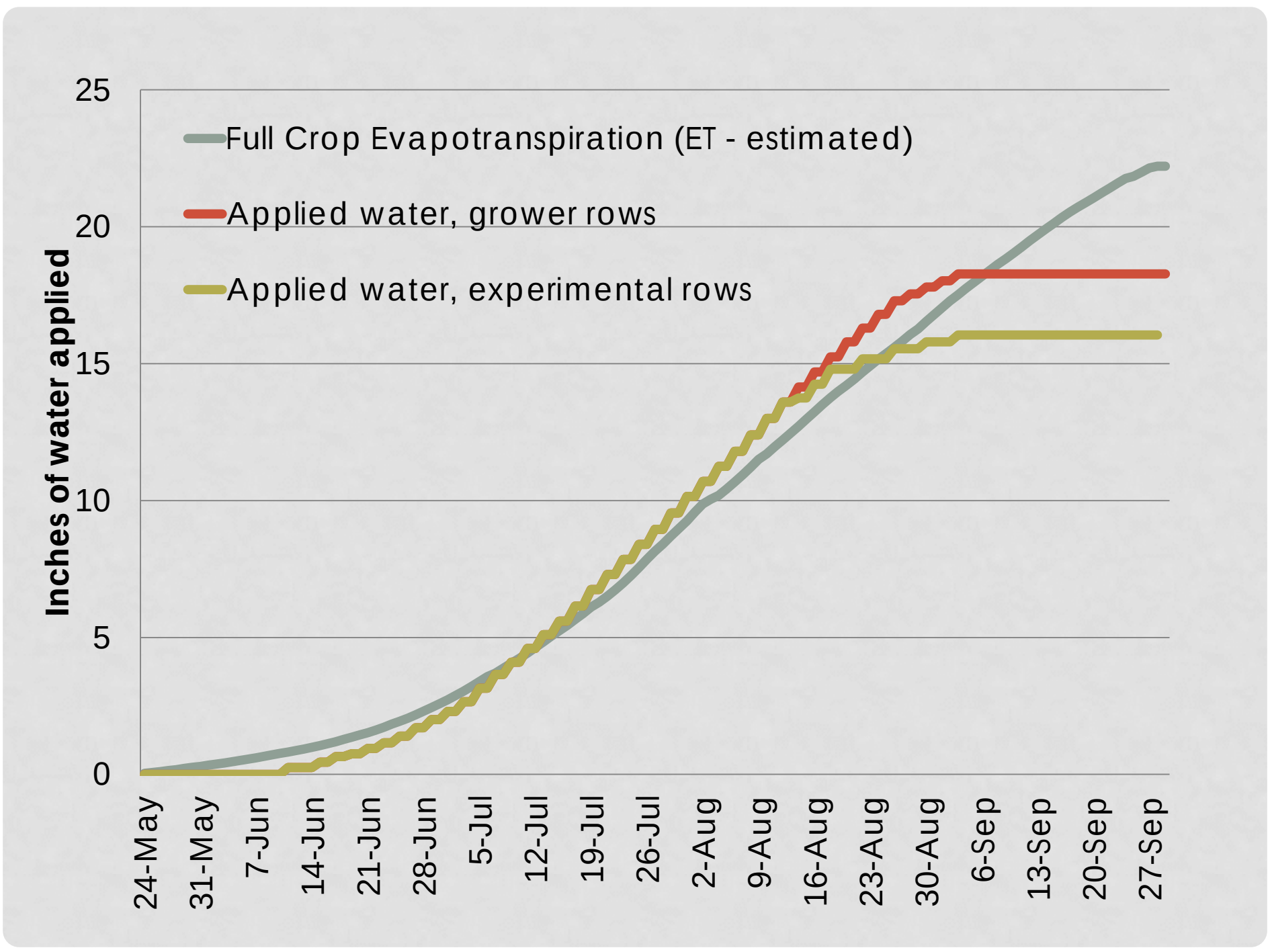
EC_W VARIES OVER THE SEASON



data from California Data Exchange Center

DRIP-IRRIGATED FIELD

- Soil sampled on May 13 after pre-irrigation
- Transplanted to UG 19406 on May 23
- Irrigation cutbacks initiated on Aug. 14, 7 weeks before harvest
- Soil sampled and harvested on Sept 29-30
- EC of irrigation water averaged 0.6 dS/m


Full Crop Evapotranspiration (ET - estimated)
Applied water, grower rows
Applied water, experimental rows
Inches of water applied
25
20
15
10
5
0
24-May
31-May
7-Jun
14-Jun
21-Jun
28-Jun
5-Jul
12-Jul
19-Jul
26-Jul
2-Aug
9-Aug
16-Aug
23-Aug
30-Aug
6-Sep
13-Sep
20-Sep
27-Sep

WATER BALANCE, DRIP FIELD

	Grower irrigation program	Experimental irrigation program
Stored soil moisture (inches in top 3 ft)		
Soil moisture at transplanting	17.6	17.3
Soil moisture at harvest	14.9	13.0
Stored soil moisture used	2.7”	4.3”
Irrigation water applied via drip system*	18.3”	16.0”
Consumptive water use (stored plus applied)	21.0”	20.3”
Estimated full crop ET**	22.2”	22.2”

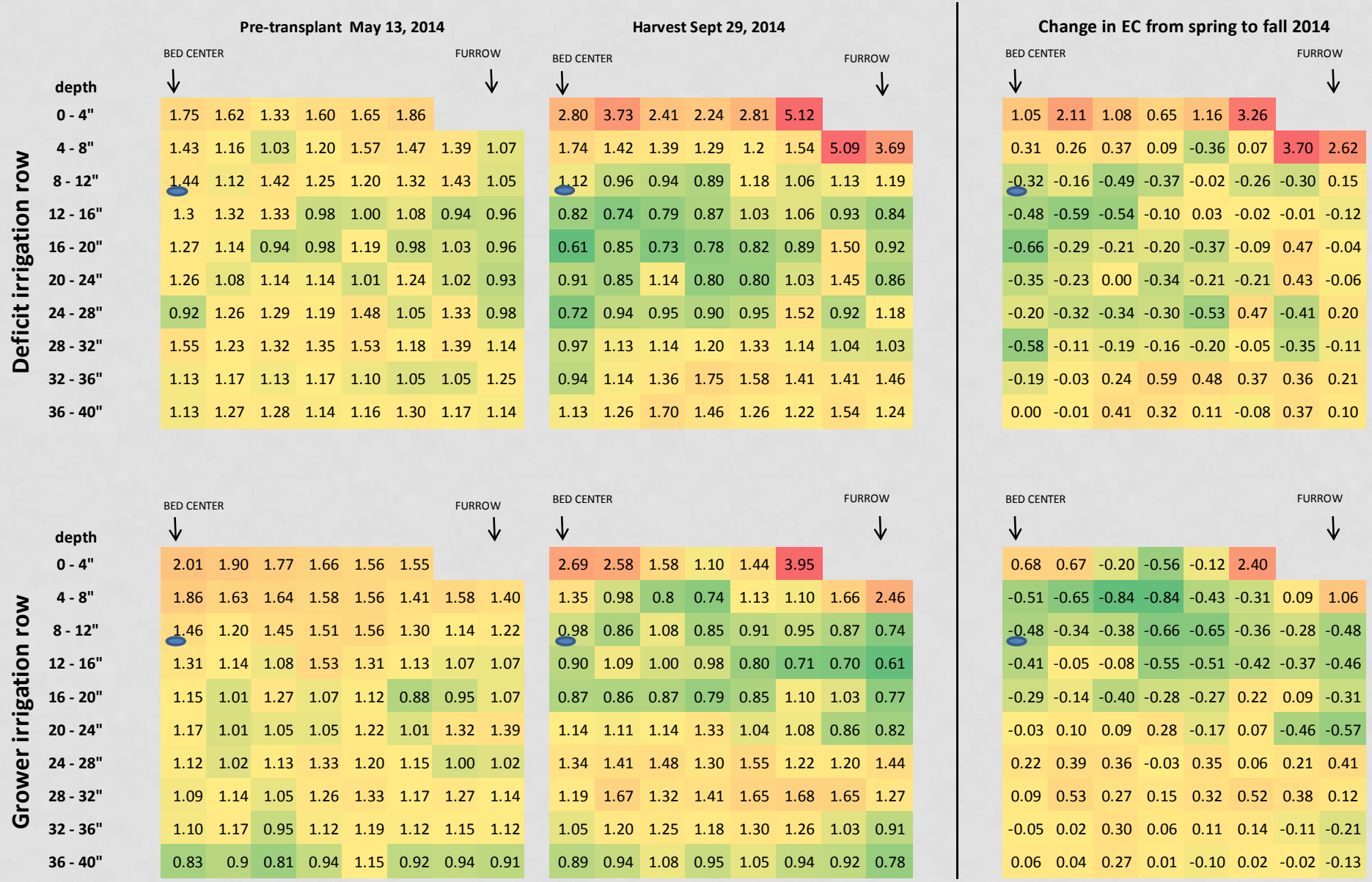
* does not include one pre-irrigation, which is captured by the soil moisture measurements.

** Estimate based on 2014 CIMIS data and crop coefficients of Hanson & May (2006).

YIELD AND FRUIT QUALITY

Irrigation Program	Yield (tons/acre)	Soluble solids (°Brix)	PTAB color	pH
Grower irrigation program	53.7	5.15	22.5	4.23
Experimental irrigation program	58.0	5.30	23.5	4.23

Drip field - Electrical Conductivity (dS/m)



Drip field - Chloride (ppm)

FURROW FIELD

- Transplanted with H5608 on Apr 29
- Soil sampled on May 20
- Irrigated weekly using alternate furrows
- EC_w averaged 0.62
- Last irrigation July 30
- Soil sampled Aug 29
- Harvested Sept 2

Furrow field - Electrical Conductivity (dS/m)

Furrow field - Chloride (ppm)

Field bottom

3 wks after transplanting

depth	BED CENTER							FURROW
0 - 4"	385	168	61	51	57	88	119	164
4 - 8"	166	105	84	78	78	83	78	86
8 - 12"	132	135	123	93	99	97	118	113
12 - 16"	130	142	132	141	126	127	169	127
16 - 20"	166	162	151	152	141	158	152	154
20 - 24"	168	182	156	156	142	152	165	165
24 - 28"	184	171	152	153	150	153	189	203
28 - 32"	238	202	189	173	207	182	205	242
32 - 36"	230	233	224	196	201	215	223	306
36 - 40"	286	281	288	217	237	202	257	347

At harvest

BED CENTER							FURROW
361	308	135	155	187	137		
84	75	82	105	124	96	104	297
116	155	130	143	141	124	119	130
269	330	249	184	167	139	216	233
376	418	246	264	294	317	368	414
293	389	352	349	352	387	394	426
310	380	383	374	394	388	393	391
377	418	414	376	375	414	398	393
381	414	426	467	506	462	414	331
281	308	350	383	466	463	386	402

Changes in chloride concentration from spring to fall

BED CENTER							FURROW
-24	140	75	104	130	48		
-81	-29	-2	27	45	13	26	211
-15	20	7	50	42	27	1	17
139	187	116	42	41	12	47	106
210	256	95	112	153	159	216	260
125	207	197	193	210	235	229	261
126	209	231	221	244	235	204	188
139	216	224	203	168	232	193	151
151	181	202	271	305	247	191	25
-5	27	62	166	229	261	130	55

Field top

3 wks after transplanting

depth	BED CENTER							FURROW
0 - 4"	273	113	64	67	100	131		
4 - 8"	91	47	55	53	43	48	55	43
8 - 12"	68	68	71	67	53	62	70	73
12 - 16"	84	85	82	76	84	93	78	72
16 - 20"	90	109	100	102	99	103	94	97
20 - 24"	114	112	109	112	113	108	119	110
24 - 28"	148	133	136	131	139	133	121	124
28 - 32"	150	161	154	140	152	158	137	138
32 - 36"	172	187	177	174	184	191	183	188
36 - 40"	180	199	187	193	206	186	214	232

At harvest

BED CENTER							FURROW
331	126	143	195	214	249		
93	91	74	76	58	61	209	
115	93	88	113	76	90	108	121
114	111	138	111	104	125	125	165
125	155	113	106	136	130	125	129
149	155	164	126	137	131	152	135
192	232	251	220	187	153	170	165
209	256	299	304	225	246	229	199
219	240	275	272	189	193	242	204
189	183	198	227	198	170	204	175

Changes in chloride concentration from spring to fall

BED CENTER							FURROW
58	13	78	128	114	118		
3	45	18	22	16	13	154	-43
48	25	18	46	23	28	37	49
30	26	56	35	20	33	47	92
35	46	13	4	37	27	31	33
34	43	55	13	24	23	34	26
44	99	116	89	48	19	49	41
60	95	145	163	73	88	92	62
47	53	98	99	5	2	58	16
9	-16	11	34	-8	-15	-9	-57

RESULTS

- Furrow field: Adequate leaching towards top of field, much poorer leaching towards bottom
- Drip field: Even with drip irrigation application volumes lower than estimated crop ET, localized leaching occurred around the drip tape (top 20 to 32 inches depending on soil texture)
- Slightly greater irrigation cutbacks with drip system did affect salinity increases somewhat
- High variability of Delta soils apparent even over short distances within the study area; soil texture and organic matter affect leaching ability

SALINITY MANAGEMENT

- Leach salts out of root zone
  - Drip tape aligned with plant row
  - Winter rainfall or irrigation
  - In-season irrigation in excess of ET
- More frequent in-season irrigations
  - Easier for plant to extract water
- Apply fertilizer modestly

RESOURCES

Free publication:

Drip Irrigation Salinity Management for Row Crops

University of California Agriculture and Natural Resouces Publication #8447

http://anrcatalog.ucdavis.edu

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