Water Quality for Turfgrass Management

Larry Stowell, Ph.D.

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What will be covered

- Turf performance goals expectations
- Climate and rainfall patterns
- Key water quality factors
- Hydraulic conductivity and drainage

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1
PAR


PALACE RESORTS
Hogar de Cocodrilos / Crocodiles Home
No molestar ni alimentar
Do not disturb, do not feed

What will be covered

- Turf performance goals - expectations
- Climate and rainfall patterns
- Key water quality factors
- Hydraulic conductivity and drainage

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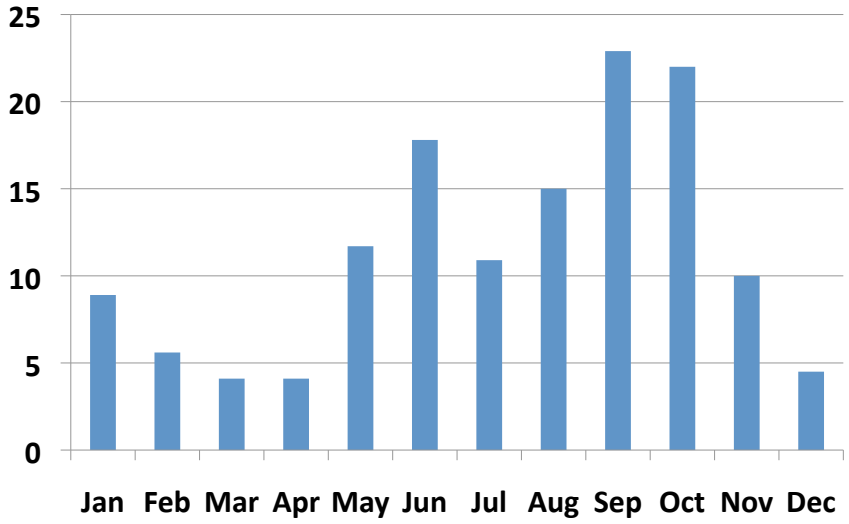
Cancun Rainfall (cm)



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Tissue Guidelines

Parameter	PACE General Guideline	Seashore Paspalum
% Nitrogen (N)	3.0 - 6.0	2.8 - 3.5
% Phosphorus (P)	0.3 - 0.5	0.3 - 0.6
% Potassium (K)	1.8 - 4.0	2.0 - 4.0
% Calcium (Ca)	0.2 - 1.0	0.25 - 1.5
% Magnesium (Mg)	0.2 - 1.0	0.25 - 0.60
% Sulfur (S)	0.2 - 0.4	0.2 - 0.6
ppm Iron (Fe)	12 - 300	50 - 500
ppm Zinc (Zn)	20 - 50	20 - 250
ppm Manganese (Mn)	17 - 200	50 - 300
ppm Copper (Cu)	6 - 50	5 - 50
ppm Boron (B)	6 - 40	5 - 60

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	Likelihood of Soil Problems		
	Low	Medium	High
ECw (dS/m,mmhos/cm)	< 0.7	0.7 - 3.0	> 3.0
TDS (mg/l, ppm)	< 450	450 - 2000	>2000
SAR 0 - 3	ECw > 0.7	ECw 0.7 - 0.2	ECw < 0.2
SAR 3 - 6	ECw > 1.2	ECw 1.2 - 0.3	ECw < 0.3
SAR 6 - 12	ECw > 1.9	ECw 1.9 - 0.5	ECw < 0.5
SAR 12 - 20	ECw > 2.9	ECw 2.9 - 1.3	ECw < 2.9
Sodium Na (me/l)	< 3	3 - 9	> 9
Sodium Na (mg/l, ppm)	< 70	70 - 200	> 200
RSC (me/l)	< 1.25	> 1.25	
Nitrate NO3 - N (mg/l, ppm)	< 5	5 - 20	> 30
Ammonium NH4 - N (mg/l,ppm)	<5	5 - 20	> 20
Boron B (mg/l, ppm)	< 0.5	0.5 - 3.0	> 3.0
Bicarbonate HCO3 (me/l)	< 1.5	1.5 - 8.5	> 8.5
Bicarbonate HCO3 (mg/l, ppm)	92	92 - 520	> 520
Chloride Cl (me/l)	< 3	> 3	
Chloride Cl (mg/l, ppm)	< 105	> 105	

Cancun Water Examples

	Playacar pump sta.	Playacar sprinkler 13	Moon sprinkler 14	Moon pump sta. Dunes	Riviera
EC dS/m	2.9	2.4	1.7	1.5	1.8
TDS ppm	1864	1564	1107	962	1125
pH	8.9	8.1	7.9	8.2	8.6
SAR	6.5	5.86	5.9	4.1	6.0
HCO3 ppm	231	298	182	124	171
Na ppm	296	289	230	184	228
RSC meq/l	0	0	0	0	0
B ppm	0.07	0.07	0.2	0.03	0.2
Cl ppm	529	518	507	386	507

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Cancun Soil Examples

Parameter	Desired value (Sufficiency)	Playacar Green	Playacar Fairway	Moon Green (Dunes)	Moon Fairway (Dunes)	Riviera Green	Riviera Fairway
pH	6.0-7.5	8.3	8.3	8.2	8.3	8.4	8.1
Phosphorous (ppm)	>50	12	3.1	16	3.9	9.0	8.8
Calcium (ppm)	>750	17,497	27,563	627	20,168	284	25,380
Magnesium (ppm)	>140	808	610	63	282	51	484
Potassium (ppm)	51 - 116	34	44	45	39	71	156
Sodium (ppm)	<110	141	191	108	96	135	737
Sulphur (ppm)	15 - 40	83	29	53	45	31	260
Boron (ppm)	0.5 – 1.5	1.5	0.6	0.6	0.7	0.9	1.5
Copper (ppm)	0.1 – 2.5	0.91	0.6	0.7	0.3	0.7	0.4
Iron (ppm)	90 - 150	11	24	26	11	17	13
Manganese (ppm)	30-50	6	12	14	2	5	6
Zinc (ppm)	1 - 2	17	4.3	7	3	1.9	8.7

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Cancun Soil Examples

% Base Saturation							
% calcium	65 – 80%	89	93	72	94	59	91
% magnesium	10 - 20%	6.9	3.4	12	2.2	18	2.9
% potassium	2 - 7%	0.1	0.1	2.6	0.1	7.6	0.3
% sodium	<3%	0.6	0.6	11	0.4	12	2.3
Other Values							
EC (dS/m)	<6	--	--	--	--	--	--
TEC (meq/100g)	>4	98	148	4.4	107	2.4	139
% Organic matter	<3%	1.8	1.6	0.04	0.1	0.1	1.9

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Greatest Challenges

1. Physical soil limitations – saturated hydraulic conductivity (Ksat) water holding capacity (wilting point)
2. Cost of cultural practices
   - Aeration
   - Deep solid tine cultivation
   - Sand top dressing where soils have low Ksat (target > 1.0 in/hr = 7 um/sec)
   - Amendments such as gypsum
3. Leaching to prevent salt accumulation
4. Drainage

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Causes of soil moisture problems

Irrigation distribution uniformity

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Irrigation system design

- Even the newest, state-of-the-art system is flawed
- 80% uniformity is the best that can be achieved with irrigation
- 60-70% is more typical
- 100% uniformity can only be achieved with rain

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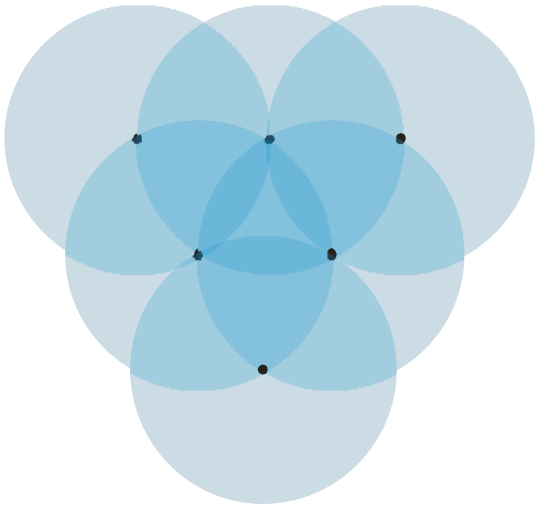
Irrigation Distribution Problems - Theoretical Best (81%)



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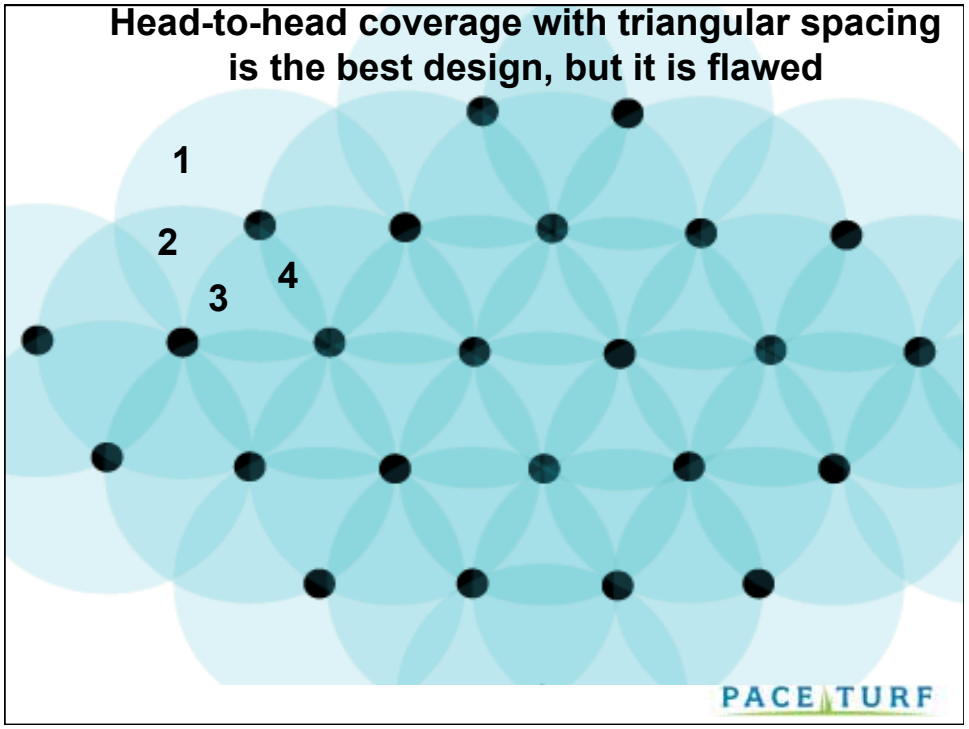
Head-to-head coverage with triangular spacing is the best design, but it is flawed
1
2
3
4
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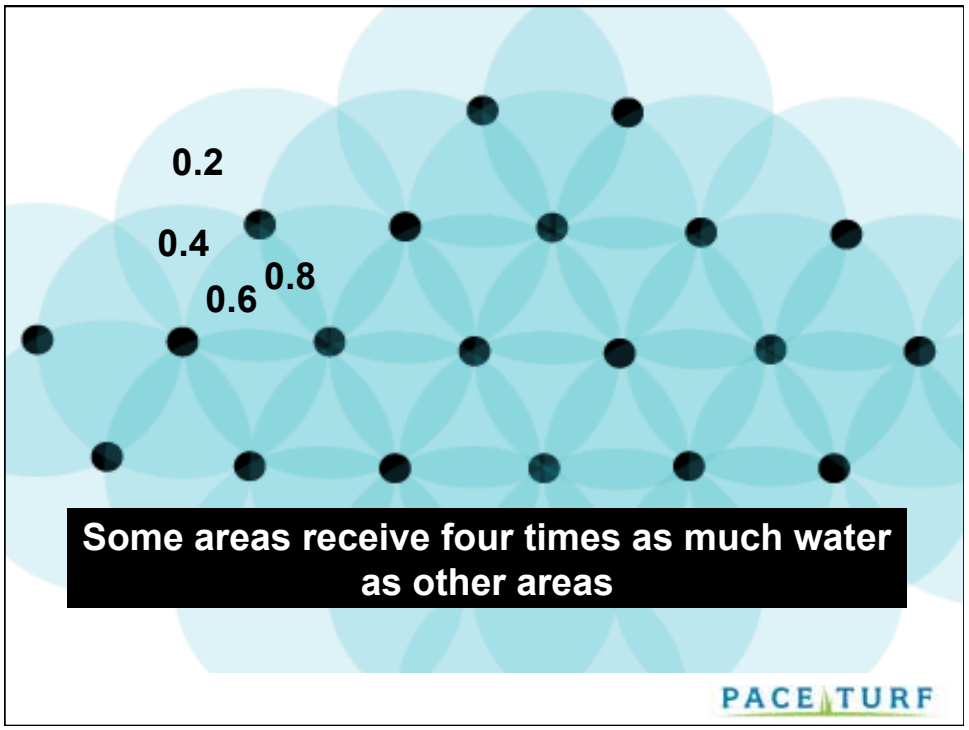
0.2
0.4
0.6
0.8
Some areas receive four times as much water as other areas
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Irrigation Distribution Problems - Healthy Turf

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Irrigation Distribution Problems - Drought-Stressed Turf

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Sprinkler performance: broken nozzles

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Sprinkler performance: broken nozzles

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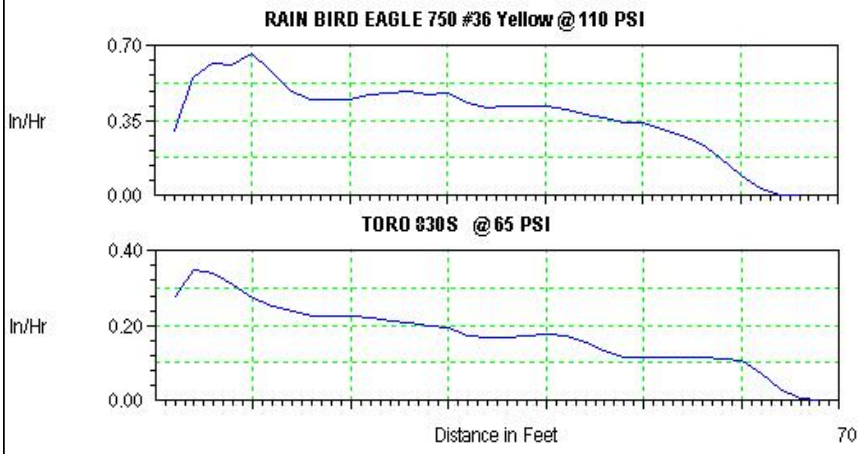
Sprinkler system design

Center for Irrigation Technology



cati.csufresno.edu/cit/good/citprofiles.html

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Obstacles: tree "irrigation shadow"

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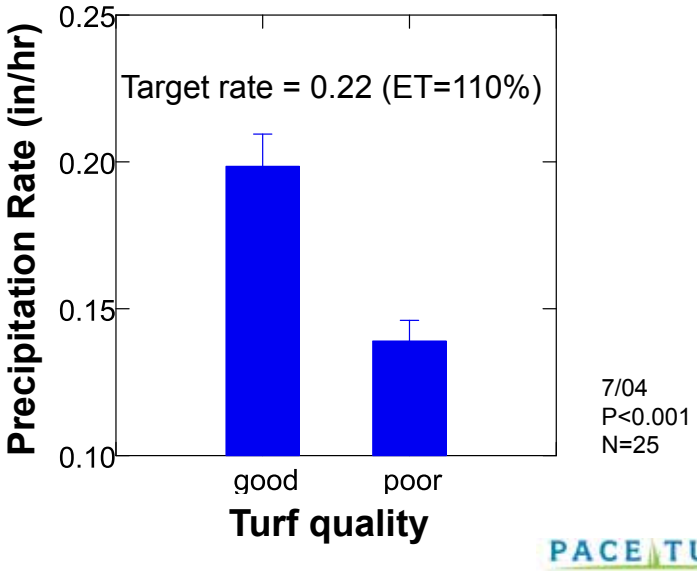
Operational problems – station adjust or other systematic error



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Causes of soil moisture problems

Soil physics: problem soils

- Heavy clay or plugged soils
- Poor drainage
- High organic matter
- Hydrophobic soils
- Compaction
- Improper grading

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Problem soils: Soil type affects drainage

Soil type	Drainage	Percolation rate (cm/hr)
Clay	Very slow	Less than .13
Silt	Slow	0.13 – 0.5
Fine sand	Moderate	2.0 – 6.6
Medium sand	Moderate-fast	6.6 – 13.2
Coarse sand	Fast	13.2 – 26.4

Typical sprinkler precipitation rates = > 2.0 cm/hr

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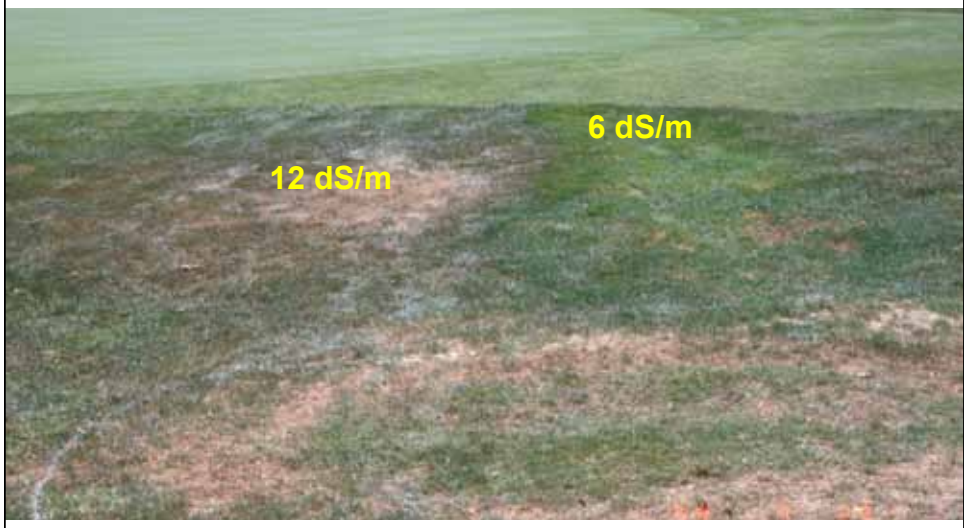
Heavy soils with poor drainage are prone to salinity problems



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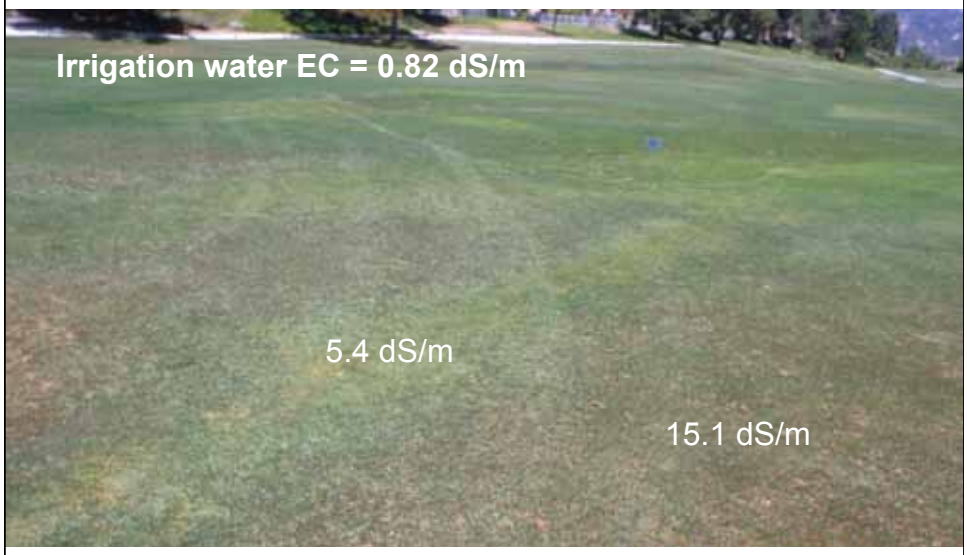
Drainage improvement alone not sufficient in heavy soils



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Drainage improvement alone not sufficient in heavy soils

Drainage improvement must be accompanied by aggressive sand topdressing program for best results

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Problem soils: hydrophobic soils

Do not absorb water fast enough. Diversion of water to other areas is the result.

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Localized dry spot

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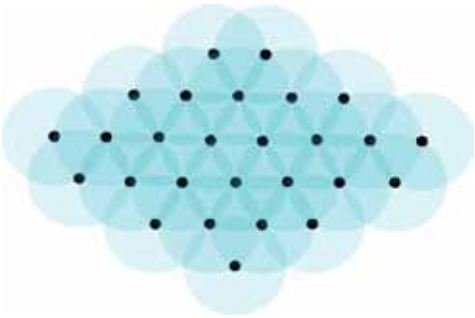
Problem soils

- Problem soils cause another, even more important issue
- Problem soils do not allow you to over-water
- Over-watering is the easiest way to deal with lack of irrigation uniformity



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Improper grading (surface slope less than 1%)

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Solving soil moisture problems

1. Characterize the problem
   - Soil moisture monitoring
   - Infiltration tests
   - Irrigation audits
   - Soil physical analysis
   - Soil mapping
2. Fix the problem
   - Irrigation system maintenance
   - Sand topdressing
   - Aeration
   - Drainage

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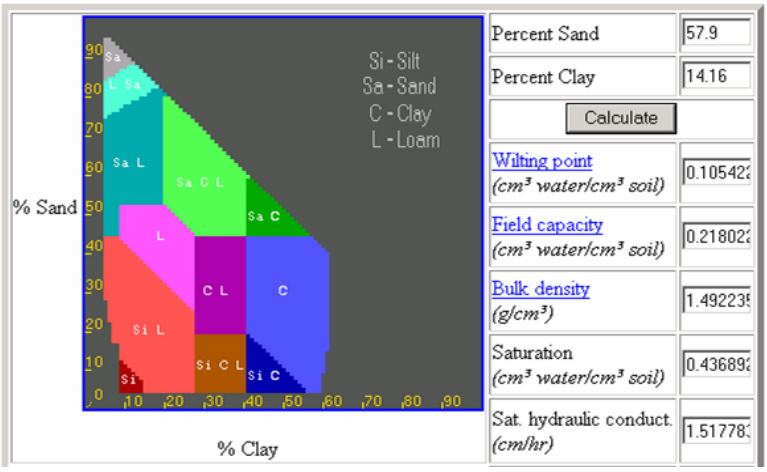
Characterize soil physical properties

(soil texture triangle hydraulic properties calculator **staffweb.wilkes.edu/brian.oram/soilwatr.htm**)



Wilting point 10.5 %

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Wilting Point

Model
WP = 10.5 %

Observed
1 = 10.6 %
2 = 14.3 %
3 = 28.9 %
4 = 26.9%

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Topdressing greens:
Apply sand to improve water movement in soil

Allows over-watering, to compensate for poor uniformity

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Sand for greens topdressing

- Light rate
- 10 – 50 lbs #30 silica sand/ 1000 ft^2 (90% in 0.25 mm + 0.5 mm particle sizes)
- Apply every 7 - 14 days during active turf growth
- Water it in

Spyker Thunderbird

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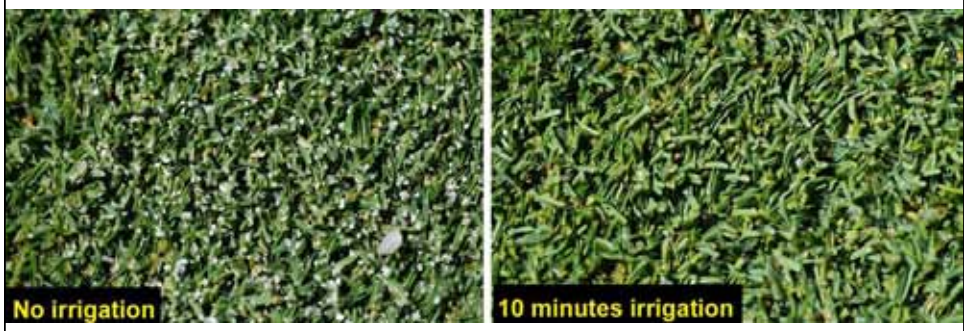
20 lbs #30 sand/1000 $feet^2$



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Monthly “venting” brings air into the system

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Top dressing and aerification on fairways

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Sand Topdressing

Improves surface layer drainage and soil structural problems

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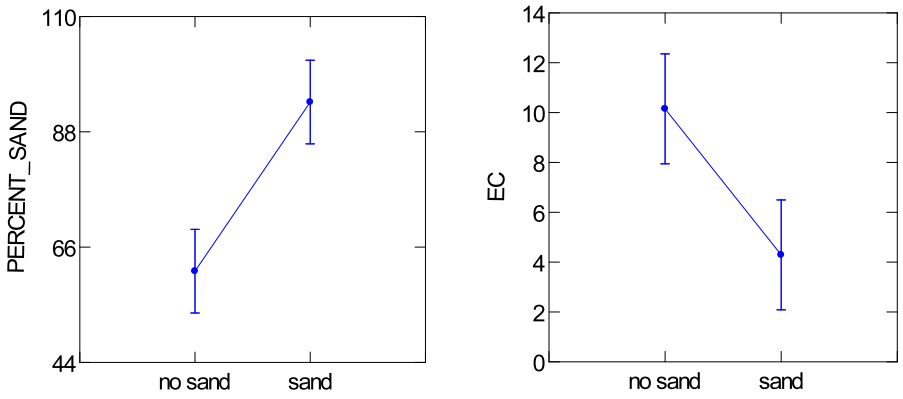
Impact of Sand Topdressing



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Cancun Water Sources

	No Restriction	Playacar Pump sta	Playacar sprinkler 13	Moon sprinkler 14	Moon pump sta. Dunes	Riviera
EC dS/m	<0.8	2.9	2.4	1.7	1.5	1.8
TDS ppm	<525	1864	1564	1107	962	1125
pH	6.5-7.8	8.9	8.1	7.9	8.2	8.6
SAR	<3.0	6.5	5.86	5.9	4.1	6
HCO_3 ppm	<50	231	298	182	124	171
Na ppm	<100	296	289	230	184	228
RSC meq/l	<1.0	0	0	0	0	0
B ppm	<0.5	0.07	0.07	0.2	0.03	0.2
Cl ppm	<90	529	518	507	386	507

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Poor-Quality Water Problems

1. Increased total dissolved salts
2. Increased sodium
3. Increased bicarbonate
4. Increased nitrogen

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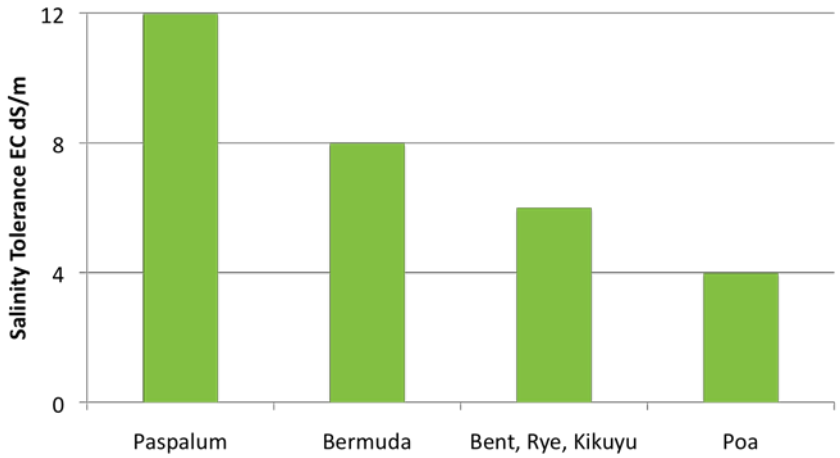
Turfgrass Tolerance to Soil Salinity (dS/m)



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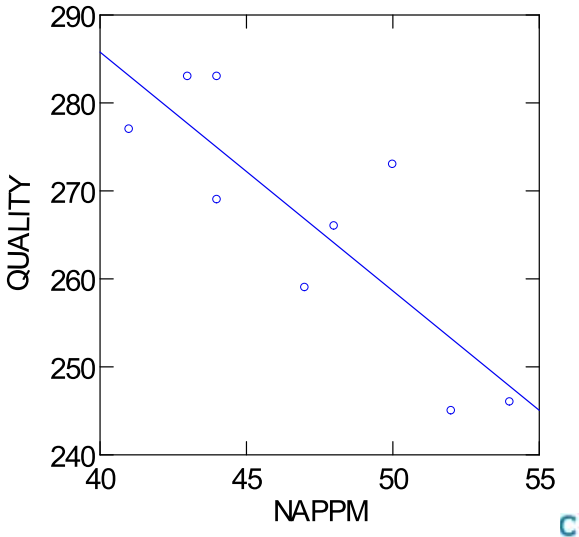
G2 Greens and Sodium



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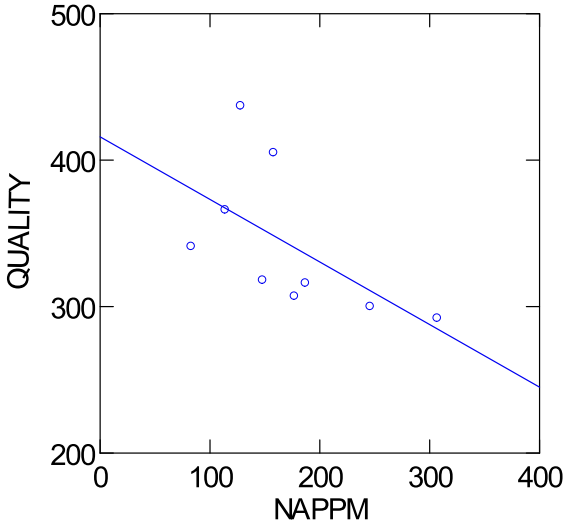
419 Fairways and Sodium



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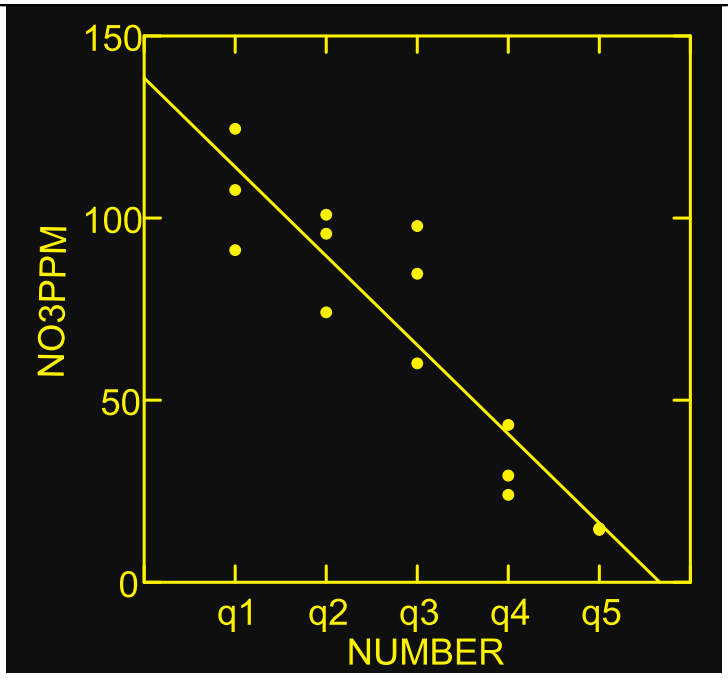
Nitrogen and Turf Quality



Soil Nitrogen

- Minimum 5 ppm
- Maximum 20 ppm
- Ammonium below 7 ppm

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Big Canyon Bermudagrass

	Domestic	Recycled	Bermuda Guideline
EC (dS/m)	0.7	1.3	1.5
TDS (ppm)	462	858	900
pH	7.9	7.5	6.5 - 7.8
SAR	3.0	9.0	5.7
HCO3 (ppm)	209	262	250
Na (ppm)	54	150	200
N (ppm)	0.3	14	8.0

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Cancun Water Sources

	No Restriction	Playacar Pump sta	Playacar sprinkler 13	Moon sprinkler 14	Moon pump sta. Dunes	Riviera
EC dS/m	<0.8	2.9	2.44	1.73	1.5	1.8
TDS ppm	<525	1864	1564	1107	962	1125
pH	6.5-7.8	8.9	8.1	7.9	8.2	8.6
SAR	<3.0	6.5	5.86	5.9	4.1	6
HCO_3 ppm	<50	231	298	182	124	171
Na ppm	<100	296	289	230	184	228
RSC meq/l	<1.0	0	0	0	0	0
B ppm	<0.5	0.07	0.07	0.2	0.03	0.2
Cl ppm	<90	529	518	507	386	507

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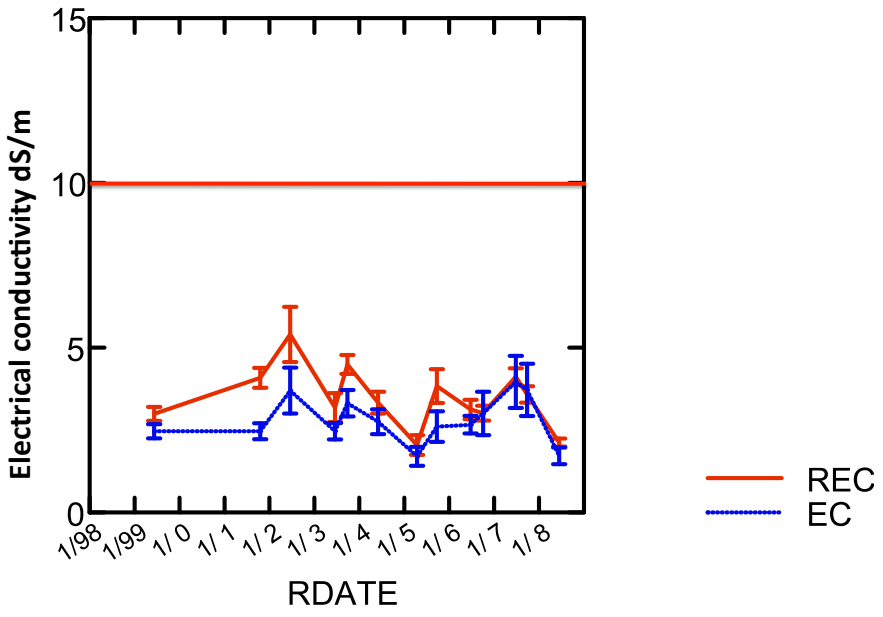
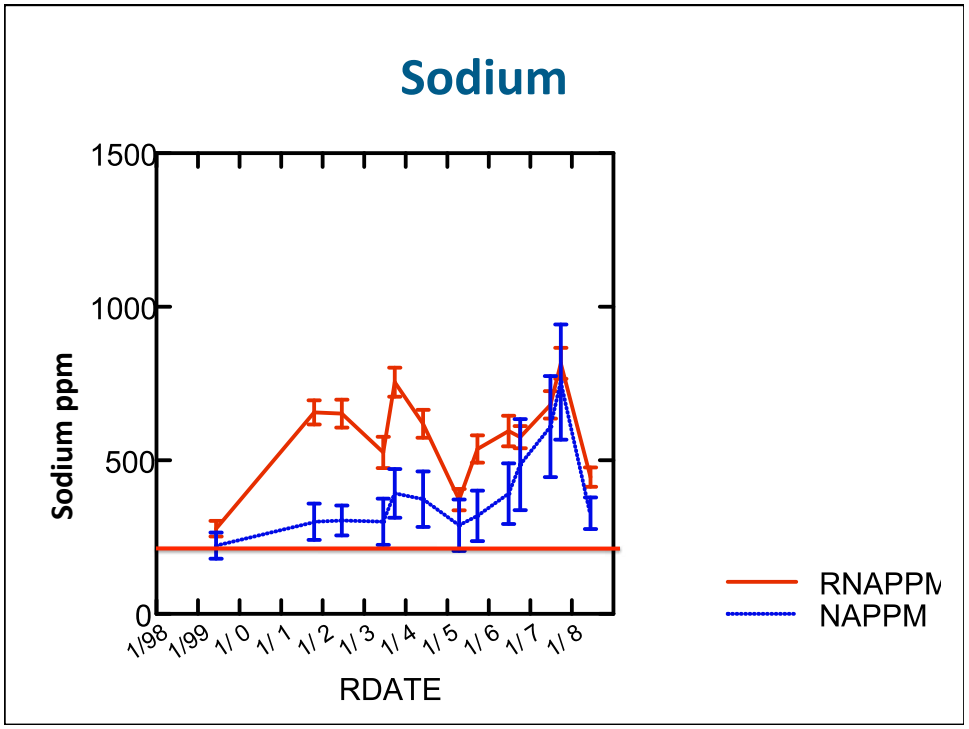
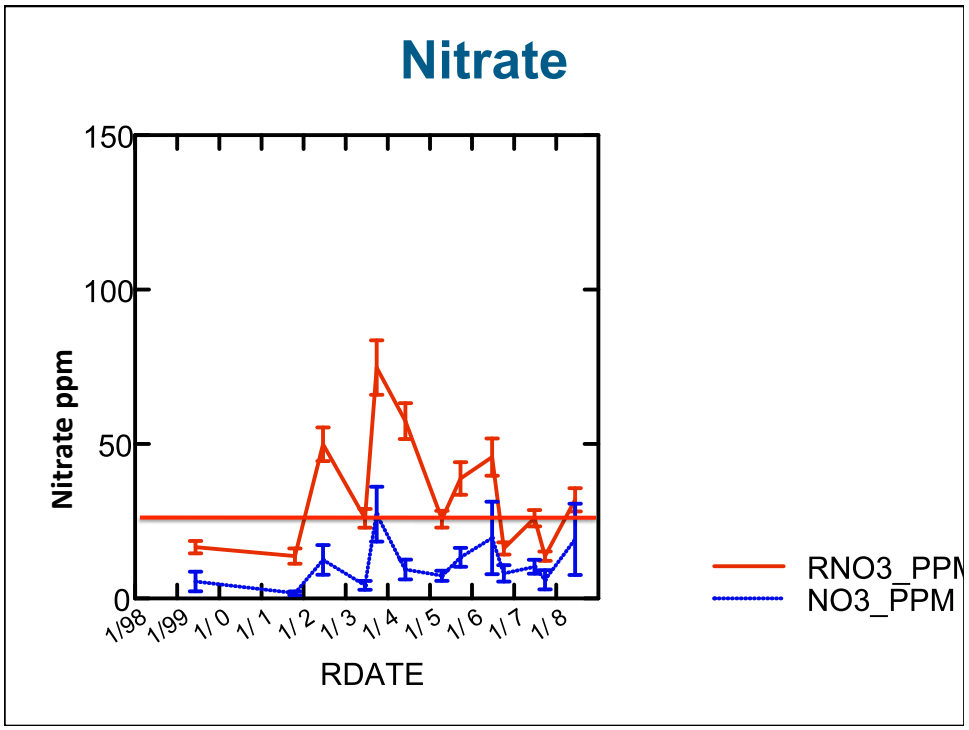
Electrical conductivity




Sodium
1500
1000
500
0
Sodium ppm
1/98
1/99
1/0
1/1
1/2
1/3
1/4
1/5
1/6
1/7
1/8
RDATE
RNAPPM
NAPPM


Nitrate
150
100
50
0
Nitrate ppm
1/98
1/99
1/0
1/1
1/2
1/3
1/4
1/5
1/6
1/7
1/8
RDATE
RNO3_PPM
NO3_PPM

Los Lagos (ryegrass)

	Domestic	Recycled	Ryegrass Guideline
EC	1.1	1.4	0.8
TDS	700	878	525
pH	7.5	7.7	6.5 - 7.8
SAR	0.8	4.7	3.1
HCO3	572	260	50
Na	43	174	100
N	NA	1.7	8.0

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Cancun Water Sources

	No Restriction	Playacar Pump sta	Playacar sprinkler 13	Moon sprinkler 14	Moon pump sta. Dunes	Riviera
EC dS/m	<0.8	2.9	2.44	1.73	1.5	1.8
TDS ppm	<525	1864	1564	1107	962	1125
pH	6.5-7.8	8.9	8.1	7.9	8.2	8.6
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B ppm	<0.5	0.07	0.07	0.2	0.03	0.2
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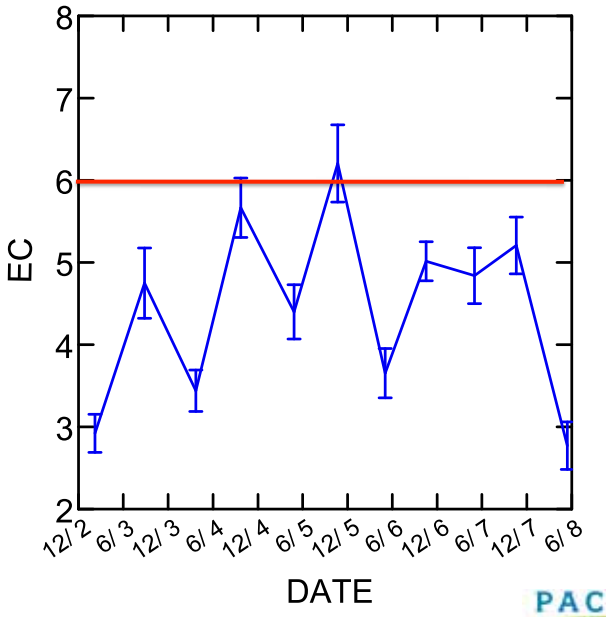
Soil Electrical conductivity dS/m



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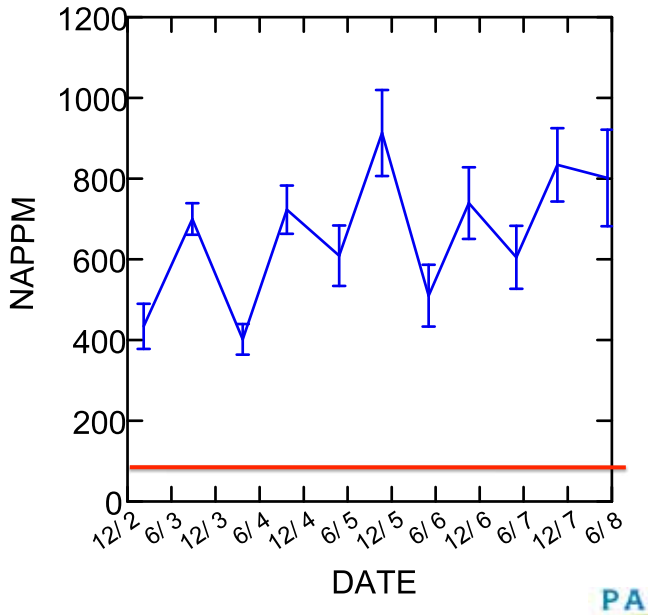
Sodium ppm



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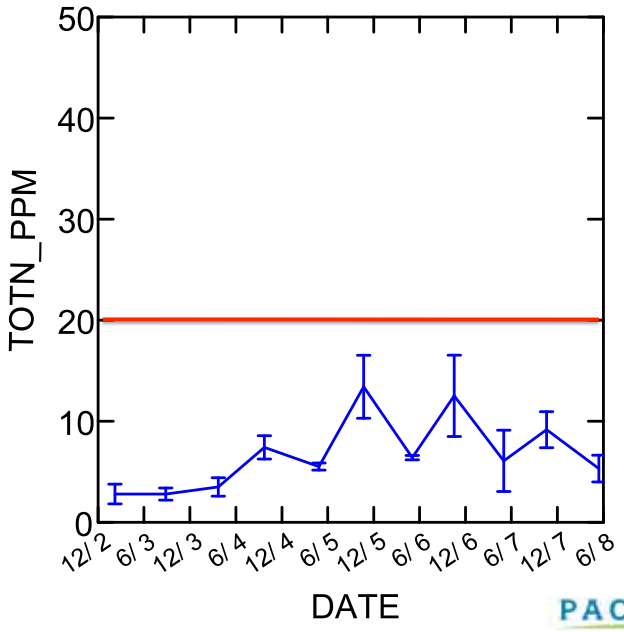
Soil Nitrate ppm



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Denver (poa/rye)

	Domestic	Recycled	Ryegrass Guideline
EC	0.3	0.9	0.8
TDS	200.0	576.0	525.0
pH	7.6	7.5	6.5 - 7.8
SAR	0.8	3.4	3.1
HCO3	118.0	123.0	50.0
Na	20.0	103.0	100.0
N	0.2	16.0	8.0

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Cancun Water Sources

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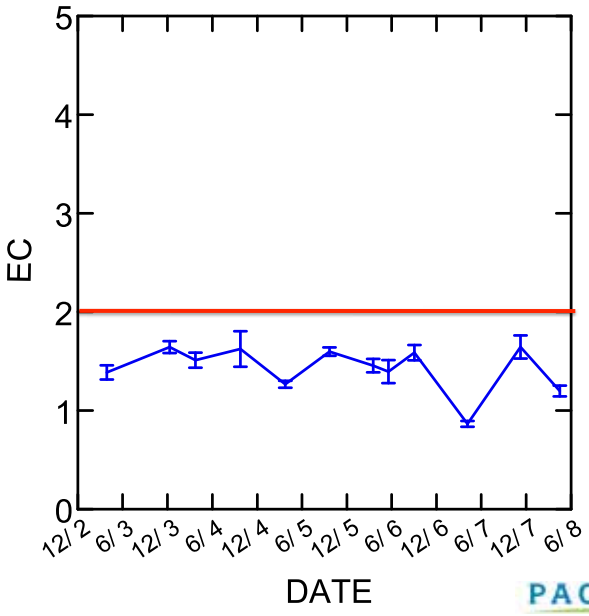
Soil Electrical conductivity dS/m



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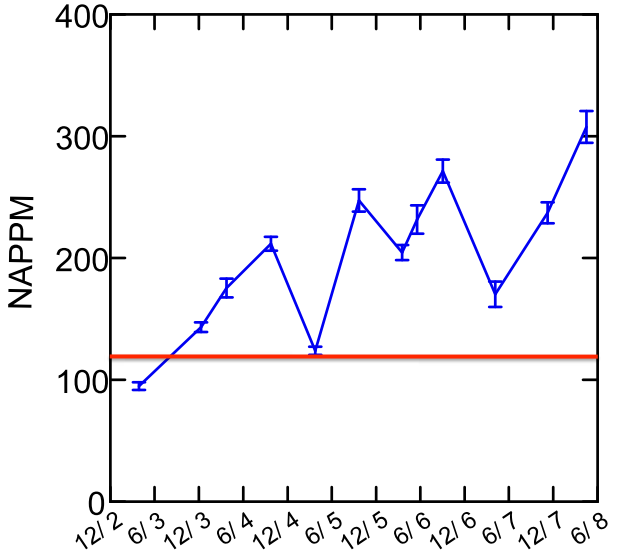
Soil Sodium ppm



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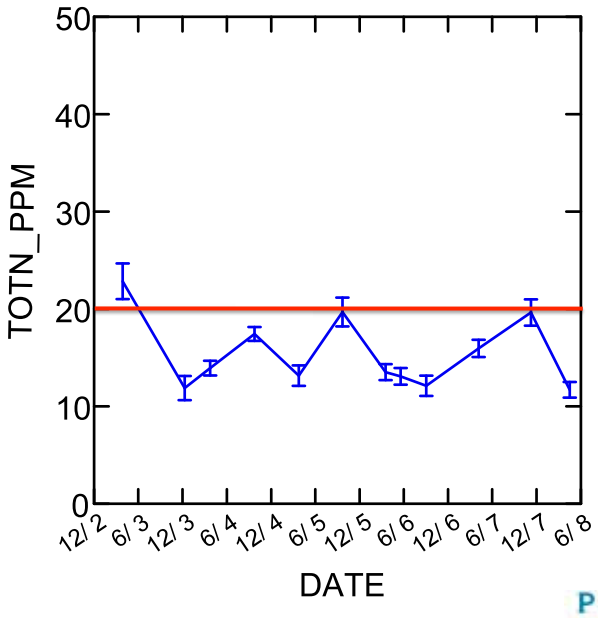
Total nitrogen ppm



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Management

- Sodium may be the weak link
- Calcium applications and leaching will be needed to move sodium out of the soil

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Calcium to Manage Sodium

- Only if soils drain well and salts are moderate, below 8 dS/m
- Gypsum: $CaSO_4*2H_2O$ (23% Ca)
  - 10 lbs/1000 sq ft monthly and leach
- Calcium chloride: $CaCl_2$ (36% Ca)
  - Fairways only so far
  - 100 – 200 lbs/acre, 5 – 6 applications
- Pounds on the ground!

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Using Calcium to Displace Sodium

- Reported Na ppm – 110 ppm = excess Na ppm
- Excess Na ppm * 2.24 = kg Ca needed per ha
- kg Ca/ 0.23 = $CaSO_4$ requirement
- kg Ca/ 0.36 = $CaCl_2$ requirement
- Only if salts are less than 8 dS/m

- Application of 1 kg/ha will increase soil elemental composition by about 2.24 ppm

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Using Calcium to Displace Sodium

	Na ppm	Gypsum Kg/ha	CaCl2 Kg/ha
Playacar green	141	300	192
Playacar fairway	191	787	502
Moon green	108	0	0
Moon fairway	96	0	0
Riviera green	135	126	81
Riviera fairway	737	3174	1,653

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Using Calcium to Displace Sodium: Precautions

- Do not apply more than 500 kg CaSO4*2H2O per ha per application to greens.
- Do not apply more than 2,000 kg CaSO4*2H2O per ha to fairways per application
- Allow minimum of 14 days between applications – 28 days if high rates used
- Do not apply more than 220 kg $CaCl_2$ per ha to fairways per application per month with an annual total of 672kg $CaCl_2$ per ha per year

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Conclusions

1. Water quality directly impacts turf performance and playability
2. High total dissolved salts, sodium, and nitrogen will require modified management practices and increased inputs in most situations
3. Soil analysis for cations should use ammonium acetate extraction on calcareous soils for accurate calcium and magnesium soil levels

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