

Soil nutritional guidelines

Iron and manganese values are reported below. The “desired” guideline values were derived based on three different sources of information: sufficiency (SLAN) guidelines, balance (BSCR) guidelines and PACE data collected from good performing golf course greens, tees and fairways. Soil analysis using Melich III extraction by Brookside Laboratories, New Knoxville, OH. Unless otherwise indicated, values are in parts per million (ppm).

Nutrient concentration (ppm)	Greens		Tees		Fairways	
	Average	Desired	Average	Desired	Average	Desired
Nitrate:Ammonium	2.7 to 1	3 to 1	4.1 to 1	3 to 1	5.5 to 1	3 to 1
Nitrate (NO₃)	6.7	3-20	17.1	3-20	24.2	3-20
Ammonium (NH₄)	2.5	<7	4.2	<7	4.4	<7
NO₃ + NH₄	9.4	<20	21.3	<20	28.6	<20
Phosphorous (P)	99	51	92	40	101	44
Potassium (K)	156	>110	135	>110	235	>110
Calcium (Ca)	1346	1327	1857	1916	2640	3043
Magnesium (Mg)	174	140	332	203	611	322
Sodium (Na)	174	<110	260	<110	584	<110
Sulfur (S)	139	<130	135	<460	490	<460
Chloride (Cl)	53	<90	122	<400	427	<400
Sulfur + Chloride	140	<200	223	<800	1015	<800
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 below	175	See below	157	See below
Manganese (Mn)	30	See below	30	See below	43	See below
Zinc (Zn)	18.9	1.3 - 3.5	13.9	1.3 - 3.5	8.4	1.3 - 3.5

Other 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	<2	3.0	<6	4.4	<6
% 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

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 ppm for pH 6 - 8.5 soils						Avg. 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

Regional variation in soil nutrients on greens. A comparison based on 120 samples from the Florida Panhandle, Coastal Louisiana and Mississippi, Minnesota, Southern California, Minnesota and Chicago, IL. Data based on a 2001 collaborative project among R. Carrow (University of Georgia); S. Davis (Bayer) and L. Stowell (PACE Turfgrass Research Institute). Additional support was provided by Arthur Clesen Inc., Turf Supply, Lesco and ProSource One.

*Desired values provided by Dr. R. Carrow, University of Georgia

Parameter	Desired*	MN	IL	CA	FL	LA/MS
pH	6.0-7.5	7.0	7.0	7.1	6.5	6.9
Phosphorous (ppm)	>50	240	105	99	85	28
Potassium (ppm)	>110	146	170	156	88	37
Calcium (ppm)	>750	1660	2726	1346	544	225
Magnesium (ppm)	>140	160	343	174	91	53
Sulphur (ppm)	15 - 40	12.5	63	139	20	4
Boron (ppm)	0.5 – 1.5	---	<1	1	1.2	3
Copper (ppm)	0.1 – 2.5	1.35	4	5	3.3	0.6
Iron (ppm)	>90	108	248	185	42	59
Manganese (ppm)	>30	24	34	30	2.9	6.7
Zinc (ppm)	1 - 4	16	20	19	6.9	5.1
Sodium (ppm)	<110	10	40	174	48	---
% Base Saturation						
% calcium	65 – 80%	69%	76%	69%	71%	69%
% potassium	2 - 7%	4%	3%	4%	4%	6%
% magnesium	10 - 20%	15%	17%	15%	20%	26%
% sodium	<3%	<1%	1%	8%	6%	---
Other Values						
EC (dS/m)	<1.5	0.25	0.48	3.2	0.05	0.14
TEC (meq/100g)	>4	7.8	17.8	9.9	2.1	1.6
% Organic matter	<4%	<3%	3%	2%	0.15%	0.15%

Saturated paste extraction values. Saturated paste extracts (SPE) are sometimes used to determine the nutritional content of soils that are calcareous or that cannot be effectively analyzed using Melich III extraction methods. However, the accuracy of using SPE for this purpose has not been thoroughly established. For this reason, the guidelines provided below are very rough, and should not be relied upon as the sole source of information in making fertility decisions. There is unfortunately no conversion factor that allows one to compare results of saturated paste extracts with results from standard extraction methods — they are two different systems entirely. The soil guidelines in References 6 and 7 are based on standard extraction methods such as the Mehlich III test

	Desired Value
pH	6.2 – 6.9
Salt (ppm)	< 1280
Chloride (ppm)	<1,000
Nitrate (ppm)	5 - 20
Ammonium	<7
Bicarbonate HCO ₃ (ppm)	<60
Phosphorous (ppm)	2 – 10
Calcium	30 - 100 ppm or >20%
Magnesium	15 - 50 ppm
Potassium	20 - 40 ppm
Sodium	0 – 30 ppm or <35%
ESP	<5.0%
SAR	< 4.0