

Project: Evaluation of Eximo plus Dispatch for reduction of sodium in USGA specification golf course greens (08060603)

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In this study, the impact of a combination of Eximo (a synthetic acid that is used to reduce sodium and bicarbonate levels) and Dispatch (surfactant) on soil chemistry, when applied prior to leaching, was evaluated. Test greens were treated either with gypsum alone or with gypsum plus Eximo and Dispatch. Both standard soil analysis and saturated paste extraction methodologies were used to evaluate soil chemistry of samples collected before treatment and leaching and after treatment and leaching.

The gypsum plus leaching treatment resulted, as expected, in significant reductions in overall salt levels (electrical conductivity, as measured in 1:2 dilution and total salts, as measured by saturated paste analysis) as well as reductions in individual salts (chloride, sulfur, magnesium, potassium, sodium) as measured by Mehlich 3 or saturated paste methods. A reduction in beneficial calcium levels was also observed; this was due to leaching and was expected.

When Eximo plus Dispatch were added to plots treated with gypsum and the plots were then leached, however, no additional benefit, in terms of reductions in damaging soil salts and/or bicarbonate levels, was observed. Calcium levels in the Eximo plus Dispatch decreased at the same rate as calcium levels in the plots treated with gypsum alone. Thus, the Eximo plus Dispatch treatment did not provide any significant advantage over the application of gypsum and leaching treatment alone.

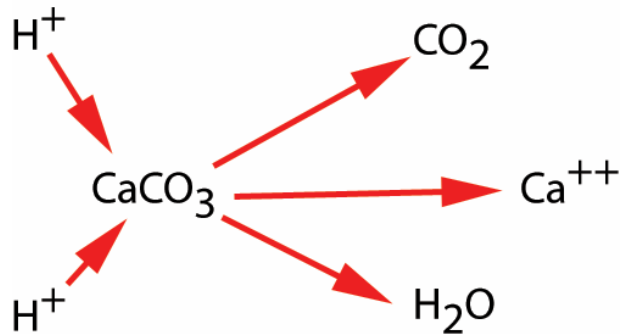
Company representatives, however, have indicated that Eximo's efficacy relies on the presence of calcium carbonate in the soil. According to the product literature (see <http://www.aquatrols.com/labelsandmsds2006/Labels/Eximo%20interim%20label.pdf>, link confirmed July 20, 2008), the proprietary acid in Eximo will attack calcium carbonate molecules in the soil. The calcium will then be released, and the carbonate will dissipate as CO₂ gas. The freed up calcium is then available to displace sodium from soil exchange sites, thus reducing sodium levels. Product claims also include reduced bicarbonate levels, improved soil structure and nutrient availability.

Therefore, for Eximo to work, the soil must contain calcium carbonate. Subsequent evaluation of the soil calcium carbonate levels at the test site indicated that there was an average of only 2.4% calcium carbonate in the soil. At such low levels, the accuracy of the calcium carbonate test is low. However, it was clear from this follow up test that there was not sufficient calcium carbonate in the soil for the effects of Eximo to be detected.

In this test, there was no evidence that Eximo lowered sodium and bicarbonate levels compared to the non-Eximo treated check plots. However, the test was conducted in a location with low levels of soil calcium carbonate. Based upon the product claim that the product is based upon a synthetic acid technology that relies on the presence of calcium carbonate in the soil, it was no surprise that differences were not detected in this location.

Figure 1. Acid and calcium carbonate.

When acids (hydrogen ions, also known as protons) are added to aqueous (water-based) solutions that contain calcium carbonate, the protons from the acid combine with the carbonate (CO_3) to form water and CO_2 . In the process, the protons from the acid are transferred to the calcium to form free calcium ions in solution that are now able to displace sodium from the soil exchange sites. If there are low levels of calcium carbonate in the soil, acid amendments, such as Eximo, will not aid in managing sodium levels in the soil.



Treatments

Six greens (South Course 4, 9, 10, 13, 15, and 18) were used to evaluate the pre leaching treatments. Soil samples (10 one-inch cores approximately 4 inches deep with the thatch and mat layer removed) were collected from each green prior to flushing on May 5, 2008 and designated “before flush.” All six greens were then treated with Maxical (gypsum at 17 lbs /1000 sq ft). Greens 13, 15, and 18 were additionally treated with Eximo (2 oz/1000 sq ft) and Dispatch (3 oz/1000 sq ft) prior to leaching.

Leaching was carried out by running the irrigation system for three hours on each green on the night of May 5th. The green drain valve was closed at the start of leaching. Once the green cavity had filled with water, the valve was opened and the irrigation turned off to flush the green. Post-flush soil samples were collected on May 6th. Samples collected prior to leach are designated with the green followed by the number “01” and samples collected after sampling are designated with the green number followed by the number “02”. Greens treated with Eximo/Dispatch are designated with a “t” and non-treated greens are designated with an “n” (see Table 1).

All soils were analyzed using standard methods (1:2 soil dilution for pH and EC, Bray II for phosphorus, and Mehlich III extraction for major and minor nutrients) and saturated paste extraction methods. Analysis of variance was conducted on each of the three treated and non-treated replicate

greens. For analysis of percentage change (Table 2), percentages were subjected to transformation (square root arc sine) prior to statistical analysis. The results are reported in Tables 2 through 4.

Table 1. Nutritional deficits, pH and EC.

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		Ca lb/M	Mg lb/M	K2O lb/M	P2O5 lb/M	Mn lb/M	Fe lb/M	pH	EC dS/m
g 0401t	before	0	0	0	0	0.0	0.0	8.10	0.67
g 0402t	after	0	0	3	0	0.0	0.0	8.10	0.58
g 0901t	before	0	0	0	0	0.0	0.0	8.30	0.63
g 0902t	after	0	0	3	0	0.0	0.0	8.00	0.58
g 1001t	before	0	0	1	0	0.0	0.0	8.20	0.63
g 1002t	after	0	0	4	0	0.0	0.0	7.90	0.58
g 1301n	before	0	0	1	0	0.0	0.0	7.80	0.63
g 1302n	after	0	0	3	0	0.0	0.0	7.70	0.56
g 1501n	before	0	0	1	0	0.0	0.0	8.10	0.63
g 1502n	after	0	0	4	0	0.0	0.0	7.80	0.56
g 1801n	before	0	0	1	0	0.0	0.0	8.00	0.67
g 1802n	after	0	0	3	0	0.0	0.0	8.00	0.58

Table 2. Percent change in key soil factors following leaching

The percentage change (before vs. after leaching) in each soil factor was analyzed to determine whether Eximo/Dispatch treatment resulted in significantly larger reductions than the treatment of gypsum alone. However, no significant difference, (Fisher's Protected LSD with $P < 0.05$) in the level of reduction was seen for calcium, sodium or bicarbonate. The increase in bicarbonate may be the result of shipping moist samples to the lab as the result of microbial activity and production of CO₂ prior to drying the samples.

	Gypsum alone	Gypsum plus Eximo/Dispatch
Ca ppm (M3)	-21 %	-9.1 %
Na ppm (M3)	-52 %	-45 %
Ca ppm (paste)	-52 %	-48 %
Na ppm (paste)	-59 %	-52 %
HCO ₃ ppm (paste)	+33 %	+54 %

Table 3. Key soil quality factors – Mehlich III analysis.

Values in the same row that are followed by the same letter are not significantly different based upon a Fisher's Protected LSD with $P < 0.05$.

Parameter	Gypsum plus Eximo and Dispatch		Gypsum alone	
	Before leaching	After leaching	Before leaching	After leaching
pH	8.2 a	8.0 ab	8.0 ab	7.8 b
Organic Matter (OM%)	1.6 a	1.5 a	1.6 a	1.2 a
Sulfur (SO ₄ -S ppm)	78 a	29 b	89 a	28 b
Phosphorous (P Bray ppm)	269 a	220 b	191 bc	178 c
Calcium (Ca ppm)	1803 a	1607 a	1897 a	1490 a
Magnesium (Mg ppm)	207 b	190 c	223 a	184 c
Potassium (K ppm)	153 a	92 b	141 a	82 b
Sodium (Na ppm)	100 a	55 b	109 a	52 b
Calcium percentage	75 a	77 a	75 a	76 a
Magnesium percentage	15 a	15 a	15 a	16 a
Potassium percentage	3.3 a	2.3 b	2.9 a	2.2 b
Sodium percentage	3.7 a	2.3 b	3.8 a	2.3 b
Electrical Conductivity (EC dS/m)	0.64 a	0.58 b	0.64 a	0.57 b
Chloride (Cl ppm)	62 a	19 b	66 a	19 b
Boron (B ppm)	1.1 a	0.94 a	1.1 a	0.93 a
Iron (Fe ppm)	135 ab	121 b	150 a	127 b
Manganese (Mn ppm)	112 a	86 b	114 a	95 ab
Copper (Cu ppm)	8.1 a	7.3 b	8.5 a	6.6 b
Zinc (Zn ppm)	27 a	22 ab	27 a	20 b
Ammonium nitrogen (NH ₄ ppm)	3.5 b	3.4 b	4.0 a	3.2 b
Nitrate nitrogen (NO ₃ ppm)	9.2 a	7.5 a	7.1 a	6.7 a
Total nitrogen (TOTN ppm)	13 a	11 a	11 a	9.8 a

Table 4. Key soil quality factors for saturated paste extraction of pre-flush treatment and post-flush treatment before and after flushing.

Values in the same row that are followed by the same letter are not significantly different based upon a Fisher's Protected LSD with $P < 0.05$.

Parameter	Gypsum plus Eximo and Dispatch		Gypsum alone	
	Before leaching	After leaching	Before leaching	After leaching
pH	8.1 a	8.1 a	8.0 a	8.1 a
Salts (ppm)	883 a	424 b	956 a	421 b
Chloride (Cl ppm)	111 a	33 b	119 a	32 b
Nitrate (NO ₃ ppm)	1.27 a	0.73 a	0.17 a	0.37 a
Ammonium (NH ₄ ppm)	9.1 a	6.5 b	9.3 a	6.2 b
Bicarbonate (HCO ₃ ppm)	167 b	258 a	186 a	246 a
Sulfur (S ppm)	105 a	28 b	119 a	27 b
Phosphorus (P ppm)	2.7 b	3.4 a	2.6 b	3.4 a
Calcium (Ca ppm)	106 a	53 b	119 a	55 b
Calcium (Ca meq)	5.3 a	2.6 b	5.9 a	2.7 b
Calcium (Ca %)	39 b	40 ab	41 a	41 a
Magnesium (Mg ppm)	31 a	17 b	35 a	18 b
Magnesium (Mg meq)	2.6 a	1.4 b	2.9 a	1.5 b
Magnesium (Mg %)	19 b	21 ab	20 b	22 a
Potassium (K ppm)	75 a	33 b	67 a	30 b
Potassium (K meq)	1.9 a	0.84 b	1.7 a	0.77 b
Potassium (%)	14 a	13 a	12 a	12 a
Sodium (Na ppm)	87 a	40 b	93 a	38 b
Sodium (Na meq)	3.8 a	1.8 b	4.0 a	1.6 b
Sodium (Na %)	28 a	27 a	28 a	25 b
Total (meq)	14 a	6.6 b	15 a	6.6 b
Boron (B ppm)	0.22 b	0.25 a	0.21 b	0.25 a
Iron (Fe ppm)	0.61 a	0.92 a	0.70 a	1.12 a
Manganese (Mn ppm)	0.26 ab	0.21 b	0.33 a	0.28 ab
Copper (Cu ppm)	0.20 a	0.24 a	0.20 a	0.23 a
Zinc (Zn ppm)	0.06 a	0.06 a	0.06 a	0.06 a
Aluminum (Al ppm)	0.66 a	1.01 a	0.82 a	1.31 a
ESP (estimated)	1.54 a	0.57 b	0.16 c	0.40 b
SAR (estimated)	1.91 a	1.24 b	1.92 a	1.13 b

Figure 2. Soil Cations reported in percentage of total extractable cations.

Desired values are: Calcium (Ca) 68%, Magnesium (Mg) 12 - 20%, sodium (Na) less than 3%.

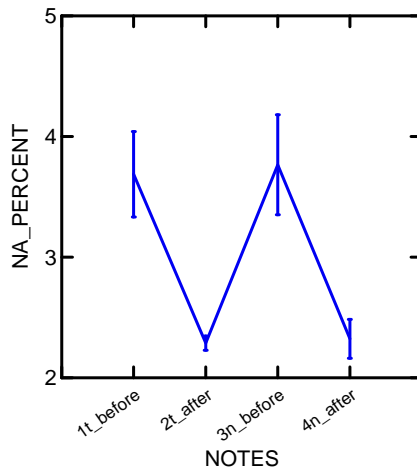
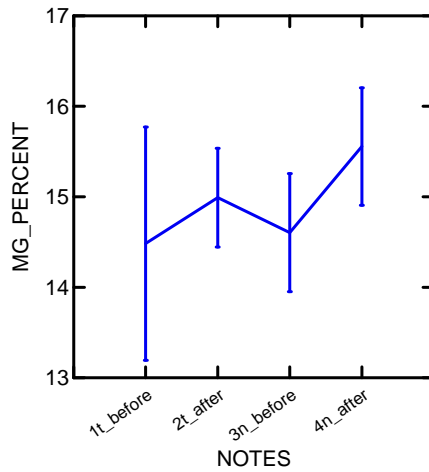
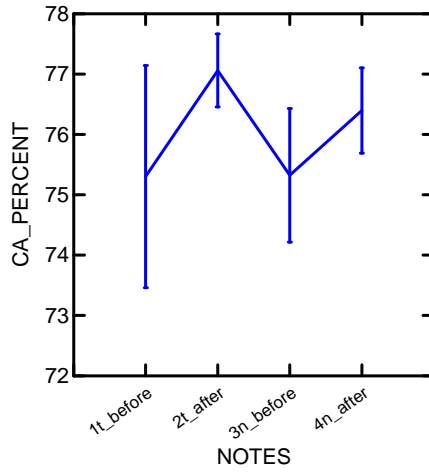


Figure 3. Soil cations reported in parts per million (ppm).

Desired values are calcium (Ca) greater than 750 ppm, magnesium (Mg) greater than 140 ppm, and sodium (Na) less than 110 ppm.

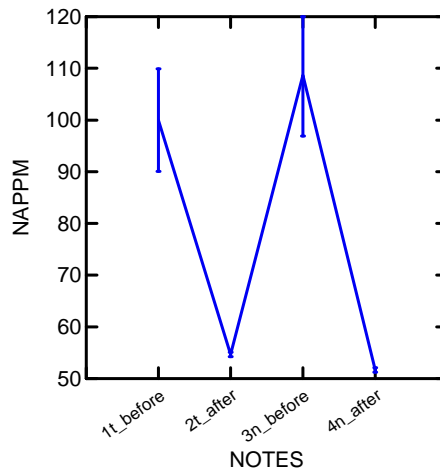
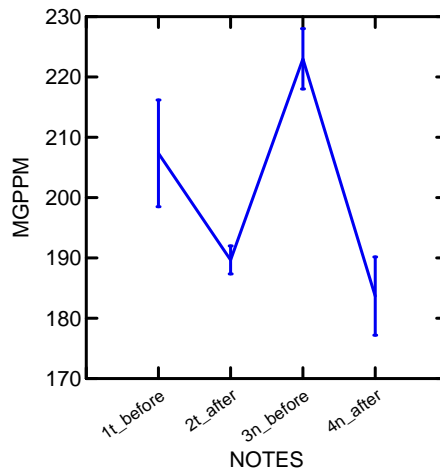
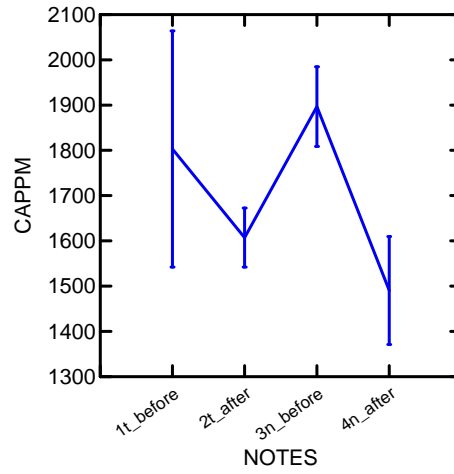


Figure 4. Soil plant available nitrogen values reported in parts per million (ppm), potassium and phosphorous (P2O5).

Desired values are: Nitrate (NO₃) between 3 and 20 ppm, ammonium (NH₄) less than 7 ppm, nitrate:ammonium (NO₃:NH₄) ratio greater than 3:1, and total plant available nitrogen less than 20 ppm. Potassium levels above 110 ppm are desired and phosphorous (BrayIIP) above 50 ppm is optimal.

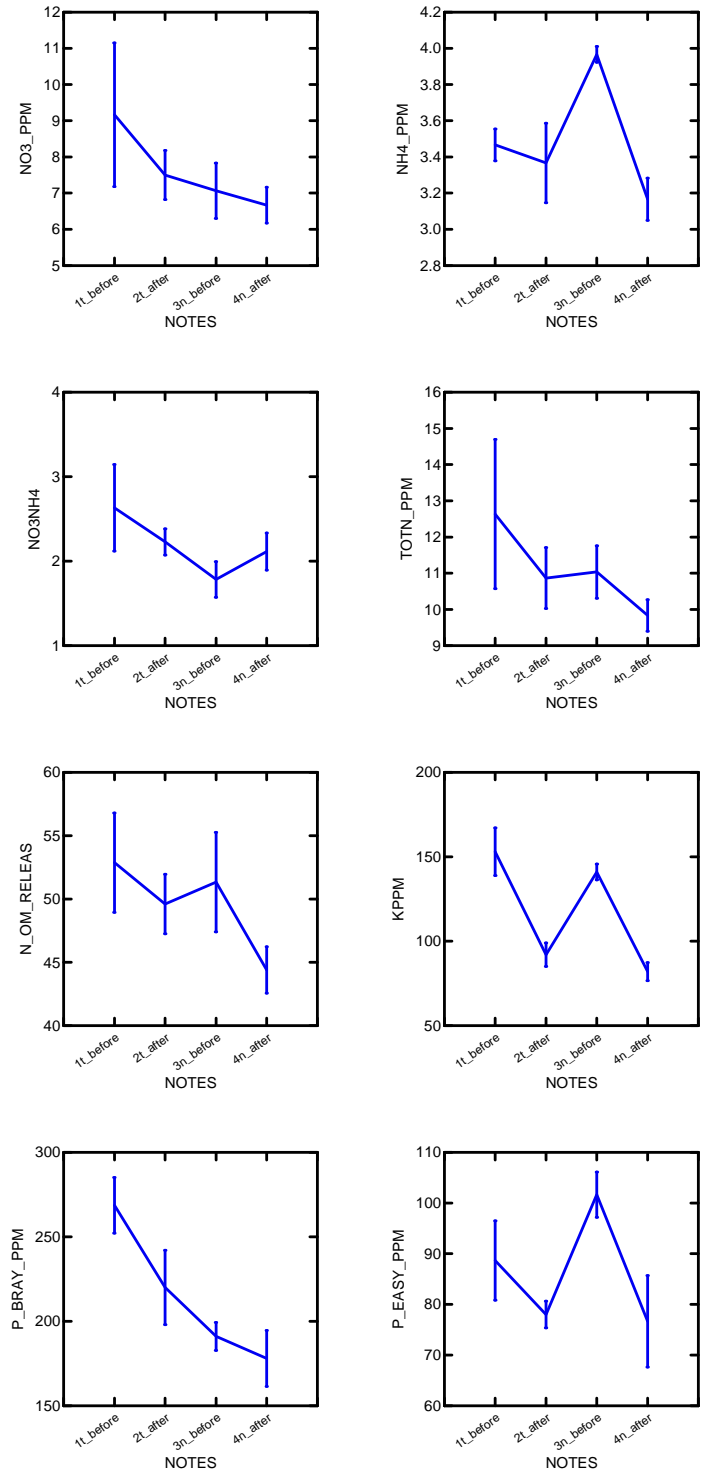


Figure 5. Soil pH, sulfate (ppm), organic matter (percentage) and electrical conductivity (EC dS/m).

Desired values are: pH between 6.2 and 7.4, sulfate between 15 and 200 ppm, organic matter less than 2% for greens and less than 4% for fairways, electrical conductivity less than 3 dS/m for poa greens, less than 4 dS/m for bentgrass greens, less than 6 dS/m for ryegrass and tall fescue, less than 8 dS/m for bermuda and less than 12 dS/m for paspalum.

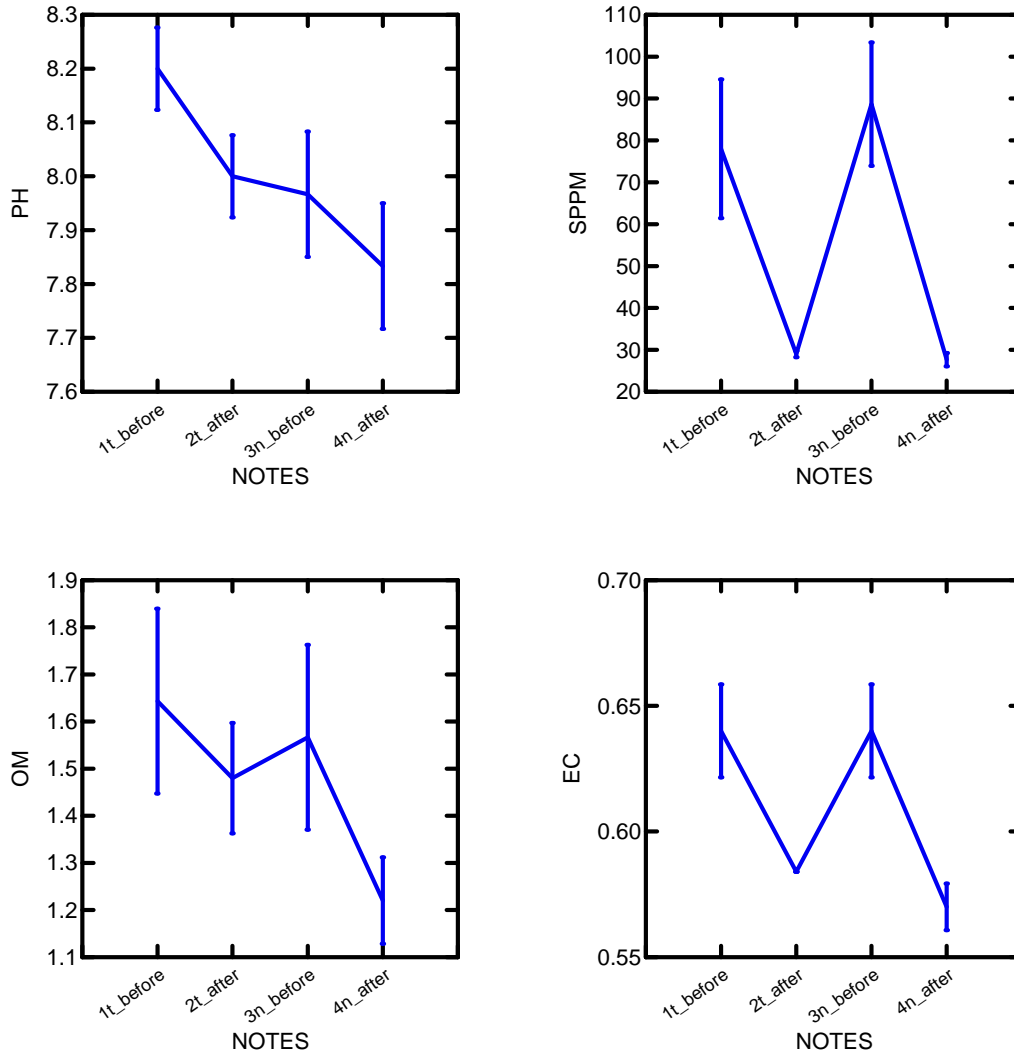
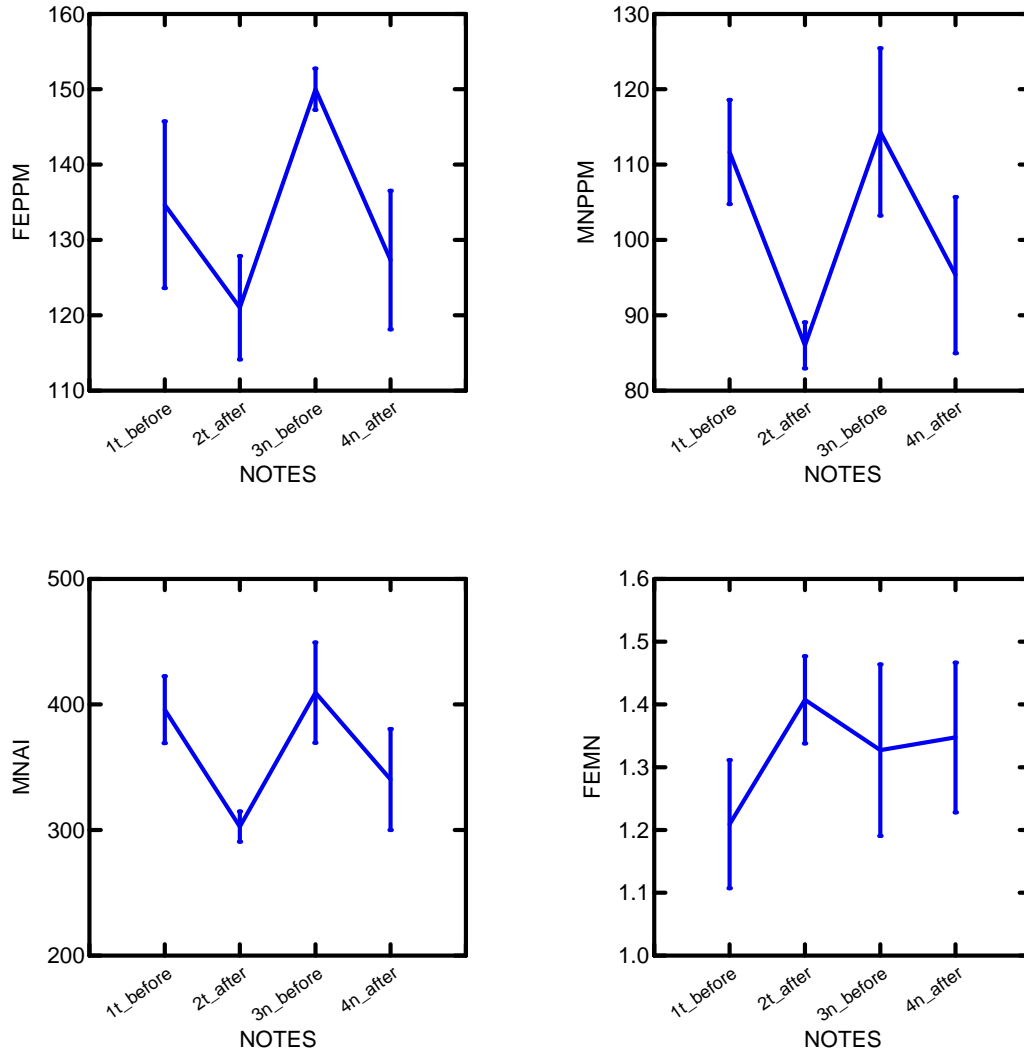


Figure 6. Iron and manganese relationships.

Desired values are currently based upon manganese availability and iron levels needed to balance the iron:manganese ratio. Manganese availability index should exceed 110. Iron should be present at three times the manganese level resulting in a iron:manganese ratio of 3:1.



Standard Soil appraisals (M3)

Major Elements and Sodium	Observed	Desired	Deficit Lb/Acre	Deficit Lb/1000 Sq Ft
Phosphorus (P) - Bray II (ppm):	271			
Phosphate P2O5 ppm:	621	121	0	0
Phosphorus (P) - Olsen (ppm):	33			
Phosphorus (P) - M3 (ppm)	80			
Phosphorus Saturation Index:	0.61	< 1.25		
Sulfur (S) ppm:	103	15-40		
Calcium (Ca) ppm:	2045	1817	0	0
Magnesium (Mg) ppm:	215	192	0	0
Potassium (K) ppm:	174			
Potash (K2O) ppm:	210	203	0	0
Sodium (Na) ppm:	115	< 67		
Aluminum (Al) ppm:	57			
Minor Elements	Observed	Desired		
Boron (B) ppm:	1.07	0.4 - 1.5		
Iron (Fe) ppm:	120.00	105		
Manganese (Mn) ppm:	113.00	35	Manganese Availability Index =	402.3
Copper (Cu) ppm:	7.23	0.6 - 2.0		
Zinc (Zn) ppm:	23.51	1.3 - 3.5		
Cations Expressed as Percent of Total Extractable Cations	Observed	Desired		
Percent Calcium (% Ca)	76.25	60 - 70 (68 optimum)		
Percent Magnesium (% Mg)	13.36	10 - 20 (12 optimum)		
Percent Potassium (% K)	3.33	1.5 - 10		
Percent Sodium (%Na)	3.73	0.5 - 3		
pH:	8.1	Plant available soil nitrogen ppm		
Percent Organic Matter (% OM):	1.7	Nitrate (NO3)	11.8	
Soluble Salts (SS) 1:2 (ppm):	51.2	Ammonium (NH4)	3.6	
Electrical Conductivity (EC) 1:2 (dS/m)	0.1	Total available	15.4	
SS estimated saturated paste (ppm)	427.5	NO3:NH4 ratio	3.3	
EC estimated saturated paste (dS/m)	0.7	Organic N release	53.6	
Total Extractable Cations (meq/100 g)	13.4			
Chloride Cl ppm	87.8			

Major Elements and Sodium	Observed	Desired	Deficit Lb/Acre	Deficit Lb/1000 Sq Ft
Phosphorus (P) - Bray II (ppm):	225			
Phosphate P2O5 ppm:	516	120	0	0
Phosphorus (P) - Olsen (ppm):	26			
Phosphorus (P) - M3 (ppm)	76			
Phosphorus Saturation Index:	0.57	< 1.25		
Sulfur (S) ppm:	30	15-40		
Calcium (Ca) ppm:	1682	1467	0	0
Magnesium (Mg) ppm:	187	155	0	0
Potassium (K) ppm:	102			
Potash (K2O) ppm:	123	181	117	3
Sodium (Na) ppm:	55	< 67		
Aluminum (Al) ppm:	63			

Minor Elements	Observed	Desired	
Boron (B) ppm:	0.99	0.4 - 1.5	
Iron (Fe) ppm:	112.00	105	
Manganese (Mn) ppm:	82.00	35	Manganese Availability Index = 286.1
Copper (Cu) ppm:	7.25	0.6 - 2.0	
Zinc (Zn) ppm:	21.90	1.3 - 3.5	

Cations Expressed as Percent of Total Extractable Cations	Observed	Desired
Percent Calcium (% Ca)	77.65	60 - 70 (68 optimum)
Percent Magnesium (% Mg)	14.39	10 - 20 (12 optimum)
Percent Potassium (% K)	2.41	1.5 - 10
Percent Sodium (%Na)	2.21	0.5 - 3

pH:	8.1	Plant available soil nitrogen ppm	
Percent Organic Matter (% OM):	1.4	Nitrate (NO3)	7.8
Soluble Salts (SS) 1:2 (ppm):	25.6	Ammonium (NH4)	3.2
Electrical Conductivity (EC) 1:2 (dS/m)	0.0	Total available	11.0
SS estimated saturated paste (ppm)	373.8	NO3:NH4 ratio	2.4
EC estimated saturated paste (dS/m)	0.6	Organic N release	48.8
Total Extractable Cations (meq/100 g)	10.8		
Chloride Cl ppm	17.23		

Major Elements and Sodium	Observed	Desired	Deficit Lb/Acre	Deficit Lb/1000 Sq Ft
Phosphorus (P) - Bray II (ppm):	289			
Phosphate P2O5 ppm:	662	119	0	0
Phosphorus (P) - Olsen (ppm):	33			
Phosphorus (P) - M3 (ppm)	86			
Phosphorus Saturation Index:	0.54	< 1.25		
Sulfur (S) ppm:	64	15-40		
Calcium (Ca) ppm:	1412	1321	0	0
Magnesium (Mg) ppm:	194	140	0	0
Potassium (K) ppm:	146			
Potash (K2O) ppm:	176	172	0	0
Sodium (Na) ppm:	92	< 67		
Aluminum (Al) ppm:	73			
Minor Elements	Observed	Desired		
Boron (B) ppm:	1.09	0.4 - 1.5		
Iron (Fe) ppm:	135.00	107		
Manganese (Mn) ppm:	102.00	36	Manganese Availability Index =	358.0
Copper (Cu) ppm:	7.84	0.6 - 2.0		
Zinc (Zn) ppm:	25.16	1.3 - 3.5		
Cations Expressed as Percent of Total Extractable Cations	Observed	Desired		
Percent Calcium (% Ca)	72.41	60 - 70 (68 optimum)		
Percent Magnesium (% Mg)	16.58	10 - 20 (12 optimum)		
Percent Potassium (% K)	3.84	1.5 - 10		
Percent Sodium (%Na)	4.1	0.5 - 3		
pH:	8.3	Plant available soil nitrogen ppm		
Percent Organic Matter (% OM):	1.4	Nitrate (NO3)	6.6	
Soluble Salts (SS) 1:2 (ppm):	38.4	Ammonium (NH4)	3.4	
Electrical Conductivity (EC) 1:2 (dS/m)	0.1	Total available	10.0	
SS estimated saturated paste (ppm)	400.6	NO3:NH4 ratio	1.9	
EC estimated saturated paste (dS/m)	0.6	Organic N release	47.4	
Total Extractable Cations (meq/100 g)	9.7			
Chloride Cl ppm	53.23			

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 after

Major Elements and Sodium	Observed	Desired	Deficit Lb/Acre	Deficit Lb/1000 Sq Ft
Phosphorus (P) - Bray II (ppm):	246			
Phosphate P2O5 ppm:	564	119	0	0
Phosphorus (P) - Olsen (ppm):	37			
Phosphorus (P) - M3 (ppm)	82			
Phosphorus Saturation Index:	0.59	< 1.25		
Sulfur (S) ppm:	28	15-40		
Calcium (Ca) ppm:	1514	1348	0	0
Magnesium (Mg) ppm:	189	143	0	0
Potassium (K) ppm:	90			
Potash (K2O) ppm:	108	174	131	3
Sodium (Na) ppm:	54	< 67		
Aluminum (Al) ppm:	62			
Minor Elements	Observed	Desired		
Boron (B) ppm:	1.13	0.4 - 1.5		
Iron (Fe) ppm:	121.00	104		
Manganese (Mn) ppm:	90.00	35	Manganese Availability Index =	317.6
Copper (Cu) ppm:	6.86	0.6 - 2.0		
Zinc (Zn) ppm:	21.95	1.3 - 3.5		
Cations Expressed as Percent of Total Extractable Cations	Observed	Desired		
Percent Calcium (% Ca)	76.08	60 - 70 (68 optimum)		
Percent Magnesium (% Mg)	15.83	10 - 20 (12 optimum)		
Percent Potassium (% K)	2.32	1.5 - 10		
Percent Sodium (%Na)	2.36	0.5 - 3		
pH:	8.0	Plant available soil nitrogen ppm		
Percent Organic Matter (% OM):	1.7	Nitrate (NO3)	8.2	
Soluble Salts (SS) 1:2 (ppm):	25.6	Ammonium (NH4)	3.7	
Electrical Conductivity (EC) 1:2 (dS/m)	0.0	Total available	11.9	
SS estimated saturated paste (ppm)	373.8	NO3:NH4 ratio	2.2	
EC estimated saturated paste (dS/m)	0.6	Organic N release	53.0	
Total Extractable Cations (meq/100 g)	9.9			
Chloride Cl ppm	21.11			

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 before

Major Elements and Sodium	Observed	Desired	Deficit Lb/Acre	Deficit Lb/1000 Sq Ft
Phosphorus (P) - Bray II (ppm):	246			
Phosphate P2O5 ppm:	564	121	0	0
Phosphorus (P) - Olsen (ppm):	45			
Phosphorus (P) - M3 (ppm)	100			
Phosphorus Saturation Index:	0.60	< 1.25		
Sulfur (S) ppm:	67	15-40		
Calcium (Ca) ppm:	1952	1721	0	0
Magnesium (Mg) ppm:	213	182	0	0
Potassium (K) ppm:	139			
Potash (K2O) ppm:	167	197	59	1
Sodium (Na) ppm:	93	< 67		
Aluminum (Al) ppm:	74			
Minor Elements				
	Observed	Desired		
Boron (B) ppm:	1.17	0.4 - 1.5		
Iron (Fe) ppm:	149.00	106		
Manganese (Mn) ppm:	120.00	35	Manganese Availability Index =	427.1
Copper (Cu) ppm:	9.34	0.6 - 2.0		
Zinc (Zn) ppm:	30.83	1.3 - 3.5		
Cations Expressed as Percent of Total Extractable Cations				
	Observed	Desired		
Percent Calcium (% Ca)	76.85	60 - 70 (68 optimum)		
Percent Magnesium (% Mg)	13.98	10 - 20 (12 optimum)		
Percent Potassium (% K)	2.81	1.5 - 10		
Percent Sodium (%Na)	3.18	0.5 - 3		
pH:	8.2	Plant available soil nitrogen ppm		
Percent Organic Matter (% OM):	1.9	Nitrate (NO3)	9.1	
Soluble Salts (SS) 1:2 (ppm):	38.4	Ammonium (NH4)	3.4	
Electrical Conductivity (EC) 1:2 (dS/m)	0.1	Total available	12.5	
SS estimated saturated paste (ppm)	400.6	NO3:NH4 ratio	2.7	
EC estimated saturated paste (dS/m)	0.6	Organic N release	57.6	
Total Extractable Cations (meq/100 g)	12.7			
Chloride Cl ppm	44.24			

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g 1002t
 after

Major Elements and Sodium	Observed	Desired	Deficit Lb/Acre	Deficit Lb/1000 Sq Ft
Phosphorus (P) - Bray II (ppm):	189			
Phosphate P2O5 ppm:	433	120	0	0
Phosphorus (P) - Olsen (ppm):	34			
Phosphorus (P) - M3 (ppm)	76			
Phosphorus Saturation Index:	0.50	< 1.25		
Sulfur (S) ppm:	29	15-40		
Calcium (Ca) ppm:	1626	1431	0	0
Magnesium (Mg) ppm:	193	152	0	0
Potassium (K) ppm:	84			
Potash (K2O) ppm:	101	179	156	4
Sodium (Na) ppm:	55	< 67		
Aluminum (Al) ppm:	70			

Minor Elements	Observed	Desired	
Boron (B) ppm:	0.69	0.4 - 1.5	
Iron (Fe) ppm:	130.00	103	
Manganese (Mn) ppm:	86.00	34	Manganese Availability Index = 304.1
Copper (Cu) ppm:	7.82	0.6 - 2.0	
Zinc (Zn) ppm:	22.90	1.3 - 3.5	

Cations Expressed as Percent of Total Extractable Cations	Observed	Desired
Percent Calcium (% Ca)	76.99	60 - 70 (68 optimum)
Percent Magnesium (% Mg)	15.23	10 - 20 (12 optimum)
Percent Potassium (% K)	2.04	1.5 - 10
Percent Sodium (%Na)	2.26	0.5 - 3

pH:	7.9	Plant available soil nitrogen ppm	
Percent Organic Matter (% OM):	1.4	Nitrate (NO3)	6.5
Soluble Salts (SS) 1:2 (ppm):	25.6	Ammonium (NH4)	3.2
Electrical Conductivity (EC) 1:2 (dS/m)	0.0	Total available	9.7
SS estimated saturated paste (ppm)	373.8	NO3:NH4 ratio	2.0
EC estimated saturated paste (dS/m)	0.6	Organic N release	47.0
Total Extractable Cations (meq/100 g)	10.5		
Chloride Cl ppm	19.72		

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g 1301n
 before

Major Elements and Sodium	Observed	Desired	Deficit Lb/Acre	Deficit Lb/1000 Sq Ft
Phosphorus (P) - Bray II (ppm):	203			
Phosphate P2O5 ppm:	465	121	0	0
Phosphorus (P) - Olsen (ppm):	42			
Phosphorus (P) - M3 (ppm)	104			
Phosphorus Saturation Index:	0.66	< 1.25		
Sulfur (S) ppm:	95	15-40		
Calcium (Ca) ppm:	1784	1644	0	0
Magnesium (Mg) ppm:	229	174	0	0
Potassium (K) ppm:	137			
Potash (K2O) ppm:	165	192	55	1
Sodium (Na) ppm:	119	< 67		
Aluminum (Al) ppm:	66			
Minor Elements	Observed	Desired		
Boron (B) ppm:	1.05	0.4 - 1.5		
Iron (Fe) ppm:	149.00	101		
Manganese (Mn) ppm:	98.00	34	Manganese Availability Index =	350.6
Copper (Cu) ppm:	8.92	0.6 - 2.0		
Zinc (Zn) ppm:	26.88	1.3 - 3.5		
Cations Expressed as Percent of Total Extractable Cations	Observed	Desired		
Percent Calcium (% Ca)	73.54	60 - 70 (68 optimum)		
Percent Magnesium (% Mg)	15.73	10 - 20 (12 optimum)		
Percent Potassium (% K)	2.9	1.5 - 10		
Percent Sodium (%Na)	4.27	0.5 - 3		
pH:	7.8	Plant available soil nitrogen ppm		
Percent Organic Matter (% OM):	1.4	Nitrate (NO3)	6.1	
Soluble Salts (SS) 1:2 (ppm):	38.4	Ammonium (NH4)	4.0	
Electrical Conductivity (EC) 1:2 (dS/m)	0.1	Total available	10.1	
SS estimated saturated paste (ppm)	400.6	NO3:NH4 ratio	1.5	
EC estimated saturated paste (dS/m)	0.6	Organic N release	47.6	
Total Extractable Cations (meq/100 g)	12.1			
Chloride Cl ppm	66.88			

Major Elements and Sodium	Observed	Desired	Deficit Lb/Acre	Deficit Lb/1000 Sq Ft
Phosphorus (P) - Bray II (ppm):	164			
Phosphate P2O5 ppm:	376	120	0	0
Phosphorus (P) - Olsen (ppm):	29			
Phosphorus (P) - M3 (ppm)	83			
Phosphorus Saturation Index:	0.55	< 1.25		
Sulfur (S) ppm:	27	15-40		
Calcium (Ca) ppm:	1662	1456	0	0
Magnesium (Mg) ppm:	190	154	0	0
Potassium (K) ppm:	90			
Potash (K2O) ppm:	108	181	144	3
Sodium (Na) ppm:	52	< 67		
Aluminum (Al) ppm:	64			

Minor Elements	Observed	Desired	
Boron (B) ppm:	1.07	0.4 - 1.5	
Iron (Fe) ppm:	140.00	100	
Manganese (Mn) ppm:	97.00	33	Manganese Availability Index = 348.4
Copper (Cu) ppm:	7.23	0.6 - 2.0	
Zinc (Zn) ppm:	21.54	1.3 - 3.5	

Cations Expressed as Percent of Total Extractable Cations	Observed	Desired
Percent Calcium (% Ca)	77.3	60 - 70 (68 optimum)
Percent Magnesium (% Mg)	14.73	10 - 20 (12 optimum)
Percent Potassium (% K)	2.15	1.5 - 10
Percent Sodium (%Na)	2.1	0.5 - 3

pH:	7.7	Plant available soil nitrogen ppm
Percent Organic Matter (% OM):	1.3	Nitrate (NO3) 7.3
Soluble Salts (SS) 1:2 (ppm):	19.2	Ammonium (NH4) 3.0
Electrical Conductivity (EC) 1:2 (dS/m)	0.0	Total available 10.3
SS estimated saturated paste (ppm)	360.3	NO3:NH4 ratio 2.4
EC estimated saturated paste (dS/m)	0.6	Organic N release 46.8
Total Extractable Cations (meq/100 g)	10.7	
Chloride Cl ppm	16.75	

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g 1501n
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Major Elements and Sodium	Observed	Desired	Deficit Lb/Acre	Deficit Lb/1000 Sq Ft
Phosphorus (P) - Bray II (ppm):	182			
Phosphate P2O5 ppm:	417	121	0	0
Phosphorus (P) - Olsen (ppm):	47			
Phosphorus (P) - M3 (ppm)	106			
Phosphorus Saturation Index:	0.64	< 1.25		
Sulfur (S) ppm:	67	15-40		
Calcium (Ca) ppm:	1892	1683	0	0
Magnesium (Mg) ppm:	216	178	0	0
Potassium (K) ppm:	138			
Potash (K2O) ppm:	166	195	57	1
Sodium (Na) ppm:	91	< 67		
Aluminum (Al) ppm:	73			

Minor Elements	Observed	Desired	
Boron (B) ppm:	1.16	0.4 - 1.5	
Iron (Fe) ppm:	147.00	105	
Manganese (Mn) ppm:	126.00	35	Manganese Availability Index = 451.1
Copper (Cu) ppm:	8.22	0.6 - 2.0	
Zinc (Zn) ppm:	27.87	1.3 - 3.5	

Cations Expressed as Percent of Total Extractable Cations	Observed	Desired
Percent Calcium (% Ca)	76.17	60 - 70 (68 optimum)
Percent Magnesium (% Mg)	14.49	10 - 20 (12 optimum)
Percent Potassium (% K)	2.85	1.5 - 10
Percent Sodium (%Na)	3.19	0.5 - 3

pH:	8.1	Plant available soil nitrogen ppm	
Percent Organic Matter (% OM):	1.9	Nitrate (NO3)	7.0
Soluble Salts (SS) 1:2 (ppm):	38.4	Ammonium (NH4)	4.0
Electrical Conductivity (EC) 1:2 (dS/m)	0.1	Total available	11.0
SS estimated saturated paste (ppm)	400.6	NO3:NH4 ratio	1.8
EC estimated saturated paste (dS/m)	0.6	Organic N release	57.2
Total Extractable Cations (meq/100 g)	12.4		
Chloride Cl ppm	52.64		

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g 1502n
 after

Major Elements and Sodium	Observed	Desired	Deficit Lb/Acre	Deficit Lb/1000 Sq Ft
Phosphorus (P) - Bray II (ppm):	167			
Phosphate P2O5 ppm:	383	119	0	0
Phosphorus (P) - Olsen (ppm):	33			
Phosphorus (P) - M3 (ppm)	84			
Phosphorus Saturation Index:	0.56	< 1.25		
Sulfur (S) ppm:	26	15-40		
Calcium (Ca) ppm:	1453	1299	0	0
Magnesium (Mg) ppm:	187	140	0	0
Potassium (K) ppm:	77			
Potash (K2O) ppm:	93	171	156	4
Sodium (Na) ppm:	51	< 67		
Aluminum (Al) ppm:	69			
Minor Elements	Observed	Desired		
Boron (B) ppm:	0.85	0.4 - 1.5		
Iron (Fe) ppm:	126.00	101		
Manganese (Mn) ppm:	108.00	34	Manganese Availability Index =	388.1
Copper (Cu) ppm:	6.38	0.6 - 2.0		
Zinc (Zn) ppm:	22.36	1.3 - 3.5		
Cations Expressed as Percent of Total Extractable Cations	Observed	Desired		
Percent Calcium (% Ca)	75.76	60 - 70 (68 optimum)		
Percent Magnesium (% Mg)	16.25	10 - 20 (12 optimum)		
Percent Potassium (% K)	2.06	1.5 - 10		
Percent Sodium (%Na)	2.31	0.5 - 3		
pH:	7.8	Plant available soil nitrogen ppm		
Percent Organic Matter (% OM):	1.2	Nitrate (NO3)	6.7	
Soluble Salts (SS) 1:2 (ppm):	19.2	Ammonium (NH4)	3.3	
Electrical Conductivity (EC) 1:2 (dS/m)	0.0	Total available	10.0	
SS estimated saturated paste (ppm)	360.3	NO3:NH4 ratio	2.0	
EC estimated saturated paste (dS/m)	0.6	Organic N release	44.4	
Total Extractable Cations (meq/100 g)	9.5			
Chloride Cl ppm	19.08			

Major Elements and Sodium	Observed	Desired	Deficit Lb/Acre	Deficit Lb/1000 Sq Ft
Phosphorus (P) - Bray II (ppm):	188			
Phosphate P2O5 ppm:	431	121	0	0
Phosphorus (P) - Olsen (ppm):	41			
Phosphorus (P) - M3 (ppm)	95			
Phosphorus Saturation Index:	0.58	< 1.25		
Sulfur (S) ppm:	104	15-40		
Calcium (Ca) ppm:	2014	1798	0	0
Magnesium (Mg) ppm:	224	190	0	0
Potassium (K) ppm:	148			
Potash (K2O) ppm:	178	202	47	1
Sodium (Na) ppm:	116	< 67		
Aluminum (Al) ppm:	69			
Minor Elements	Observed	Desired		
Boron (B) ppm:	1.03	0.4 - 1.5		
Iron (Fe) ppm:	154.00	104		
Manganese (Mn) ppm:	119.00	35	Manganese Availability Index =	426.4
Copper (Cu) ppm:	8.25	0.6 - 2.0		
Zinc (Zn) ppm:	24.69	1.3 - 3.5		
Cations Expressed as Percent of Total Extractable Cations	Observed	Desired		
Percent Calcium (% Ca)	75.89	60 - 70 (68 optimum)		
Percent Magnesium (% Mg)	14.07	10 - 20 (12 optimum)		
Percent Potassium (% K)	2.86	1.5 - 10		
Percent Sodium (%Na)	3.8	0.5 - 3		
pH:	8.0	Plant available soil nitrogen ppm		
Percent Organic Matter (% OM):	1.5	Nitrate (NO3)	8.1	
Soluble Salts (SS) 1:2 (ppm):	51.2	Ammonium (NH4)	3.9	
Electrical Conductivity (EC) 1:2 (dS/m)	0.1	Total available	12.0	
SS estimated saturated paste (ppm)	427.5	NO3:NH4 ratio	2.1	
EC estimated saturated paste (dS/m)	0.7	Organic N release	49.2	
Total Extractable Cations (meq/100 g)	13.2			
Chloride Cl ppm	77.73			

Major Elements and Sodium	Observed	Desired	Deficit Lb/Acre	Deficit Lb/1000 Sq Ft
Phosphorus (P) - Bray II (ppm):	203			
Phosphate P2O5 ppm:	465	119	0	0
Phosphorus (P) - Olsen (ppm):	27			
Phosphorus (P) - M3 (ppm)	63			
Phosphorus Saturation Index:	0.47	< 1.25		
Sulfur (S) ppm:	30	15-40		
Calcium (Ca) ppm:	1356	1214	0	0
Magnesium (Mg) ppm:	174	140	0	0
Potassium (K) ppm:	79			
Potash (K2O) ppm:	95	166	141	3
Sodium (Na) ppm:	52	< 67		
Aluminum (Al) ppm:	60			

Minor Elements	Observed	Desired	
Boron (B) ppm:	0.86	0.4 - 1.5	
Iron (Fe) ppm:	116.00	104	
Manganese (Mn) ppm:	81.00	35	Manganese Availability Index = 283.9
Copper (Cu) ppm:	6.20	0.6 - 2.0	
Zinc (Zn) ppm:	15.84	1.3 - 3.5	

Cations Expressed as Percent of Total Extractable Cations	Observed	Desired
Percent Calcium (% Ca)	75.67	60 - 70 (68 optimum)
Percent Magnesium (% Mg)	16.18	10 - 20 (12 optimum)
Percent Potassium (% K)	2.26	1.5 - 10
Percent Sodium (%Na)	2.52	0.5 - 3

pH:	8.0	Plant available soil nitrogen ppm
Percent Organic Matter (% OM):	1.1	Nitrate (NO3) 6.0
Soluble Salts (SS) 1:2 (ppm):	25.6	Ammonium (NH4) 3.2
Electrical Conductivity (EC) 1:2 (dS/m)	0.0	Total available 9.2
SS estimated saturated paste (ppm)	373.8	NO3:NH4 ratio 1.9
EC estimated saturated paste (dS/m)	0.6	Organic N release 42.0
Total Extractable Cations (meq/100 g)	8.9	
Chloride Cl ppm	21.66	

Saturated Paste Soil appraisals (SP)

Los Angeles Country Club

gs 0401t

08060603res Saturated Paste Extraction
6/10/2008 Brookside

5346

before

			Desired	
	pH	8.1	6.2 - 6.9	
	Electrical Conductivity dS/m	1.73	<2.0	
	Chloride (Cl) ppm:	151	<3,000	
	Nitrate (NO3) ppm:	1.7	5 - 20	
	Bicarbonate (HCO3) ppm:	173.37	< 60	
	ESP (exchangeable sodium percentage)	1.69	< 5	
	SAR (Sodium Adsorption Ratio)	2.02	< 4	
		ppm	Desired	Percent
	Sulfur:	145.87		Desired
	Phosphorous:	2.6	2 - 10	
	Calcium:	135.36	60 - 200	39.91 > 20
	Magnesium:	39.91	20 - 70	19.39
	Potassium (ppm):	92.4	40-100	13.96
	Sodium	104.04	0 - 30	26.73 < 35

Los Angeles Country Club

gs 0402t

08060603res Saturated Paste Extraction
6/10/2008 Brookside

5347

after

			Desired	
	pH	8.3	6.2 - 6.9	
	Electrical Conductivity dS/m	0.63	<2.0	
	Chloride (Cl) ppm:	27	<3,000	
	Nitrate (NO3) ppm:	1.6	5 - 20	
	Bicarbonate (HCO3) ppm:	296.62	< 60	
	ESP (exchangeable sodium percentage)	0.52	< 5	
	SAR (Sodium Adsorption Ratio)	1.21	< 4	
		ppm	Desired	Percent
	Sulfur:	26.48		Desired
	Phosphorous:	3.39	2 - 10	
	Calcium:	51.02	60 - 200	40.02 > 20
	Magnesium:	15.02	20 - 70	19.41
	Potassium (ppm):	36.02	40-100	14.48
	Sodium	38.17	0 - 30	26.09 < 35

Los Angeles Country Club**gs 0901t**08060603res Saturated Paste Extraction
6/10/2008 Brookside

5348

before

			Desired	
	pH	8.2	6.2 - 6.9	
	Electrical Conductivity dS/m	1.31	<2.0	
	Chloride (Cl) ppm:	97	<3,000	
	Nitrate (NO3) ppm:	0	5 - 20	
	Bicarbonate (HCO3) ppm:	165.24	< 60	
	ESP (exchangeable sodium percentage)	1.51	< 5	
	SAR (Sodium Adsorption Ratio)	1.89	< 4	
		ppm	Desired	Percent
	Sulfur:	90.71		Desired
	Phosphorous:	2.55	2 - 10	
	Calcium:	95.92	60 - 200	37.87 > 20
	Magnesium:	29.08	20 - 70	18.92
	Potassium (ppm):	73.38	40-100	14.85
	Sodium	82.43	0 - 30	28.36 < 35

Los Angeles Country Club**gs 0902t**08060603res Saturated Paste Extraction
6/10/2008 Brookside

5349

after

			Desired	
	pH	8.1	6.2 - 6.9	
	Electrical Conductivity dS/m	0.70	<2.0	
	Chloride (Cl) ppm:	37	<3,000	
	Nitrate (NO3) ppm:	0.4	5 - 20	
	Bicarbonate (HCO3) ppm:	280.37	< 60	
	ESP (exchangeable sodium percentage)	0.62	< 5	
	SAR (Sodium Adsorption Ratio)	1.28	< 4	
		ppm	Desired	Percent
	Sulfur:	29.03		Desired
	Phosphorous:	3.26	2 - 10	
	Calcium:	55	60 - 200	39.45 > 20
	Magnesium:	17.88	20 - 70	21.14
	Potassium (ppm):	34.63	40-100	12.73
	Sodium	42.69	0 - 30	26.68 < 35

Los Angeles Country Club**gs 1001t**08060603res Saturated Paste Extraction
6/10/2008 Brookside

5350

before

		Desired
pH	8.1	6.2 - 6.9
Electrical Conductivity dS/m	1.10	<2.0
Chloride (Cl) ppm:	86	<3,000
Nitrate (NO3) ppm:	2.1	5 - 20
Bicarbonate (HCO3) ppm:	161.18	< 60
ESP (exchangeable sodium percentage)	1.41	< 5
SAR (Sodium Adsorption Ratio)	1.83	< 4

	ppm	Desired	Percent	Desired
Sulfur:	79.52			
Phosphorous:	3.06	2 - 10		
Calcium:	85.33	60 - 200	38.54	> 20
Magnesium:	25.01	20 - 70	18.62	
Potassium (ppm):	58.14	40-100	13.46	
Sodium	74.65	0 - 30	29.38	< 35

Los Angeles Country Club**gs 1002t**08060603res Saturated Paste Extraction
6/10/2008 Brookside

5351

after

		Desired
pH	8	6.2 - 6.9
Electrical Conductivity dS/m	0.66	<2.0
Chloride (Cl) ppm:	34	<3,000
Nitrate (NO3) ppm:	0.2	5 - 20
Bicarbonate (HCO3) ppm:	196.39	< 60
ESP (exchangeable sodium percentage)	0.56	< 5
SAR (Sodium Adsorption Ratio)	1.24	< 4

	ppm	Desired	Percent	Desired
Sulfur:	27.9			
Phosphorous:	3.63	2 - 10		
Calcium:	52.58	60 - 200	40.66	> 20
Magnesium:	16.77	20 - 70	21.37	
Potassium (ppm):	27.36	40-100	10.84	
Sodium	40.28	0 - 30	27.13	< 35

Los Angeles Country Club

gs 1301n

08060603res Saturated Paste Extraction
6/10/2008 Brookside

5340

before

			Desired
	pH	8	6.2 - 6.9
	Electrical Conductivity dS/m	1.62	<2.0
	Chloride (Cl) ppm:	125	<3,000
	Nitrate (NO3) ppm:	0.1	5 - 20
	Bicarbonate (HCO3) ppm:	154.4	< 60
	ESP (exchangeable sodium percentage)	1.61	< 5
	SAR (Sodium Adsorption Ratio)	1.96	< 4

	ppm	Desired	Percent	Desired
Sulfur:	139.5			
Phosphorous:	2.53	2 - 10		
Calcium:	137.59	60 - 200	42.24	> 20
Magnesium:	38.74	20 - 70	19.6	
Potassium (ppm):	70.6	40-100	11.11	
Sodium	101.1	0 - 30	27.04	< 35

Los Angeles Country Club

gs 1302n

08060603res Saturated Paste Extraction
6/10/2008 Brookside

5341

after

			Desired
	pH	8.2	6.2 - 6.9
	Electrical Conductivity dS/m	0.59	<2.0
	Chloride (Cl) ppm:	27	<3,000
	Nitrate (NO3) ppm:	0.8	5 - 20
	Bicarbonate (HCO3) ppm:	188.26	< 60
	ESP (exchangeable sodium percentage)	0.34	< 5
	SAR (Sodium Adsorption Ratio)	1.08	< 4

	ppm	Desired	Percent	Desired
Sulfur:	22.42			
Phosphorous:	3.21	2 - 10		
Calcium:	48.25	60 - 200	40.88	> 20
Magnesium:	15.03	20 - 70	20.99	
Potassium (ppm):	30.61	40-100	13.29	
Sodium	33.65	0 - 30	24.84	< 35

Los Angeles Country Club

gs 1501n

08060603res Saturated Paste Extraction
6/10/2008 Brookside

5342

before

			Desired
	pH	8	6.2 - 6.9
	Electrical Conductivity dS/m	1.26	<2.0
	Chloride (Cl) ppm:	92	<3,000
	Nitrate (NO3) ppm:	0.3	5 - 20
	Bicarbonate (HCO3) ppm:	189.62	< 60
	ESP (exchangeable sodium percentage)	1.41	< 5
	SAR (Sodium Adsorption Ratio)	1.83	< 4

	ppm	Desired	Percent	Desired
Sulfur:	89.62			
Phosphorous:	3.03	2 - 10		
Calcium:	96.43	60 - 200	39.09	> 20
Magnesium:	29.67	20 - 70	19.82	
Potassium (ppm):	61.77	40-100	12.83	
Sodium	79.99	0 - 30	28.25	< 35

Los Angeles Country Club

gs 1502n

08060603res Saturated Paste Extraction
6/10/2008 Brookside

5343

after

			Desired
	pH	8	6.2 - 6.9
	Electrical Conductivity dS/m	0.74	<2.0
	Chloride (Cl) ppm:	35	<3,000
	Nitrate (NO3) ppm:	0.1	5 - 20
	Bicarbonate (HCO3) ppm:	333.19	< 60
	ESP (exchangeable sodium percentage)	0.4	< 5
	SAR (Sodium Adsorption Ratio)	1.13	< 4

	ppm	Desired	Percent	Desired
Sulfur:	28.15			
Phosphorous:	3.55	2 - 10		
Calcium:	61.74	60 - 200	42.17	> 20
Magnesium:	20.75	20 - 70	23.36	
Potassium (ppm):	30.3	40-100	10.61	
Sodium	40.1	0 - 30	23.86	< 35

Los Angeles Country Club**gs 1801n**08060603res Saturated Paste Extraction
6/10/2008 Brookside

5344

before

		Desired
pH	8	6.2 - 6.9
Electrical Conductivity dS/m	1.60	<2.0
Chloride (Cl) ppm:	140	<3,000
Nitrate (NO3) ppm:	0.1	5 - 20
Bicarbonate (HCO3) ppm:	212.64	< 60
ESP (exchangeable sodium percentage)	1.64	< 5
SAR (Sodium Adsorption Ratio)	1.98	< 4

	ppm	Desired	Percent	Desired
Sulfur:	129.24			
Phosphorous:	2.38	2 - 10		
Calcium:	123.03	60 - 200	40.33	> 20
Magnesium:	37.31	20 - 70	20.15	
Potassium (ppm):	68.7	40-100	11.54	
Sodium	97.93	0 - 30	27.97	< 35

Los Angeles Country Club**gs 1802n**08060603res Saturated Paste Extraction
6/10/2008 Brookside

5345

after

		Desired
pH	8.1	6.2 - 6.9
Electrical Conductivity dS/m	0.64	<2.0
Chloride (Cl) ppm:	34	<3,000
Nitrate (NO3) ppm:	0.2	5 - 20
Bicarbonate (HCO3) ppm:	215.35	< 60
ESP (exchangeable sodium percentage)	0.47	< 5
SAR (Sodium Adsorption Ratio)	1.17	< 4

	ppm	Desired	Percent	Desired
Sulfur:	28.98			
Phosphorous:	3.38	2 - 10		
Calcium:	53.66	60 - 200	40.88	> 20
Magnesium:	17.37	20 - 70	21.81	
Potassium (ppm):	29.8	40-100	11.63	
Sodium	38.69	0 - 30	25.68	< 35

Soil chemical guidelines - Melich III extraction

Table 1. Guidelines for iron and manganese, for soils at a range of different pHs. Note that the desired levels of micronutrients increases as soil pH increases. Maintaining higher levels of manganese and iron helps to overcome their tendency to become bound, and therefore unavailable, to the plant in more basic soils. We have paid special attention to these two micronutrients because plants are more likely to be deficient in iron than any other micronutrient. And higher levels of manganese appear to play a role in suppressing turf diseases caused by *Gaeumannomyces* such as bermudagrass decline, kikuyugrass decline, and take-all patch.

	Desired soil concentrations (ppm) for pH 6 - 8.5 soils						Average range for greens, tees & fairways (across all pHs)
	6	6.5	7	7.5	8	8.5	
Iron (Fe)	80	86	92	98	104	110	157-185
Manganese (Mn)	27	29	31	33	35	37	30-43

Table 2. Soil nutritional guidelines. Iron and manganese values are reported in Table 1 above.

Nutrient concentration (ppm)	Greens		Tees		Fairways	
	Average	Desired	Average	Desired	Average	Desired
Nitrate (NO ₃)	6.7	3-20	17.1	3-20	24.2	3-20
Ammonium (NH ₄)	2.5	<7	4.2	<7	4.4	<7
NO ₃ + NH ₄	9.4	<20	21.3	<20	28.6	<20
Phosphorous (P)	99	51	92	40	101	44
Potassium (K)	156	144	135	174	235	229
Calcium (Ca)	1346	1327	1857	1916	2640	3043
Magnesium (Mg)	174	140	332	203	611	322
Sodium (Na)	174	<67	260	<67	584	<67
Sulfate (SO ₄)	139	15 - 40	135	15 - 40	490	15 - 40
Boron (B)	1.0	0.4 - 1.5	1.2	0.4 - 1.5	1.7	0.4 - 1.5
Copper (Cu)	4.7	0.6 - 2.0	3.1	0.6 - 2.0	2.4	0.6 - 2.0
Iron (Fe)	185	See Table 1	175	See Table 1	157	See Table 1
Manganese (Mn)	30	See Table 1	30	See Table 1	43	See Table 1
Zinc (Zn)	18.9	1.3 - 3.5	13.9	1.3 - 3.5	8.4	1.3 - 3.5

Other soil measurements	Greens		Tees		Fairways	
	Average	Desired	Average	Desired	Average	Desired
pH	7.1	6.5 - 7.5	7.4	6.5 - 7.5	7.2	6.5 - 7.5
EC (dS/m)	3.2	<3.0	3.0	<3.0	6.4	<3.0
TEC (meq/100 g)	9.9	NA	14.5	NA	24	NA
OM%	2.0	NA	3.0	NA	4.4	NA
% Ca	69	68	66	68	59	68
% Mg	15	12-20	20	12-20	23	12-20
% K	4	4	3	4	3	4
%Na	8	<3	8	<3	11	<3
% H	0	10 - 15	0	10 - 15	0	10 - 15

These guidelines are based upon PACE data collected from golf course greens, tees and fairways. Soil analysis using Melich III extraction by Brookside Laboratories, New Knoxville, OH. This data can be used as an aid in developing turf fertility programs, but should always be used in conjunction with specific soil test results from your golf course.

Soil chemical guidelines - Saturated Paste Extraction

Soil Saturated Paste Analysis desired values for soils that are calcareous or for soils that otherwise can not be effectively analyzed using Melich III extraction methods.

	Desired
PH	6.2 – 6.9
Salt (ppm)	< 1280
Chloride (ppm)	<3,000
Nitrate (ppm)	5 - 20
ammonium	<7
Bicarb HCO ₃ (ppm)	<60
Phosphorous (ppm)	2 – 10
Calcium	60 – 200 ppm or >20%
Magnesium	20 – 70 ppm
Potassium	40 – 100 ppm
Sodium	0 – 30 ppm or <35%
ESP	<5.0%
SAR	< 4.0