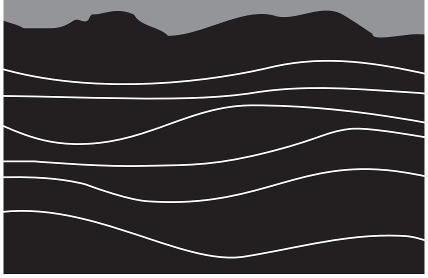
A3030

Optimum soil test levels for Wisconsin



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Soil test results for phosphorus, potassium, and other mineral elements are interpreted on Wisconsin soil test reports in terms ranging from very low to excessively high. This publication explains the meaning of the ratings and how they are derived for various crops and soils. Farmers and others can use this publication along with their soil test results to evaluate the overall fertility status of their farms, estimate the likelihood of profitable fertilizer responses from the fields, and decide where to invest in lime and fertilizer for the greatest economic return and crop quality.

Why test soils?

The goal of the fertilizer recommendations generated by the Wisconsin soil test program is to suggest appropriate nutrient levels for specific crops. When nutrient levels are deficient or excessive, the crop suffers.

Nutrient shortages markedly lower crop yield and quality. For example, potassium deficiencies have been linked to poor winter survival of alfalfa, lowered disease resistance, and increased lodging in corn and other grains. Insufficient amounts of nitrogen or sulfur can reduce protein levels in forages. Low calcium levels in fruits and vegetables can increase their susceptibility to several diseases.

Excesses of some elements can reduce yields by causing imbalances. Excessive amounts of boron, manganese, copper, and zinc can lead to toxicities. Also, once soil tests reach the high level, adding more nutrients is of little economic benefit. Excess nutrients build up when more fertilizer or manure is added than is removed by the harvested portions of the crop. It is important to know when to cut back on certain nutrients as well as when to add more. Maintaining nutrients at optimum levels avoids economically damaging nutrient stress throughout the growing season while avoiding excesses that can cause agronomic or environmental problems. The best combination of economic return and maintenance of environmental quality is provided by considering nutrients from all sources. This means storing somewhat lower quantities of nutrients in the soil and meeting nutrient needs from both fertilizer applications and soil reserves.

Understanding soil test interpretations

Soil test interpretations estimate the likelihood of a profitable yield increase when a given nutrient is added. The interpretation categories are described in table 1. The tests have been calibrated so that the addition of recommended amounts of nutrients are strongly suggested when the tests are at or below the optimum level. At these levels, the likelihood of obtaining a profitable economic response to applied nutrients is very good (greater than 30%).

The optimum soil test level for a given nutrient depends on a number of factors, including crop to be grown, soil type, and contributions from the subsoil.

Interpretive levels for soil pH are given graphically on the soil test report in relation to the target pH for the most acid-sensitive crop in the indicated rotation. Table 2 lists the optimum pH levels for crops grown in Wisconsin.

Most routine soil testing programs give no interpretations for nitrogen or organic matter. Under normal or higher rainfall and optimum fertilization programs, nitrogen usually does not accumulate in soil. Because nitrogen may leach over winter, attempting to build up nitrogen in the soil is neither practical nor environmentally wise. Recommended application rates given in the routine soil test report are estimates of crop nitrogen needs for the indicated soil and assume good soil management practices are used. The recommended rates of nitrogen were determined through experiments that measured plant response on various soils. These studies showed that for some crops, including corn, the optimum rate of nitrogen on a given soil was similar in both high- and low-yielding years. For this reason, recommended nitrogen rates for corn are not based on expected yield but are soil specific. Use of special tests (e.g., spring preplant profile nitrate test and presidedress nitrogen test) can more precisely determine the specific nitrogen need.

Soil organic matter levels are controlled by factors such as soil aeration, drainage and tillage systems and cannot be increased easily without large additions of manure or other organic material or by switching to reduced tillage.

Crop demand levels

Crops differ in their need for nutrients. The optimum potassium level for alfalfa is higher than that needed for red clover. To account for different phosphorus and potassium needs, crops have been placed in one of six demand levels: (1) corn; (2) soybeans and low-demand field crops; (3) alfalfa, irrigated field crops, and low-demand vegetable crops; (4) red clover and other medium-demand field crops; (5) high-demand vegetable crops; and (6) potatoes.

The demand level assignments for the various crops are given in table 2. These demand levels were established so that if the soil test is in the optimum range, then crop yield and profit are optimized by adding the quantity of nutrients approximately equivalent to the amount present in the harvested part of the crop.

Subsoil contributions

Nutrients present in the subsoil can contribute significantly to the nutrition of crops. Roots that reach down into the subsoil can use the nutrients stored there, so the level of phosphorus and potassium present in the plow layer becomes slightly less important. For example, recent research at Arlington showed that alfalfa obtained about 100 lb of potash (K_2O equivalent) per year from the subsoil.

Some subsoils are higher in phosphorus and potassium than others. To reflect this difference, the soil test report uses the subsoil fertility groups illustrated in figure 1 to distinguish different soils. These groups are based on soil samples collected at a depth of 8–30 inches from every county in a 1960 statewide survey.

When sending in soil samples for testing and fertilizer recommendations, include the soil name on the information sheet. The soil name is used to assign the correct subsoil group and to interpret soil test phosphorus and potassium data (tables 3 and 4). If the name is not given, the computer “guesses” the soil group based on soil pH, soil texture, organic matter, and county of origin. This procedure obviously does not permit as precise a fertilizer recommendation as when soil name is given. For soil name information contact your county Extension office or Natural Resource Conservation Service (NRCS). A list of the subsoil fertility groups for each of the 699 soil types currently recognized in Wisconsin may be found in Extension publication *Soil Test Recommendations for Field, Vegetable, and Fruit Crops* (A2809).

Subsoil fertility groups are also used to determine nutrient buffering capacities or how much phosphate or potash is required to raise soil test P or K to the optimum level. As shown in figure 1, soil in subsoil group D requires 18 pounds of P_2O_5 per acre to change soil test P by 1 part per million (ppm). A soil in subsoil group E, on the other hand, requires only 12 pounds of P_2O_5 per acre to raise soil test P by 1 ppm.

Secondary nutrients and micronutrients

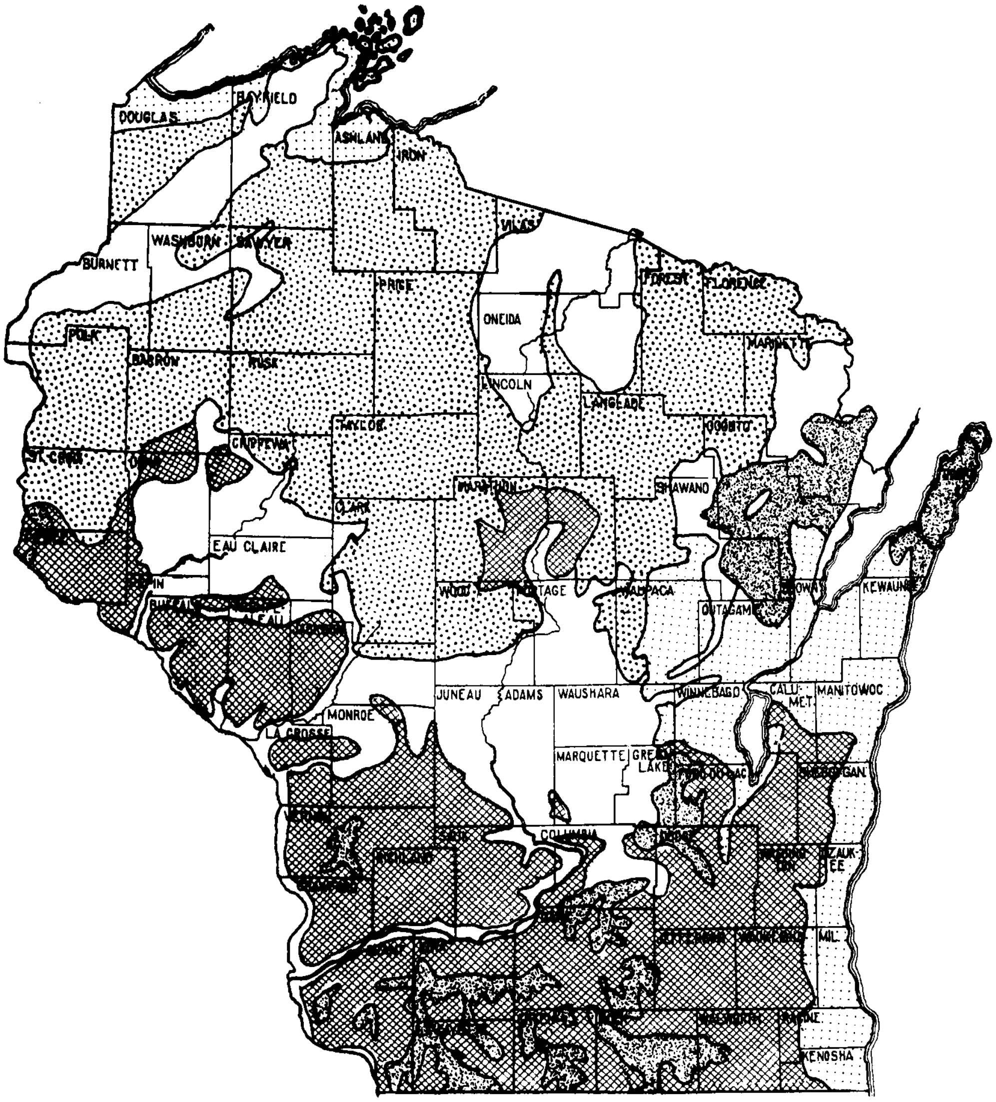
Soil tests are available upon request for secondary nutrients calcium, magnesium, and sulfur as well as trace nutrients zinc, boron, and manganese. The interpretations for these tests are given in table 5.

The sulfur availability index in table 5 is calculated by summing sulfur contributions from estimates of sulfur released from organic matter, precipitation, subsoil, and manure as well as sulfate sulfur (SO_4-S) determined by the soil test. The procedures for estimating the amounts of sulfur contributed from these sources are described in Extension publication *Soil Test Recommendations for Field, Vegetable, and Fruit Crops* (A2809).

Available manganese is influenced both by soil pH and organic matter. When organic matter exceeds 6%, manganese availability is predicted from soil pH rather than the manganese test itself. This interpretation is shown in table 5.

Presently, there are no soil tests for copper, iron, molybdenum, and chlorine calibrated for Wisconsin soil conditions. The likelihood of deficiencies of these micronutrients is too rare to justify developing soil tests for them. If you suspect deficiencies of these nutrients, plant analysis should be used to confirm the need for making an application.

Figure 1. General subsoil fertility groups, based on available phosphorus and potassium in subsoils



Subsoil group	Legend	Nutrient supplying power[a]	Nutrient buffering capacity[b] P_2O_5	K_2O
A		P high, K medium	18	7
B		P medium, K medium	18	7
C		P low, K high	18	7
D		P medium, K low	18	7
E		P variable, K low	12	6
O	*	P variable, K low	18	5
X	*	P low	18	—

*Scattered throughout the state.

[a]All data refer to subsoils (8" to 30") only. Low, medium and high ratings are relative and are not defined in absolute units. Adapted from M.T. Beatty and R.B. Corey, 1961.

[b]The soil nutrient buffering capacity is the approximate amount of fertilizer in lb/a (oxide basis) required to change the soil test level (elemental basis) by 1 ppm.

Table 1. Codes and descriptions of soil test interpretation categories

Category: Name	Category: Symbol	Description	Probability of yield increase[a] (%)
Very low	VL	Substantial quantities of nutrients are required to optimize crop yield. Buildup should occur over a 5- to 8-year period. Response to secondary or micronutrients is likely or possible for high or medium demanding crops, respectively.	>90
Low	L	Somewhat more nutrients than those removed by crop harvest are required. Response to secondary or micronutrients is possible for high demanding crops, but unlikely for medium or low demanding crops.	60–90
Optimum	Opt	This is economically and environmentally the most desirable soil test category. Yields are optimized at nutrient additions approximately equal to amounts removed in the harvested portion of the crop. Response to secondary or micronutrients is unlikely regardless of crop demand level.	30–60
High	H	Some nutrients are required, and returns are optimized at rates equal to about one-half of nutrient removal by the crop.	5–30
Very high	VH	Used only for potassium. Soil tests are above the optimum range and gradual draw-down is recommended. Approximately one-fourth of nutrient removal is recommended.	≈5
Excessively high	EH	No fertilizer is recommended for most soils since the soil test level will remain in the nonresponsive range for at least two to three years. On medium- and fine-textured soils, a small amount of starter fertilizer is advised for row crops.	<2

[a] Percentage of fields that can be expected to show a profitable yield increase when recommended nutrients are applied.

Table 2. Crop codes, optimum soil pH values, and phosphorus and potassium demand levels for each crop

Crop code and name		Lime rec. Target pH		P and K demand level
		Mineral	Organic	
1	Alfalfa	6.8	—	3
2	Alfalfa seeding	6.8	—	3
3	Asparagus	6.0	5.6	5
4	Barley	6.6	5.6	4
5	Bean, dry (kidney, navy)	6.0	5.6	3
6	Bean, lima	6.0	5.6	3
7	Beet, table	6.0	5.6	5
8	Brassica, forage	6.0	5.6	3
9	Broccoli	6.0	5.6	5
10	Brussels sprout	6.0	5.6	5
11	Buckwheat	5.6	5.4	2
12	Cabbage	6.0	5.6	5
13	Canola	5.8	5.6	1
14	Carrot	5.8	5.6	5
15	Cauliflower	6.0	5.6	5
16	Celery	6.0	5.6	5
17	Corn, grain	6.0	5.6	1
18	Corn, silage	6.0	5.6	1
19	Corn, sweet	6.0	5.6	3
20	Cucumber	5.8	5.6	5
21	Flax	6.0	5.6	2
22	Ginseng	6.3	5.6	5
23	Lettuce	5.8	5.6	5
24	Lupine	6.3	5.6	4
25	Melon	5.8	5.6	5
26	Millet	5.6	5.4	2
27	Mint, oil	6.0	5.6	5
28	Oat	5.8	5.6	4
29	Oatlage[a]	6.8	—	4
30	Oat-pea forage[a]	6.8	—	4
31	Onion	5.6	5.4	5
32	Pasture, unimproved	6.0	5.6	2
33	Pasture, managed[b]	6.0	5.6	1
34	Pasture, legume-grass	6.0	—	4
35	Pea, canning	6.0	5.6	3
36	Pea (chick, field, cow)	6.0	5.6	3
37	Pepper	6.0	5.6	5
38	Popcorn	6.0	5.6	3
39	Potato	5.2/6.0	5.2/5.6	6
40	Pumpkin	6.0	5.6	5
41	Reed canarygrass	6.0	5.6	2
42	Red clover	6.3	5.6	4
43	Rye	5.6	5.4	4
44	Snapbean	6.8	5.6	3
45	Sod	6.0	5.6	2
46	Sorghum, grain	5.6	5.4	2
47	Sorghum-sudan forage	5.6	5.4	2
48	Soybean	6.3	5.6	2
49	Spinach	6.0	5.6	5
50	Squash	6.0	5.6	5
51	Sunflower	6.0	5.6	1
52	Tobacco	5.8	5.6	5
53	Tomato	6.0	5.6	5
54	Trefoil, birdsfoot	6.0	5.6	4
55	Triticale	6.0	5.6	4
56	Truck crops	6.0	5.6	5
57	Vetch (crown, hairy)	6.0	5.6	4
58	Wheat	6.0	5.6	3
59	Miscellaneous	—	—	—
60	Apple[c]	6.0	—	3
61	Blueberry	4.5	4.5	3
62	Cherry[c]	6.0	—	3
63	Cranberry	4.5	4.5	3
64	Raspberry	6.0	5.6	3
65	Strawberry	6.0	5.6	3
66	CRP, alfalfa	6.6	—	3
67	CRP, red clover	6.3	5.6	4
68	CRP, grass	5.6	5.4	2

[a]Assumes alfalfa underseeding.

[b]Includes bromegrass, fescue, orchardgrass, ryegrass, and timothy.

[c]Lime recommendations for apples and cherries apply only to preplant tests. Adjustment of pH is impractical once an orchard is established.

Table 3. Soil test interpretation ranges for phosphorus

Subsoil fert. group	Very low (VL)	Low (L)	Optimum (Opt)	High (H)	Excessively high (EH)
	Soil test category — soil test P, ppm[a]				
Demand level 1 (corn)					
A	<5	5–10	11–15	16–25	>25
B	<10	10–15	16–20	21–30	>30
C	<10	10–15	16–20	21–30	>30
D	<8	8–12	13–18	19–28	>28
E	<12	12–22	23–32	33–42	>42
O	<12	12–22	23–32	33–42	>42
X	<5	5–8	9–15	16–25	>25
Demand level 2 (soybeans and low-demand field crops)					
A	—	<6	6–10	11–20	>20
B	—	<6	6–10	11–20	>20
C	—	<8	8–13	14–23	>23
D	—	<6	6–10	11–20	>20
E	—	<10	10–15	16–25	>25
O	—	<10	10–15	16–25	>25
X	—	<6	6–10	11–17	>17
Demand level 3 (alfalfa, irrigated field crops, and low-demand vegetable crops)					
A	<10	10–15	16–23	24–32	>32
B	<10	10–17	18–23	24–30	>30
C	<12	12–17	18–25	26–35	>35
D	<10	10–15	16–23	24–30	>30
E	<18	18–25	26–37	38–55	>55
O	<18	18–25	26–37	38–55	>55
X	<5	5–10	11–15	16–23	>23
Demand level 4 (red clover and medium-demand field crops)					
A	<10	10–15	16–20	21–25	>25
B	<10	10–15	16–20	21–25	>25
C	<12	12–17	18–23	24–30	>30
D	<8	8–12	13–18	19–23	>23
E	<15	15–22	23–30	31–38	>38
O	<15	15–22	23–30	31–38	>38
X	<5	5–10	11–15	16–20	>20
Demand level 5 (high-demand vegetable crops)					
A	<15	15–30	31–45	46–75	>75
B	<15	15–30	31–45	46–75	>75
C	<15	15–30	31–45	46–75	>75
D	<15	15–30	31–45	46–75	>75
E	<18	18–35	36–50	51–80	>80
O	<18	18–35	36–50	51–80	>80
X	<10	10–25	26–40	41–60	>60
Demand level 6 (potato)					
A	<100	100–160	161–200	>200	—
B	<100	100–160	161–200	>200	—
C	<100	100–160	161–200	>200	—
D	<100	100–160	161–200	>200	—
E	<60	60–90	91–125	126–160	>160
O	<60	60–90	91–125	126–160	>160
X	<36	36–60	61–75	76–120	>120

[a]ppm (wt/vol; g/m^3)

Table 4. Soil test interpretation ranges for potassium

Subsoil fert. group	Very low (VL)	Low (L)	Optimum (Opt)	High (H)	Very high (H)	Excessively high (EH)
	Soil test category					
	soil test K, ppm[a]					
Demand level 1 (corn)						
A	<60	60–80	81–100	101–140	—	>140
B	<70	70–90	91–110	111–150	—	>150
C	<60	60–70	71–100	101–140	—	>140
D	<70	70–100	101–130	131–160	—	>160
E	<45	45–65	66–90	91–130	—	>130
O	<45	45–65	66–90	91–130	—	>130
Demand level 2 (soybeans and low-demand field crops)						
A	<50	50–80	81–100	101–120	121–140	>140
B	<50	50–80	81–100	101–120	121–140	>140
C	<40	40–70	71–90	91–110	111–130	>130
D	<70	70–100	101–120	121–140	141–160	>160
E	—	<60	60–80	81–100	101–120	>120
O	—	<60	60–80	81–100	101–120	>120
Demand level 3 (alfalfa, irrigated field crops and low-demand vegetable crops)						
A	<70	70–90	91–120	121–150	151–170	>170
B	<70	70–90	91–120	121–150	151–170	>170
C	<55	55–70	71–100	101–130	131–150	>150
D	<90	90–110	111–140	141–170	171–200	>200
E	<50	50–80	81–120	121–160	161–180	>180
O	<50	50–80	81–120	121–160	161–180	>180
Demand level 4 (red clover and medium-demand field crops)						
A	<55	55–70	71–100	101–120	121–150	>150
B	<55	55–70	71–100	101–120	121–150	>150
C	<50	50–65	66–90	91–110	111–130	>130
D	<60	60–80	81–120	121–140	141–160	>160
E	<45	45–60	61–90	91–110	111–130	>130
O	<45	45–60	61–90	91–110	111–130	>130
Demand level 5 (high-demand vegetable crops)						
A	<60	60–120	121–180	181–200	201–220	>220
B	<60	60–120	121–180	181–200	201–220	>220
C	<50	50–110	111–160	161–180	181–200	>200
D	<80	80–140	141–200	201–220	221–240	>240
E	<50	50–100	101–150	151–165	166–180	>180
O	<50	50–100	101–150	151–165	166–180	>180
Demand level 6 (potato)						
A	<80	80–120	121–160	161–180	181–210	>210
B	<80	80–120	121–160	161–180	181–210	>210
C	<70	70–100	101–150	151–170	171–190	>190
D	<80	80–120	121–170	171–190	191–220	>220
E	<70	70–100	101–130	131–160	161–190	>190
O	<70	70–100	101–130	131–160	161–190	>190

[a]ppm (wt/vol; gm/m^3)

Table 5. Interpretation of soil test values for secondary nutrients and micronutrients

Element	Soil texture code[a]	Very low (VL)	Low (L)	Optimum (Opt)	High (H)	Excessively high (EH)
		Soil test category — soil test, ppm				
Calcium	1	0–200	201–400	401–600	>600	—
	2,3,4	0–300	301–600	601–1000	>1000	—
Magnesium	1	0–25	26–50	51–250	>250	—
	2,3,4	0–50	51–100	101–500	>500	—
Boron	1	0–0.2	0.3–0.4	0.5–1.0	1.1–2.5	>2.5
	2,4	0–0.3	0.4–0.8	0.9–1.5	1.6–3.0	>3.0
	3	0–0.5	0.6–1.0	1.1–2.0	2.1–4.0	>4.0
Zinc	1,2,3,4	0–1.5	1.6–3.0	3.1–20	21–40	>40
Manganese						
O.M. less than 6.1%	1,2,3,4	—	0–10	11–20	>20	—
				Soil pH		
O.M. more than 6.0%	1,2,3,4	—	>6.9	6.0–6.9	<6.0	—
				SAI[b]		
Sulfur	1,2,3,4	—	<30	30–40	>40	—

[a]Soil texture codes: 1 = sandy soils; 2 = loams, silts, and clays; 3 = organic soils; 4 = red soils.

[b]Sulfur availability index (SAI) includes estimates of sulfur released from organic matter, sulfur in precipitation, subsoil sulfur and sulfur in manure if applied, as well as sulfate sulfur (SO_4-S) determined by soil test.

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