Salinity Management in Alfalfa Fields

Michelle Leinfelder-Miles

Delta Farm Advisor, San Joaquin County

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Presentation outline

- Background – salts, soils, and plant responses
- Management approaches
- Research results
- Summary

Background

- Saline soil
- Saline-sodic soil
- Sodic soil

- Electrical conductivity (EC)
- Exchangeable sodium percentage (ESP)
- Sodium adsorption ratio (SAR)

Background

EC: the ability of a solution to conduct an electric current.

- Soil saturated paste (ECe), water (ECw), units dS/m

ESP: the degree to which the soil exchange complex is saturated with sodium.

SAR: the comparative concentration of Na^{+}, Calcium (Ca^{2+}), and Magnesium (Mg^{2+}) on the soil exchange complex.

Both ESP and SAR characterize the sodium status of an alkaline soil, but SAR is becoming more widely used.

Background

Saline soil: has sufficient soluble salts to impair productivity.

- ECe > 4 dS/m, SAR < 13, pH < 8.5

Saline-sodic soil: has sufficient soluble salts and exchangeable Na^+ to impair productivity

- ECe > 4 dS/m, SAR > 13, pH < 8.5

Sodic soil: has sufficient Na^+ to impair productivity

- ECe < 4 dS/m, SAR > 13, pH > 8.5

Background

Visual indicators of salt problems:

- White crusts on soil surface *(saline)*
- Black crusts on soil surface *(sodic)*
- Slick spots *(sodic)*
- Marginal leaf burn
- Presence of salt-tolerant weeds

Background

Effects on plants:

- Osmotic stress
- Physical changes to the soil
- Toxicities

Why is salinity an important consideration in alfalfa?

- Limited water supplies exacerbate salinity.
- Deficit irrigation may be employed, especially during droughts.

How can we manage salinity?

- More precise methods of irrigation (e.g. drip) may increase salinity if there isn't sufficient water applied to meet crop evapotranspiration (ET) and leaching.
- Alfalfa is being grown on lower quality soils with lower quality water (e.g. recycled or degraded).
- Alfalfa is higher value than many other salt-tolerant plants

(Text modified from D. Putnam.)

Site selection

When sites have adequate rooting depth, nutrition, aeration, and water,

and no salinity or alkalinity problems,

and when good management practices are employed, average annual yields can meet or exceed 8-10 tons/acre.

Characteristic	Ideal	Marginal	Undesirable
Soil texture	Sandy loam, silt loam, clay loam	Loamy sand, silty clay	Sand, clay
Soil depth (feet)	>6	3-6	<3
pH	6.3-7.5	5.8-6.3 and 7.5-8.2	<5.8 or >8.2
ECe (dS/m)	0-2	2-5	>5
ESP	<7	7-15	>15
Boron (mg/L)	0.5-2.0	2-6	>6
Water logging or high water table	Never	Only during dormant period	Sometimes during periods of active growth
Slope	Nearly level	Slightly sloping to 12% slope	>12% slope
pH of water	6.5-7.5	7.5-8.2	>8.2
ECw (dS/m)	<1.3	1.3-3.0	>3.0
SAR	<6.0	6.0-9.0	>9.0

(From Irrigated Alfalfa Management, UC ANR 3512)

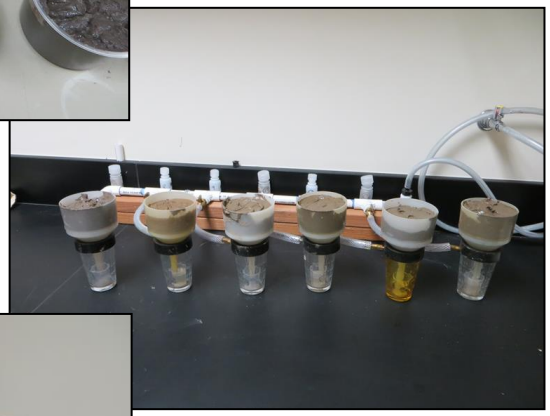
Site selection

There's an app for that!

Search Soil Web in your app store, or visit http://casoilresource.lawr.ucdavis.edu/drupal/node/902 for more information on smart phone and Google technologies. Brought to you by the California Resource Soil Lab at UC Davis.

Monitor soil and water

- Sample soil down several feet, keeping depths separate.
- Sample in several places in the field.
- Laboratory analysis includes grinding the soil, making a saturated paste, and measuring the ECe.



Variety evaluation

Tolerance**	Var. #	Variety name	EC_w(dS/m)		
			5	10	15
T	18	AZGERM SALT II	98.0	79.2	57.0
"	17	AZ90NDCST	98.0	77.3	57.6
"	7	HYBRIFORCE800	95.5	76.2	56.3
"	9	FG96T707	97.9	74.7	53.6
"	8	DS067092	95.6	75.2	48.0
MT	2	SW8421S	97.6	70.3	52.6
"	13	CW8028	95.8	72.1	47.8
"	5	WL656HQ	97.5	69.6	46.4
"	3	6906N	97.2	68.3	46.4
"	12	CW58S	96.2	65.7	42.7
"	15	SW9215	96.9	64.5	43.2
MS	11	CW48S	96.2	62.2	40.8
"	14	DS077661	97.2	60.5	39.3
"	1	SW9720	96.2	57.2	41.9
"	6	AMERISTAND901SQ	97.0	57.9	40.8
"	20	CUF101(a)	94.7	54.9	44.3
"	4	CUF101(b)	94.6	54.7	43.9
S	10	CW9S	97.0	44.6	40.6
"	16	AZ88NDC	96.1	49.8	35.4
"	19	MESA SIRSA	98.3	45.8	32.5

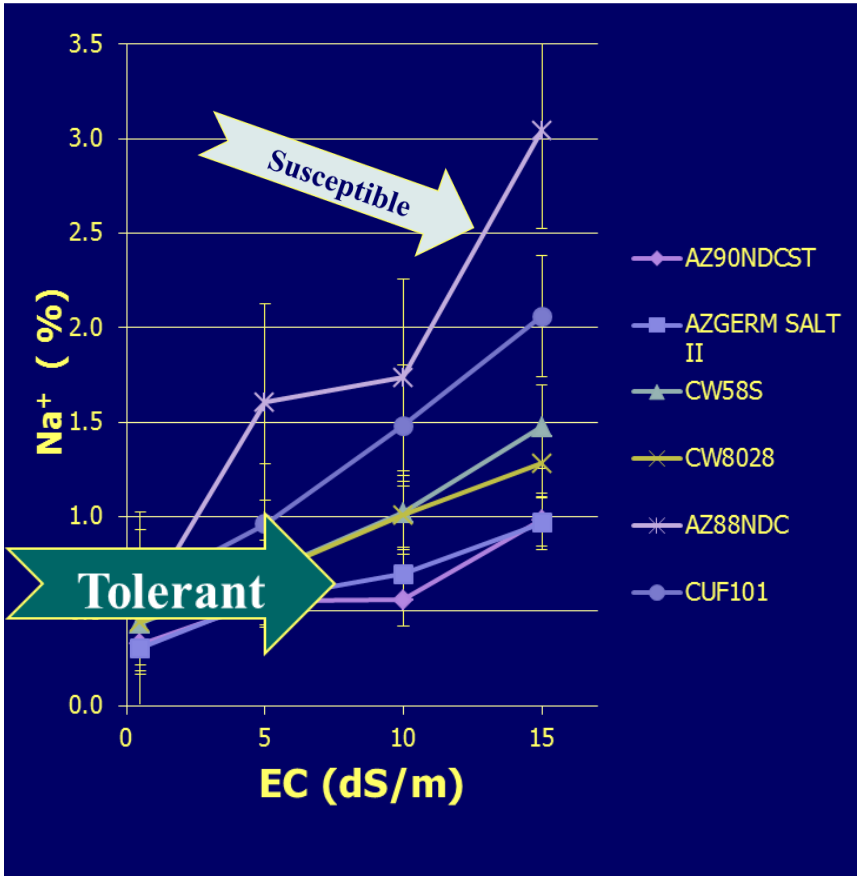
- Relative yield (RY, %)* – cumulative over 7 cuttings
- Ranking based on RY at 10 dS/m
- T (Tolerant) = > 75% RY
- MT (Mod. Tolerant) = 65 - 74% RY
- MS (Mod. Sensitive) = 55 - 64% RY
- S (sensitive) = < 50% RY

* Relative to non-saline 0.5 dS/m treatment

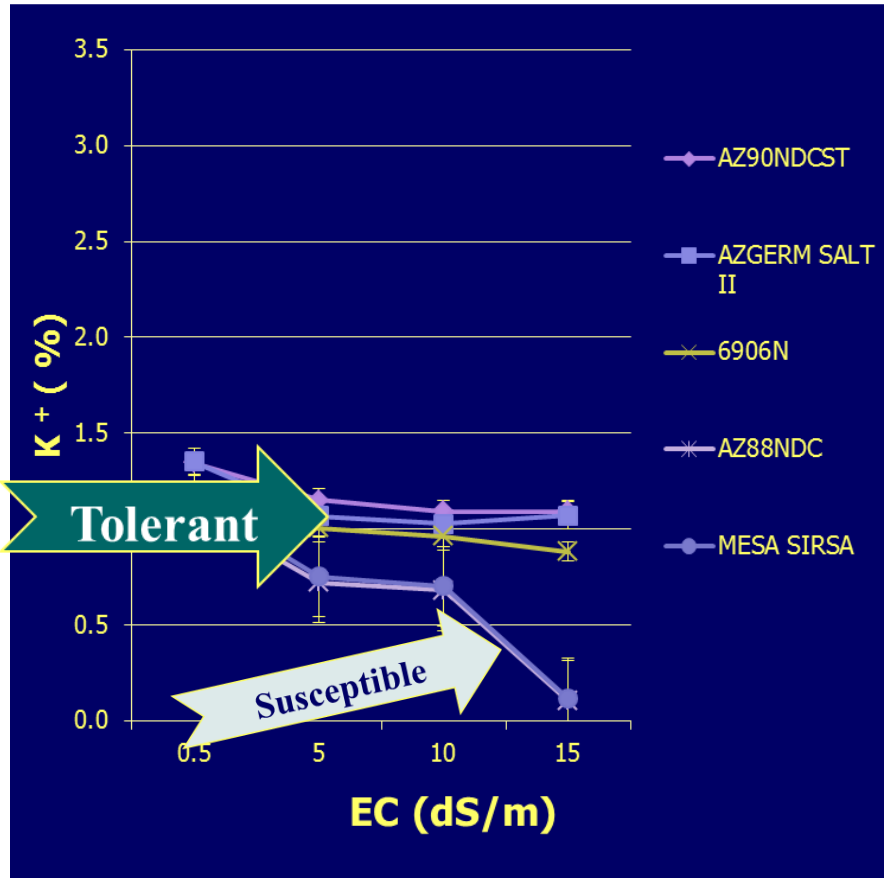
(Courtesy D. Putnam)

Variety evaluation

Na (%) accumulated in alfalfa shoots



K (%) accumulated in alfalfa shoots



(Courtesy D. Putnam)

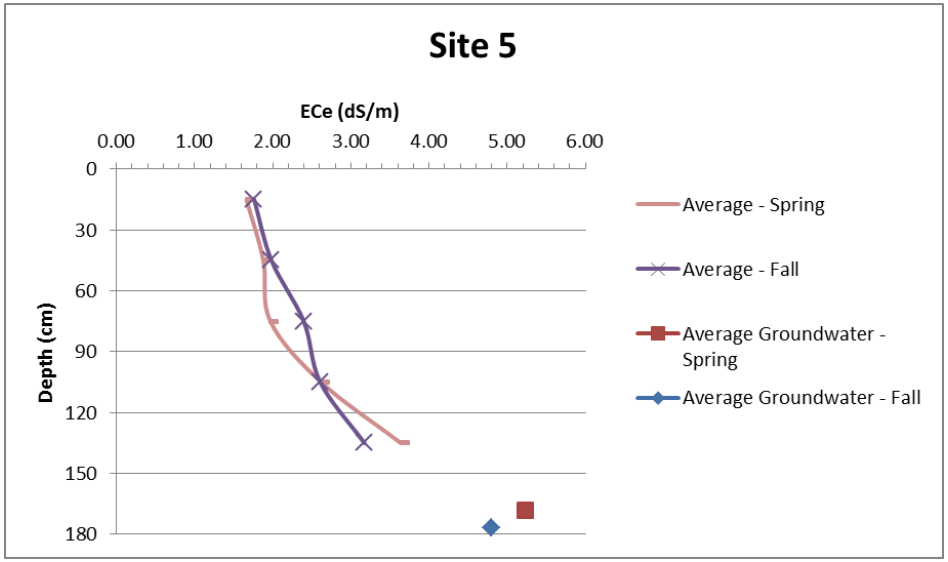
Soil salinity management

- Plant breeding is not a substitute for soil salinity management.
- Leaching occurs when water is applied in excess of what the crop needs to meet its ET requirement.
- Leaching fraction is the fraction of water that passes below the root zone divided by the total applied water.

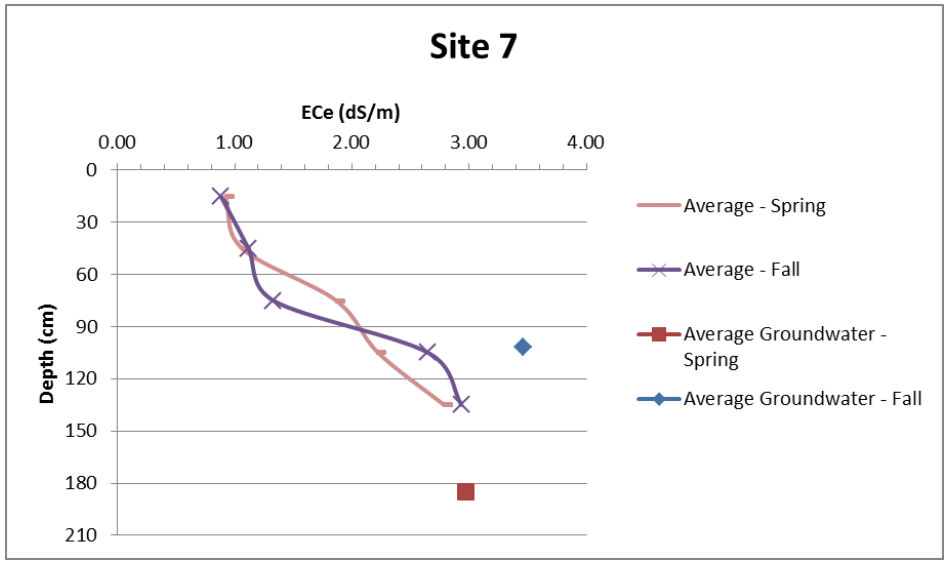
Delta research

Site	Soil Series	Root Zone ECe (dS/m)		Irrigation Water ECw (dS/m)	
		Range	Average	Range	Average
1	Merritt silty clay loam	1.9-10.8	6.8	0.2-0.7	0.6
2	Merritt silty clay loam	1.5-14.1	8.9	0.5-1.0	0.8
3	Merritt silty clay loam	0.9-1.2	1.0	0.2-0.7	0.6
4	Merritt silty clay loam	1.3-9.5	5.1	0.3-0.8	0.5
5	Grangeville fine sandy loam	1.8-3.2	2.4	0.3-2.8	1.8
6	Grangeville fine sandy loam	2.4-8.1	5.7	0.6-1.1	0.9
7	Ryde clay loam	0.9-2.9	1.8	0.3-0.4	0.4

Delta research

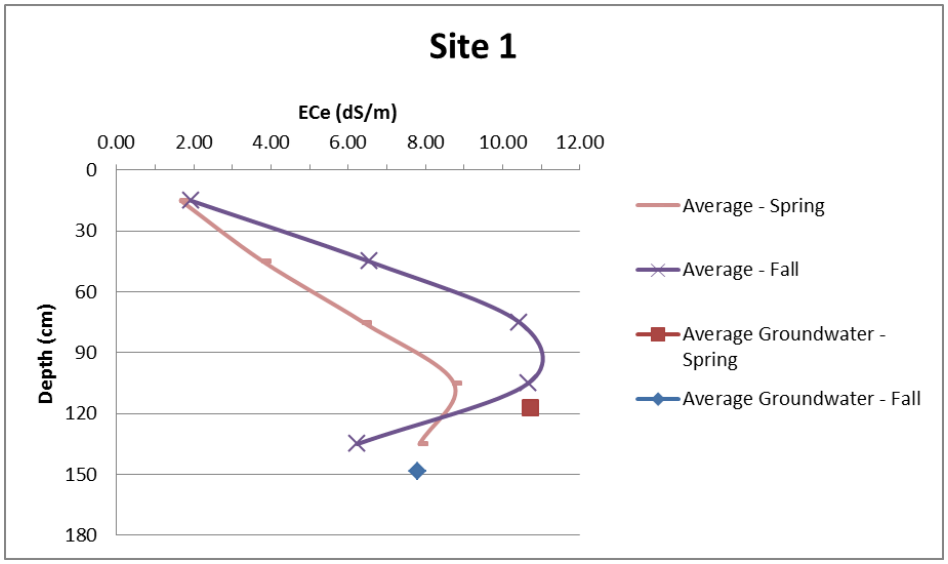


ECe = 2.4 dS/m (root zone average)
ECw = 1.8 dS/m (seasonal average)
Fine sandy loam
Ksat = 101 mm/hr to 152 cm depth

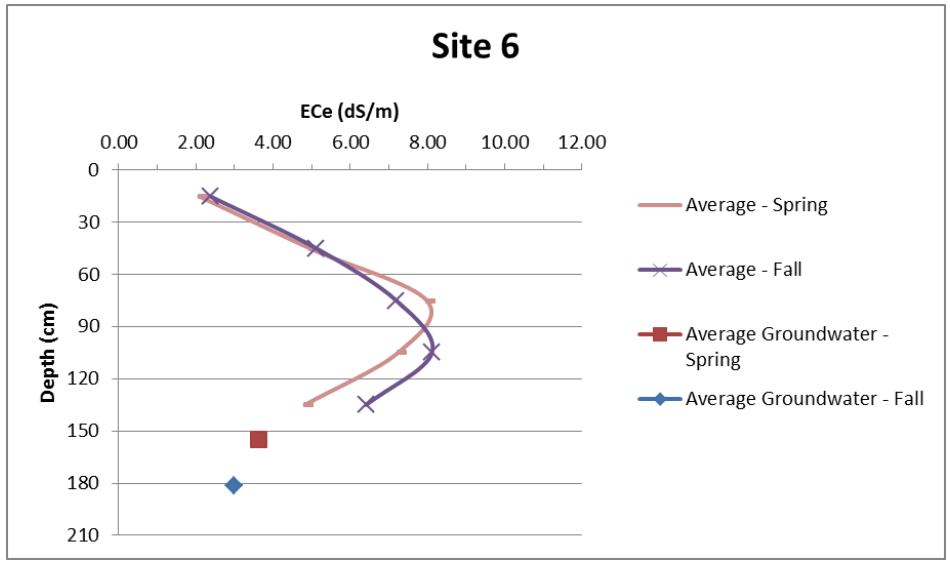


ECe = 1.8 dS/m (root zone average)
ECw = 0.4 dS/m (seasonal average)
Clay loam
Ksat = 10 mm/hr to 70 cm depth

Delta research

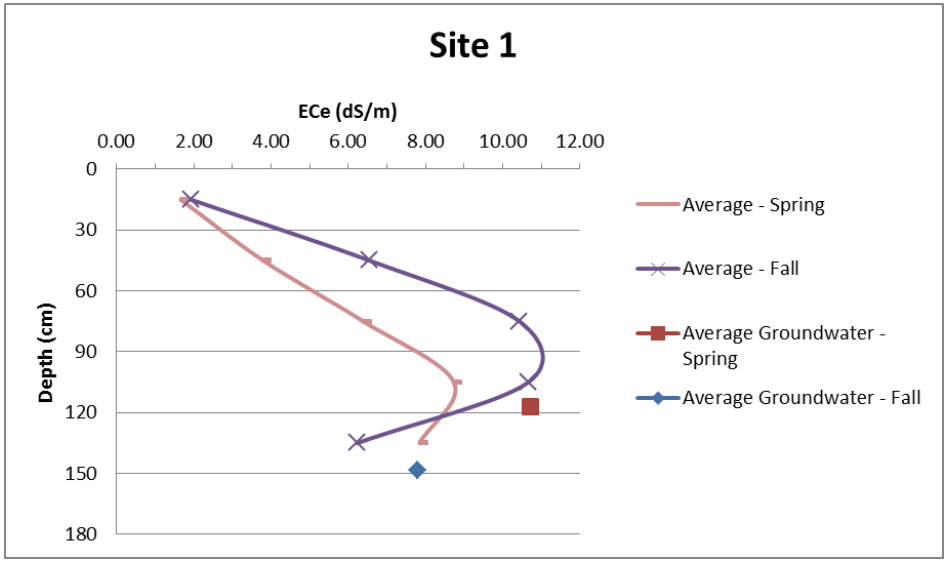


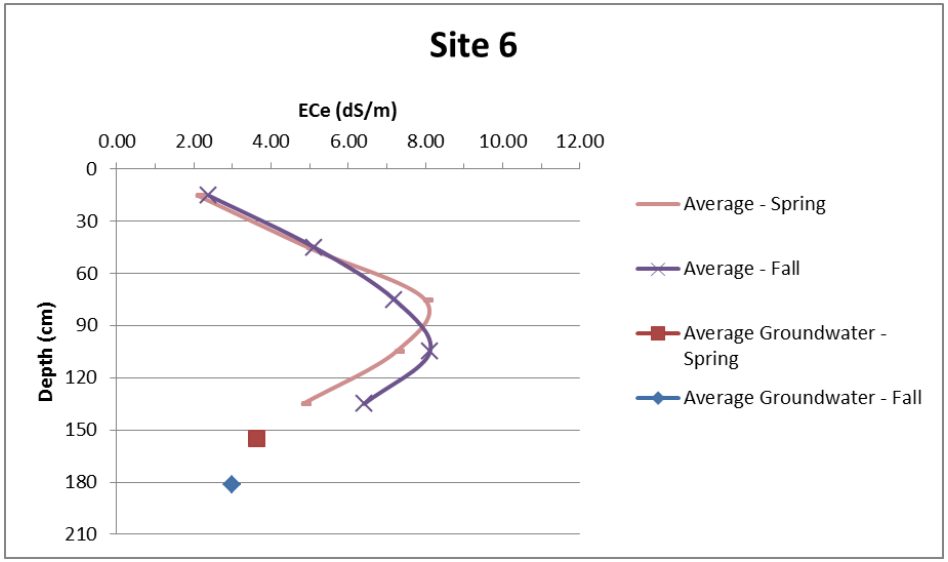
ECe = 6.8 dS/m (root zone average)
ECw = 0.6 dS/m (seasonal average)
Silty clay loam
Ksat = 10 mm/hr to 124 cm depth

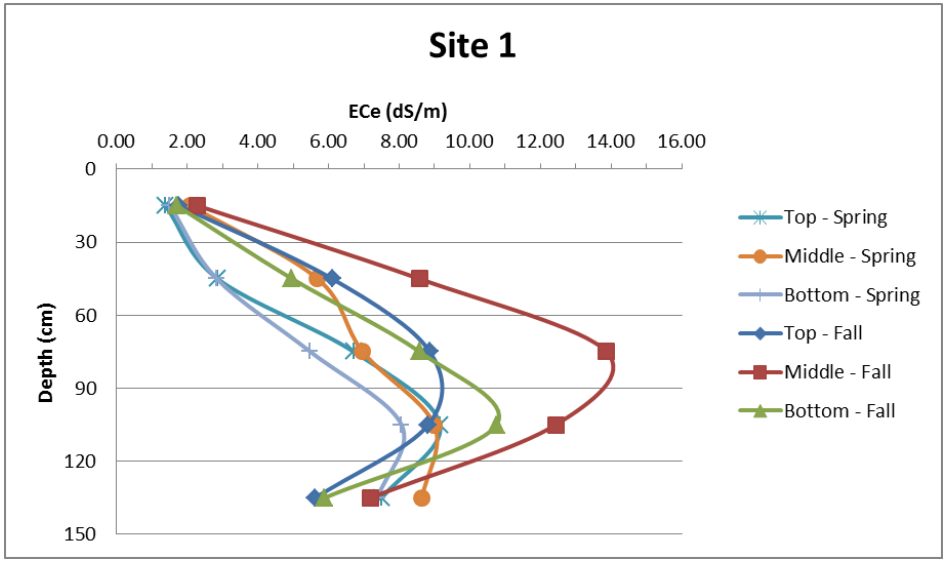


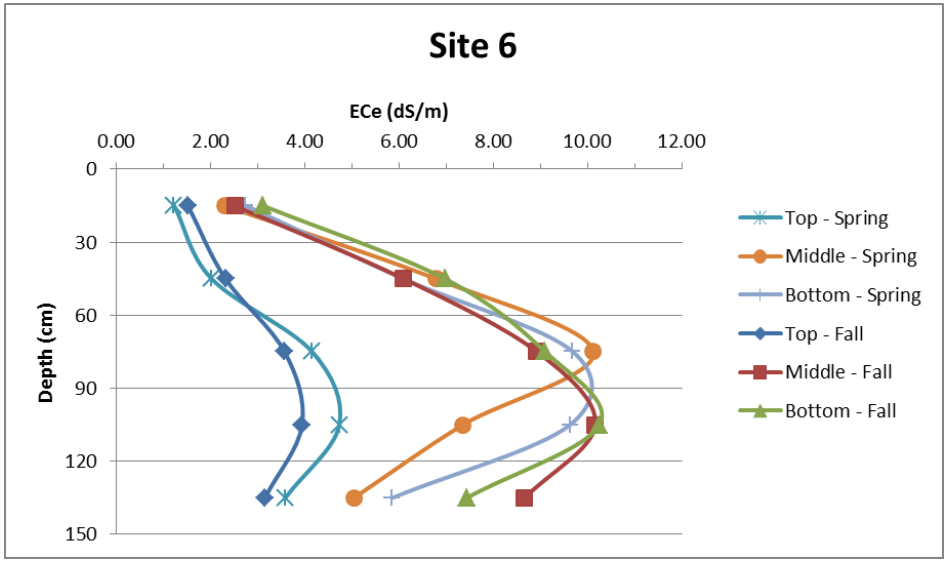
ECe = 5.7 dS/m (root zone average)
ECw = 0.9 dS/m (seasonal average)
Fine sandy loam
Ksat = 101 mm/hr to 152 cm depth

Delta research









Summary

- Site selection:
  - Know your soil series and its inherent characteristics (texture, Ksat, EC)
- Monitor soil and irrigation water salinity
- Variety selection
  - Research currently being conducted by Dan Putnam and others
  - Preliminary results show ECw tolerance up to 10 dS/m
  - Tolerant varieties accumulate K^+ over Na^+ in the shoots

Summary

- Soil salinity management
  - Leaching: applying water in excess of ET.
  - Establish stand with best quality water (if different sources are available).
  - Blend water when multiple sources are available.
  - Look for seasonal patterns and patterns across the field and down the border check. Consider ways to manage irrigation based on those patterns.
  - Leach during the off-season by leveraging rainfall with irrigation water to wet profile before a rain event.

Thank you!

Michelle Leinfelder-Miles

(209) 953-6120

mmleinfeldermiles@ucanr.edu

http://ucanr.edu/sites/deltacrops/