Milwaukee

Precision Agriculture Testing Manual
For
pH & Electrical Conductivity (EC)
In
Soil – Fertilizer – Water

pH

Good nutrition is essential to growing plants successfully. One of the first questions to consider to improve production is, "Have you tested your soil?" Soil pH is a measure of how acidic or "basic" (the opposite of acidic) your soil is. Soil pH is important since it affects the growth of plants and the severity of some diseases.

pH affects the ability of plant roots to absorb nutrients. Calcium, phosphorus, potassium and magnesium are likely to be unavailable to plants in acidic soils. Plants have difficulty absorbing copper, zinc, boron, manganese and iron in basic soils. By managing soil pH, you can create an ideal environment for plants and often discourage plant pests at the same time.

Measuring pH

pH is measured on a scale of 0-14. A soil or water pH reading below 7 is considered acidic, while a pH reading above 7 is basic. A pH reading of 7 is neutral, and is ideal for many plants and spray materials.

The pH scale is logarithmic, which means that a pH reading of 6 is 10 times more acidic than a reading of 7.

You can measure the pH of your soil, your spray tank water, or your irrigation/fertigation water.

Soil: Crops, ornamentals and turf need careful pH management to maintain their best quality and appearance. The wrong pH can lock nutrients in the soil, making them unavailable to plant roots. A pH that's too high or low can make disease, insect and weed problems worse.

Spray tank water: If your spray tank water is too acidic (low pH) or too basic (high pH), the pesticides you mix in can be deactivated and may even burn your plants.

Irrigation/fertigation water: The pH of water you apply to your plants should match your desired soil pH. Otherwise it will gradually change the soil pH

pH levels

Acceptable pH varies by plant type. If you're not sure what's best for your plants, you can check a reference book or ask your seed or Ag Chemical dealer, Cooperative Extension agent, or private consultant.

Remember, when you adjust soil pH levels you can affect plant growth, nutrition and susceptibility to pests. When setting a pH goal for your soil, you will want to take all of these considerations into account.

Acidic fertilizers can be used to lower pH. Limestone is often used to raise pH. The type of limestone applied and your soil type can make a difference in how quickly and how much the pH will change

Testing Your Soil pH

1.) Sample — When taking samples, use a soil probe or trowel, a clean plastic bucket for collecting and mixing samples, and plastic bags or wax paper sacks to hold sub samples for testing. Make sure that you use clean tools. If the soil in your field is uniform, take 15 to 20 samples from random locations throughout the field and mix them together in the plastic bucket. If the soil is highly variable from one part of the field to the other, divide the field into several more uniform sections and take samples from each one. Write down where the samples were taken in a notebook.

Do not take samples from only one side of the field, only from the corners of the field, or from the same spot on each side of the field. Also, avoid taking soil samples near lime or manure piles, animal droppings, fresh fertilized rows, low spots, fences and roads.

When taking samples in turf and other shallow rooted crops, sample the top three inches of the soil. In ornamentals and other deep-rooted cultivated crops, sample the top six inches of soil — though you may test a shallower sample if it is taken shortly after tillage. In non-cultivated crops, soil samples should be six to eight inches deep. With deep-rooted non-legume crops such as corn, wheat and cotton, take a soil sample of seven inches to 24 inches in addition to the tillage sample.

2.) Mix — Place these samples in a clean plastic container.

3.) Measure — Remove a small amount (coffee measure) of <u>**2 parts**</u> soil from your mix and add <u>**1 part**</u> bottle drinking water. Pack soil in cup and always use a flat bottom measure cup to assure proper proportions.

4.) Shake and wait — Stir or shake the soil and water mixture vigorously. Then let sit for 1 to 2 minutes.

5.) Test — Turn on your pH meter, be sure you have calibrated your meter before running the test (see owners manual) remove the cap to expose the sensor, and dip the sensor completely in the solution. Record the reading displayed on the meter

<u>Understand Your Soil Test: pH-Excess Lime-Lime Needs</u>

The relationships among pH, soil type, and lime requirements are explained.

Accurate soil tests can be an excellent management tool. Misuse of soil tests leads to increased production costs, yield losses, or both. The elements required by plants for proper growth have been determined by experimentation. Experience has shown that soils differ greatly in their capacity to supply these elements. The amount of each element supplied by a soil depends on several factors. Two important ones are: (1) the type of material from which the soil was formed, and (2) the treatment the soil has received since being placed under cultivation. Not all of a particular element in a soil is available to a plant. Thus, the soil test must be able to predict whether a soil contains sufficient amounts of available nutrient elements for a specific crop.

The acid and base levels of a soil solution are important because microorganisms and plants are responsive to their chemical environment. Three possible chemical reaction conditions for the soil solution are acidity, neutrality, and alkalinity. The reaction of the soil solution can be defined by an index using the concentration of hydrogen ions in the soil solution. This index is called the pH. A pH of 7 is neutral, pHs less than 7 are acid, and pHs greater than 7 denote a basic (alkaline) condition. Soil pH can be an indicator of the kind of nutrient problems to expect in a soil. Obviously the pH is not a "cure-all" analysis, but may indicate a possible problem, which may then be investigated with additional analysis. In mineral soils, pH is a general indicator of soil nutrient availability, presence of free lime (calcium carbonate), presence of excess sodium, and excess hydrogen. Almost all soils are mineral soils; thus, soil pH is a good indicator for possible nutrient problems. For example, sulfur is available from pH 5.5 to 8.5; boron, copper, and zinc are most readily available from pH 5 to 7; and iron and manganese are abundant below pH 5, but moderately available from pH 5 to 7. Iron chlorosis frequently occurs at pH above 7.7.

Factors Influencing pH

Initially, factors such as parent material, rainfall, and type of vegetation were dominant in determining the pH of soils. Under cultivation, however, organic acids from plant roots, repeated use of acid-forming fertilizers, plant removal, and replacement of calcium and magnesium by hydrogen eventually lowers the pH of topsoil. Most of the nitrogen and phosphorus fertilizers used today are acid forming. For example, about 1.5 pounds of lime is required to neutralize the effect of applying 1 pound of anhydrous ammonia to the soil. Some irrigation water in contains substantial quantities of calcium and magnesium bicarbonates (lime) which help neutralize the acidifying effects. Thus, soils (without free lime) under production become increasingly acid unless lime is artificially applied or is present in the irrigation water. This means farmers need to frequently check soil pH to determine whether they are maintaining a proper soil acidity level.

Large Area pH Adjustment Tables

The table below offers a field method of estimating the amount of lime needed in your specific soil condition. It uses pH, texture and organic matter content of the soil to serves as a **general guide**.

	Average amount of powdered limestone ($CaCO_3$) in pounds per acre for soils of average organic content to bring pH to 7.0			
PH Test Result Show Soil @	**Sandy Soil**	**Sandy Loam**	**Loam**	**Silt & Clay Loams**
4.0	2500	5000	6500	9000
4.5	2000	4000	5200	7200
5.0	1500	3000	4000	5500
5.5	1100	2000	2800	3800
6.0	700	1000	1500	2000
6.5	300	500	800	1000
7.0	0	0	0	0
7.5	0	0	0	0
8.0	0	0	0	0

	Average amount of powdered limestone ($CaCO_3$) in pounds per acre for soils of average organic content to bring pH to 5.5			
PH Test Result show Soil @	**Sandy Soil**	**Sandy Loam**	**Loam**	**Silt & Clay Loams**
4.0	1200	2000	2700	3700
4.5	700	1000	1500	2000
5.0	350	500	750	1000
5.5	0	0	0	0
6.0	0	0	0	0
6.5	0	0	0	0
7.0	***See next page for procedures to lower soil pH***			
7.5				
8.0				

<u>Acidifying soils or lowering their pH</u>: This is done mainly to increase solubility of iron and manganese for plants that can not get adequate supplies from high pH soils. e.g. azaleas, rhododendron, pin oak trees, some red maple trees, etc. Common methods of lowering the pH include:

- Powdered sulfur (oxidizes slowly to sulfuric acid)
- Ferrous sulfate or aluminum sulfate
- Sulfuric acid (reacts rapidly and is expensive - must be handled with care)
- NH_4 fertilizers: $(NH_4)_2SO_4$,NH_4NO_3, NH_3 $(NH_4)_2SO_4$ produce acid as the NH_4^+ converts to $NO_3^-$and releases pH. Acidifying a soil with fertilizer is a slow, long term effect.

Small Area pH Adjustment Tables

	Average amount of powdered limestone (CaCO3) in pounds per square yard for soils of average organic content to bring pH to 7.0			
PH Test Result Show Soil @	**Sandy Soil**	**Sandy Loam**	**Loam**	**Silt & Clay Loams**
4.0	½ lb per sq yd	1 lb per sq yd	1.5 lb per sq yd	2 lb per sq yd
5.0	¼ lb per sq yd	½ lb per sq yd	1 lb per sq yd	1.5 lb per sq yd
6.0	1/8 lb per sq yd	¼ lb per sq yd	½ lb per sq yd	1 lb per sq yd
7.0	0	0	0	0
7.5	0	0	0	0
8.0	0	0	0	0

	Average amount of powdered limestone (CaCO3) in pounds per square yard for soils of average organic content to bring pH to 5.5			
PH Test Result Show Soil @	**Sandy Soil**	**Sandy Loam**	**Loam**	**Silt & Clay Loams**
4.0	¼ lb per sq yd	½ lb per sq yd	1 lb per sq yd	1.5 lb per sq yd
5.0	1/8 lb per sq yd	¼ lb per sq yd	½ lb per sq yd	1 lb per sq yd
6.0	0	0	0	0
**** See below the Average "alum" needed to acidify different alkaline soils in pounds per square yard***				
7.0	½ lb per sq yd	1 lb per sq yd	1 lb per sq yd	1.5 lb per sq yd
7.5	1 lb per sq yd	1 lb per sq yd	1.5 lb per sq yd	2 lb per sq yd
8.0	1.5 lb per sq yd	1.5 lb per sq yd	2 lb per sq yd	2.5 lb per sq yd

❖ In small gardens it may be more convenient to apply the alum in solution; for example, if ½ pound per square yard was required, this amount could be dissolved in one gallon of water and applied.

In the table above the term "alum" is used in a general sense and the most economical form in which to apply such an acidifying chemical is as commercial aluminum sulphate. This may be broadcast over the soil at the rate indicated in the table but is preferably applied during a rainy spell so that crystals will dissolve promptly. As indicated above it is highly recommended to apply this in liquid form.

Acidifying most calcareous soils is not feasible because of the large amount of calcium magnesium carbonates they contain.

Table Below gives pH Preferences to Various Crops, Turf Grass, Plants, Shrubs, Etc.

Common Name	Plant pH Preference
Abelia	6.0 – 8.0
Acacia	6.0 – 8.0
Acanthus, Soft	6.0 – 7.0
Adder’s Tongue, Common	6.0 – 7.0
Ageratum, White	6.0 – 7.0
Ailanthus	6.0 – 8.0
Alder	5.5 – 6.5
Alfalfa	6.0 – 7.0
Almond	6.0 – 8.0
Alpine Azalea	4.0 – 5.0
Alsike Clover	6.0 – 7.0
Alumroot, Hairy	5.0 – 6.0
Alyssum	6.0 – 8.0
Amaryllis	5.0 – 6.0
American Hophornbeam	6.0 – 7.0
American Plum	6.0 – 8.0
Ampelopsis	6.0 – 8.0
Anemone	6.0 – 8.0
Apple	5.5 – 6.5
Aralia	6.0 – 8.0
Arborvitae	6.0 – 8.0
Arbutus, Trailing	4.0 – 5.0
Arethusa	4.0 – 5.0
Arnica	5.0 – 6.0
Arrow Bamboo	6.0 – 8.0
Ash	6.0 – 8.0
Asparagus	6.0 – 7.0
Aster	6.0 – 8.0
Aster, Bigleaf	5.0 – 6.0
Aster, Seaside	5.0 – 6.0
Aster, Skydrop	5.0 – 6.0
Aster, Stiff	5.0 – 6.0
Aster, Wave	6.0 – 7.0
Astilbe	6.0 – 8.0
Atamasco Lily	5.0 – 6.0
Avacado	6.0 – 8.0
Bittersweet	5.5 – 6.5
Blackberry	6.0 – 8.0
Blackcap, Common	6.0 – 7.0
Banana	6.8 – 7.0
Baneberry	6.0 – 8.0
Barberry	6.0 – 8.0
Barley	6.0 – 7.0
Bayberry	5.0 – 6.0
Beach Plum	6.0 – 8.0
Bean	6.0 – 7.5
Bean, Lima	5.5 – 6.5
Beauty Berry	6.0 – 7.0
Bedstraw, Northern	5.0 – 6.0
Beech	6.0 – 7.0
Bee Balm, Oswego	6.0 - 7.0
Beet	5.8 – 7.0
Beet, Sugar	6.0 – 7.0
Begonia	6.0 – 8.0
Bellflower	6.0 – 8.0
Bent Grass, Carpet	5.5 – 6.5
Bent Grass, Rhode Island	5.0 – 6.5
Birch, Sweet	5.0 – 6.0
Bishop’s Cap, Lace	5.0 – 6.0
Bitter Nightshade	6.0 – 8.0
Bittersweet	5.5 – 6.5
Blackberry	6.0 – 8.0
Blackcap, Common	6.0 – 7.0
Baddernut	6.0 – 8.0
Blazing Star	5.0 – 6.0
Bleeding Heart, Fringed	5.0 – 6.0
Bloodroot	5.5 – 6.5
Bluebead	4.0 – 5.0
Bluebell, Feather	5.0 – 6.0
Bluebell, Virginia	6.0 – 8.0
Blueberry	5.0 – 6.0
Bluegrass, Kentucky	6.0 – 7.0
Bluets	6.0 – 7.0
Bluets, Creeping	5.0 – 6.0
Bogbean, Common	5.0 – 6.0
Bog Rosemary	4.0 – 5.0
Bowman’s Root	6.0 – 7.0
Box, common	6.0 – 8.0

Common Name	Plant pH Preference
Bracken	5.0 – 6.0
Brake	6.0 – 8.0
Bristly Sarsparilla	6.0 – 7.0
Broccoli	6.0 – 7.0
Broomgrass	6.0 – 8.0
Clubmoss, Shining	5.0 – 6.0
Coffee	5.0 – 6.0
Coleus, Common	6.0 – 8.0
Colorado Spruce	6.0 – 7.0
Coltsfoot, Common	6.0 – 8.0
Columbine	6.0 – 8.0
Columbine, Colorado	6.0 – 7.0
Columbine, Golden	6.0 – 7.0
Columbine, Hybrid Colorado	6.0 – 7.0
Coneflower	6.0 – 8.0
Convolvulus	6.0 – 8.0
Coreopsis	5.5 – 6.5
Coreopsis, Hairy	5.0 – 6.0
Coreopsis, Rose	5.0 – 6.0
Coreopsis, Threadleaf	5.0 – 6.0
Coreopsis, Trefoil	5.0 – 6.0
Corn, Indian	6.0 – 7.0
Cosmos, Common	6.0 – 8.0
Cotoeneaster	6.0 – 8.0
Cotton, Upland	5.5 – 6.5
Cowpea, Common	5.5 – 6.5
Cranberry, Mountain	5.0 – 6.0
Cranesbill	6.0 – 8.0
Crinkleroot	5.0 – 6.0
Crocus	6.0 – 8.0
Crowberry	4.0 – 5.0
Cuckooflower	6.0 – 7.0
Cucumber	6.0 – 8.0
Cucumber Root	5.0 – 6.0
Currant	6.0 – 8.0
Cyclamen	6.0 – 8.0
Cypress	5.0 – 6.0
Daffodil	6.0 – 6.5
Dahlia	6.0 – 8.0
Dahoon	5.0 – 6.0
Dalibarda	5.0 – 6.0
Dandelion	6.0 – 8.0
Daphne, Winter	5.0 – 6.0
Daphne, February	7.0 – 8.0

Common Name	Plant pH Preference
Daylily	6.0 – 8.0
Deutzia	6.0 – 8.0
Devils-Walking Stick	6.0 – 7.0
Dewberry, Swamp	5.0 – 6.0
Dogbane, Spreading	6.0 – 7.0
Dogwood	6.0 – 8.0
Dogwood, Flowering	6.0 – 7.0
Douglas Fir	6.0 – 7.0
Dropwart	6.0 – 7.0
Dutchman’s Pipe	6.0 – 8.0
Easterbells	5.0 – 6.0
Eggplant, Common	6.0 – 7.0
Elaeagnus	6.0 – 8.0
Elder	6.0 – 8.0
Elm	6.0 – 8.0
English Ivy	6.0 – 8.0
English Oak	6.0 – 8.0
Eucalyptus	6.0 – 8.0
Eulalia	6.0 – 7.0
Euonymus	6.0 – 8.0
European Mountain Ash	6.0 – 8.0
European Turkey Oak	6.0 – 8.0
Evening Primrose	6.0 – 8.0
Everlasting Pearl	5.0 – 6.0
Fairy Bells	5.0 – 6.0
False Indigo	6.0 – 8.0
False Spirea	6.0 – 8.0
Fairy Wand	5.0 – 6.0
Feather Fleece	4.0 – 5.0
Fern, Asparagus	6.0 – 8.0
Fern, Bladder	6.0 – 8.0
Fern, Braun’s Holly	6.0 – 8.0
Fern, Crested	6.0 – 7.0
Fern, Christmas	6.0 – 8.0
Fern, Evergreen Wood	6.0 – 7.0
Fern, Goldie’s	6.0 – 8.0
Fern, Hartford	4.0 – 5.0
Fern, Hay Scented	5.0 – 6.0
Fern, Maidenhair	6.0 – 8.0
Fern, Male	6.0 – 8.0
Fern, Marsh	6.0 – 7.0
Fern, Massachusetts	4.0 – 5.0
Fern, Narrow-Leafed Chain	4.0 – 5.0
Fern, New York	6.0 – 7.0

Common Name	Plant pH Preference
Fern, Sword	6.0 – 8.0
Fern, Upland Lady	5.0 – 6.0
Fern, Walking	6.0 – 8.0
Fescue, Sheep	5.0 – 6.0
Fir	5.0 – 6.0
Firethorn	6.0 – 8.0
Flax	6.0 – 7.0
Fleece Flower	6.0 – 8.0
Flowering Quince	6.0 – 8.0
Flytrap, Venus	4.0 – 5.0
Forget-Me-Not	6.0 – 8.0
Forsythia	6.0 – 8.0
Fothergilla, Dwarf	5.0 – 6.0
Foxglove	6.0 – 8.0
Foxtail, Meadow	6.0 – 8.0
Franklinia	5.0 – 6.0
Fringe Orchid, Green	5.0 – 6.0
Fringe Orchid, Large Purple	5.0 – 6.0
Fringe Orchid, Lesser Orange	4.0 – 5.0
Fringe Orchid, White	4.0 – 5.0
Fringe Orchid, Yellow	5.0 – 6.0
Fringe Tree, White	5.0 – 6.0
Fumitory, Rock	5.0 – 6.0
Fumitory, Climbing	6.0 – 7.0
Gaillardia	6.0 – 8.0
Galax	4.0 – 5.0
Gardenia	5.5 – 6.5
Gayfeather, Grassleaf	5.0 – 6.0
Gentian	6.0 – 8.0
Geranium	6.0 – 8.0
Gerbera Daisy	6.0 – 7.0
Gilia	6.0 – 8.0
Ginseng, American	6.0 – 8.0
Gladiolus	6.0 – 8.0
Globeflower	6.0 – 8.0
Goatsrue, Common	6.0 – 8.0
Golden Aster, Maryland	6.0 – 7.0
Glodenrod	6.0 – 8.0
Goldenrod, Fragrant	5.0 – 6.0
Goldenrod, White	5.0 – 6.0
Goldenstar	6.0 – 7.0
Goldeye Grass	5.0 – 6.0
Goldthread	4.0 – 5.0
Gorse, Common	5.0 – 6.0

Common Name	Plant pH Preference
Grapes	6.0 – 8.0
Grapefern, Broadleaf	5.0 – 6.0
Grapefern, Cutleaf	5.0 – 6.0
Grapefern, Triangle	5.0 – 6.0
Grapefruit*	5.0 - 7.0
Grass, Orchard	6.0 – 8.0
Grass, Carpet	6.0 – 7.0
Grass, Centipede	6.0 – 7.0
Grass, Velvet	6.0 – 8.0
Greenbrier, Coral	5.0 – 6.0
Greenbrier, Laurel	5.0 – 6.0
Ground Cedar	5.0 – 6.0
Ground Pine	5.0 – 6.0
Groundsel	6.0 – 8.0
Groundsel Bush	7.0 – 8.0
Gypsophila	6.0 – 8.0
Hackberry	6.0 – 8.0
Hardhack	5.0 – 6.0
Hartstongue	6.0 – 8.0
Haw, Possum	7.0 – 8.0
Hawthorn	7.0 – 8.0
Hazelnut, Beaked	6.0 – 7.0
Heath	5.0 – 6.0
Heather	5.0 – 6.0
Heath Huckleberry	5.0 – 6.0
Heliotrope	6.0 – 8.0
Hemlock, Carolina	5.0 – 6.0
Hemlock, Common	5.0 – 6.0
Hepatica	6.0 – 8.0
Hibiscus	6.0 – 8.0
Hobblebush	5.0 – 6.0
Holly, Inkberry	5.0 – 6.0
Holly, American	5.0 – 6.0
Hollyhock	6.0 – 8.0
Honey Locust	6.0 – 8.0
Honeysuckle	6.0 – 8.0
Hop Tree	6.0 – 8.0
Hornbeam	6.0 – 8.0
Horseradish	6.0 – 8.0
House Leek	6.0 – 8.0
huckleberry	5.0 – 6.0
Hyacinth, Common	6.0 – 8.0
Indian Pipe	5.0 – 6.0
Inkberry	5.0 – 6.0

Common Name	Plant pH Preference
Iris	6.0 – 8.0
Iris, Cubeseed	4.0 – 5.0
Iris, Japanese	5.0 – 6.0
Iris, Oregon	5.0 – 6.0
Iris, Southern Blueflag	5.0 – 6.0
Iris, Vernal	4.0 – 5.0
Jersey Tea	5.0 – 6.0
Jetbead	6.0 – 8.0
Juniper	5.5 – 7.0
Juniper, Common	6.0 – 7.0
Juniper, Creeping	5.0 – 6.0
Juniper, Mountain	5.0 – 6.0
Kale	5.0 – 8.0
Kalmia, Bag	4.0 – 5.0
Kentucky Coffee	6.0 – 8.0
Kerria	6.0 – 8.0
Labrador Tea, True	4.0 – 5.0
Laburnum	6.0 – 8.0
Ladies-Tresses, Slender	5.0 – 6.0
Ladies-Tresses, Sweet	5.0 – 6.0
Lady-Slipper, Pink	4.0 – 5.0
Lady-Slipper, Ramshead	5.0 – 6.0
Lambkill	5.0 – 6.0
Larkspur	6.0 – 8.0
Larkspur, Orange	6.0 – 7.0
Leatherleaf	5.0 – 6.0
Leek	6.0 – 8.0
Lemon*	5.5 – 7.0
Lettuce, Garden	6.0 – 7.0
Leucothoe	5.0 – 6.0
Lilac	6.0 – 8.0
Lily, American Turkscap	5.0 – 6.0
Lily, Carolina	5.0 – 6.0
Lily-of-the-Valley	5.0 – 6.0
Lily, Orangecup	5.0 – 6.0
Lily, Pinebarren	4.0 – 5.0
Linden	6.0 – 8.0
Lipfern, Hairy	5.0 – 6.0
Lipfern, Woolly	6.0 – 7.0
Lobelia	6.0 – 8.0
Loblolly Bay	5.0 – 6.0
Locust	6.0 – 8.0
Loosestrife	6.0 – 8.0
Loosestrife, Purple	6.0 – 8.0

Common Name	Plant pH Preference
Lupine, European blue	5.5 – 6.5
Lupine, Sundial	5.0 – 6.0
Lychee	6.0 – 7.0
Lugwart	6.0 – 8.0
Magnolia	5.0 – 6.0
Maidenhair Tree	6.0 – 7.0
Mangosteen	6.0 – 8.0
Maple	6.0 – 8.0
Maple, Mountain	5.0 – 6.0
Maple, Striped	5.0 – 6.0
Mariposa	6.0 – 8.0
Marjoram	6.0 – 8.0
Marsh Marigold	6.0 – 8.0
Matrimony Vine	6.0 – 8.0
Meadow Beauty	4.0 – 5.0
Mignonette, Common	6.0 – 8.0
Milkweed, Red	4.0 – 5.0
Mint	6.0 – 8.0
Mock Orange	6.0 – 8.0
Molinia	4.0 – 5.0
Morning Glory	6.0 – 8.0
Mountain Ash, American	4.0 – 5.0
Mountain Dandelion	5.0 – 6.0
Mountain Holly	5.0 – 6.0
Mountain Laurel	5.0 – 6.0
Mulberry	6.0 – 8.0
Muskmelon	6.0 – 7.0
Nailwart, Allegheny	4.0 – 5.0
Nailwart, Spreading	5.0 – 6.0
Narcissus	6.0 – 8.0
Nasturtium	6.0 – 8.0
Neillia, Tube	5.0 – 6.0
Nightshade	6.0 – 8.0
Ninebark	6.0 – 8.0
Oats	6.0 – 7.0
Oconee Bell	5.0 – 6.0
Okra	6.0 – 8.0
Onion	6.0 – 7.0
Onion, Acid Soil	5.0 – 6.0
Orange*	5.0 – 7.0
Orchid, Grass Pink	4.0 – 5.0
Orchid, Green Roundleaf	5.0 – 6.0
Pansy	6.0 – 8.0
Parsley	5.0 – 7.0

Common Name	Plant pH Preference
Parsnip	6.0 – 8.0
Pea, Common	6.0 – 8.0
Pea, Sweet	6.0 – 8.0
Peach	6.0 – 8.0
Peanut	5.0 – 6.0
Pear	6.0 – 8.0
Pecan	6.0 – 7.0
Pentstemon	6.0 – 8.0
Pepper	6.0 – 6.5
Pineapple	5.0 – 6.0
Pink	6.0 – 8.0
Pitcher Plant	4.0 – 5.0
Poppy	6.0 – 8.0
Potato	6.0 – 8.0
Potato, Sweet	5.5 – 7.0
Purpleleaf Plum	6.0 – 8.0
Radish	6.0 – 8.0
Raspberry, European	5.0 – 6.0
Red Bud	6.0 – 8.0
Redtop	6.0 – 8.0
Rhododendron	5.0 – 6.0
Rhodora	5.0 – 6.0
Rice	6.0 – 7.0
Rose	6.0 – 8.0
Rose Mallow	6.0 – 8.0
Running Pine	5.0 – 6.0
Rye	6.0 – 7.0
Sage	6.0 – 7.0
Sassafras	6.0 – 7.0
Shooting Star	6.0 – 8.0
Silver Bell, Great	5.0 – 6.0
Snapdragon	6.0 – 7.0
Snowbell, American	5.0 – 6.0
Soybean	6.0 – 7.0
Spinach, Common	6.4 – 7.0
Spring Beauty, Carolina	5.0 – 6.0
Squash	6.0 – 8.0

Common Name	Plant pH Preference
Star of Bethlehem	6.0 – 8.0
Stonecrop, English	5.0 – 6.0
Stonemint	5.0 – 6.0
St. Johns Wart	6.0 – 8.0
Strawberries*	5.0 – 6.0
Sugar Cane	6.0 – 8.0
Sunflower	6.0 – 8.0
Sweet Birch	5.0 – 6.0
Sweet Fern	6.0 – 8.0
Sweet Gum	6.0 – 8.0
Sweet Spire	6.0 – 7.0
Tobacco	5.0 – 8.0
Tomato	6.0 – 7.0
Tulip	6.0 – 7.0
Tung Oil Tree	5.0 – 6.0
Turnip	6.0 – 8.0
Violet	6.0 – 8.0
Walnut	6.0 – 8.0
Watermelon	6.0 – 7.0
Wheat	6.0 – 7.0
Wild Indigo, Yellow	5.0 – 6.0
Wild Ginger, Heartleaf	5.0 – 6.0
Willow	6.0 – 8.0
Wintergreen	5.0 – 6.0
Winter Jasmine	6.0 – 8.0
Witch Hazel	6.0 – 7.0
Yellowroot	5.0 – 6.0
Yew	5.5 – 7.0
Yucca	6.0 – 8.0
Zinna	6.0 – 8.0

Electrical Conductivity (EC)

EC stands for electrical conductivity, or the ability of a solution to conduct electricity. Electricity moves efficiently through water with high levels of salt present (high EC), and with more resistance through pure water (low EC). EC indicates how much dissolved salt is in a given sample. That's why EC is also referred to as TDS (total dissolved salts) or salinity (the amount of salts in a solution). <u>All nutrients are salts, so EC is a measure of your total nutrients. Knowing your EC levels will help in plant production and monitoring of inputs</u>. Moisture in soil that has a high salt level will not move into the plant's roots, causing drought symptoms, even when there is plenty of water present.

EC is measured in mS/cm (milliSiemens per centimeter), but in older literature it was referred to as mmhos/cm (millimhos per centimeter). One mS/cm is equivalent to one mmhos/cm. Various EC meters measure in different ranges. Some meters even read low enough levels to measure in µ S/cm (micromhos per centimeter). It takes 1,000 µ S/cm to equal one mS/cm or one mmhos/cm

Testing methods

Measuring the EC of aqueous solutions is fairly simple. You calibrate the meter, see your operator manual, then submerse the sensor into the liquid.

The best method for your Milwaukee EC meter is a 2:1 method of mixing two part soil with one part bottled drinking water, then testing the soil slurry. For convenience, you can also test the same solution you prepared for pH readings in a 2:1 ratio (<u>See Testing for pH for procedures</u>). For quick soil EC measurements. Your local Extension agent or land grant university are good sources of additional information on how to take soil EC measurements.

Soluble salts levels by the 2:1 dilution method and associated interpretation.

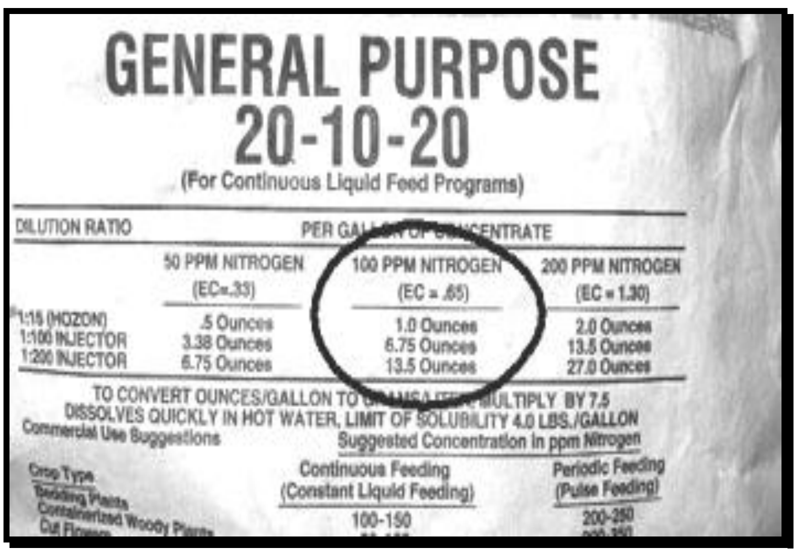
EC Meter Reading	Interpretation
0.00 - 0.25	Very low - indicates probable deficiency.
0.25 - 0.75	Suitable for seedlings and salt-sensitive plants.
0.75 - 1.50	Desirable level for most Ag plants.
1.75 - 2.25	Reduced growth, leaf marginal burn.

EC in fertigation systems

Fertigation is a system that applies soluble fertilizer to plants through irrigation water. It's common in greenhouse, hydroponics and irrigated high-value crop and ornamental production. Adding fertilizer to irrigation water increases the EC.

To use EC to check fertilizer levels, take an EC reading of a precise mixture of your fertilizer and irrigation water in the desired concentration. You can check your fertigation water at any point along the system. Its EC should match your sample. If it doesn't, check the injectors, valves and nozzles in the system for blockage or other problems.

Always check the EC of your water first, and subtract that number from the EC reading of your solution to determine your fertilizer concentration.



Checking the fertilizer EC.

Another way to determine the output of your fertilizer injector is by measuring the electrical conductivity (EC) of the dilute fertilizer solution. You can get a good estimate of the fertilizer concentration by measuring the EC of the solution by using a Milwaukee EC meter. Be sure to calibrate your Milwaukee EC meter prior to each use and be sure to subtract the EC of your clear water from the fertilizer reading. Compare the corrected value for the EC of your fertilizer solution to that listed on the fertilizer bag for the ppm N you intended to be applying. During the crop cycle, especially for short-term crops like bedding plants, you should measure the EC of your fertilizer solution on a weekly basis to check that the injector is working properly.

The fertilizer label presents the EC of several concentrations of the diluted fertilizer. Circled is the EC of 100 ppm N, EC=.65. For weekly checks of injector accuracy, measure the EC of the dilute fertilizer solution and subtract the EC of your clear water and compare it to the EC given on the bag.

Soil Electrical Conductivity Mapping

Summary

Soil electrical conductivity (EC) mapping is a simple, inexpensive tool precision farmers can use to quickly and accurately characterize soil differences within farm fields

Soil EC is a measurement that correlates to soil properties affecting crop productivity, including soil texture, cation exchange capacity, drainage conditions, organic matter level and subsoil characteristics

With field verification, soil EC can be related to specific soil properties that affect crop yield, such as topsoil depth and water-holding capacity

Soil EC maps can be used to visually explain yield map variation or the data points can be correlated with yield, elevation, plant population, surface hydrology or remotely sensed data

Potential uses of soil EC maps include guiding directed soil sampling, assigning variable rates of crop inputs, fine-tuning NRCS soil maps, improving the placement and interpretation of on-farm tests, salinity diagnosis and drainage remediation planning

Introduction

Precision farmers can now collect more detailed information about the spatial characteristics of their farming operation than ever before. In addition to yield, boundary and field attribute maps, a wide array of new electronic, mechanical and chemical sensors are being developed to measure and map many soil and plant properties. Soil electrical conductivity (EC) is one of the simplest, least expensive soil measurements available to precision farmers today.

Soil EC is a measurement that correlates to soil properties affecting crop productivity. These include water content, soil texture, soil organic matter, depth to clay pans, cation exchange capacity, salinity and exchangeable Ca and Mg.

Soil EC measurements can add value to the farming operation if they help interpret yield variation. That increased understanding must then lead to improved management opportunities that either boost yields, reduce input costs, or accurately predict the benefits from whole-field improvements (such as tiling, liming, irrigation or windbreaks).

Soil EC mapping is a practical tool to characterize soil differences in Turf and row crop farm fields. EC mapping can also improve the management of variable-rate inputs as well as strengthen a grower's decision-making ability for many other agronomic practices.

History and Uses of EC Mapping

Terrain surveys which measure EC have been used since early in the 20th century to map sub-surface geological features. Practical applications include determination of bedrock type and depth, location of aggregate and clay deposits, measurement of groundwater extent and salinity, detection of pollution plumes in groundwater, location of geothermal areas and characterization of archeological sites.

More recently, EC mapping has been useful in locating saline seeps in the northern Great Plains (Halvorson and Rhoades, 1974) and for diagnosing salinity related problems in the irrigated Southwest (Rhoades and Corwin, 1981). Researchers have also used soil EC to measure or estimate many other chemical and physical properties of non-saline soils, including water content (Kachanoski, 1988), clay content (Williams and Hoey, 1987), cation exchange capacity and exchangeable Ca and Mg (McBride et al., 1990), depth to clay pans (Doolittle et al., 1994), soil organic carbon (Jaynes et al., 1996) and herbicide behavior in soil (Jaynes et al. 1994). With the advent of the Global Positioning System (GPS), practitioners can now place EC measuring devices on GPS-equipped field vehicles and create EC maps for all types of forest, range and agricultural soils.

Soil Testing for Macronutrients Levels of Nitrogen – Phosphorus – Potassium:

Once testing for EC has been accomplished and areas of low or very high EC readings are determined it is advisable to perform a chemical soil analysis to establish the macronutrient level. First a general overview of the three essential nutrient elements and at the end of this section a table of macronutrients levels for optimum plant growth is provided.

Nitrogen:

Nitrogen (N) is a unique element in that it composes 80% of the earth's atmosphere. Plants, for the most part, cannot utilize atmospheric nitrogen. However the legume group of plants have the capability to convert atmospheric nitrogen into a form which can be utilized by the plant. Nitrogen fixation by legumes is conducted through a symbiotic association between the plant root and Rhizobium bacteria in the soil. The site where the nitrogen capturing process occurs is in the visible nodules formed on the plant roots. Some of the most common legumes are peanuts, soybeans, lespedeza, alfalfa, clovers, and vetches. These are noted by an ***** in the following table.

The most common sources of nitrogen for non-legumes are through the decomposition of organic matter and application of commercial nitrogen fertilizers.

Nitrogen is a component of the chlorophyll in plants, thus giving plants the rich green color characteristic of a healthy plant. Nitrogen promotes succulence in forage crops and leafy vegetables. When used at the recommended rates, nitrogen improves the overall quality of leaf crops and stimulates the utilization of phosphorus, potassium and other essential nutrient elements.

Given the benefits of nitrogen in crop production, it is important to note that excessive nitrogen can have an adverse effect on crops. Excess nitrogen can delay crop maturity, increase lodging due to weakened stems, produce excessive vegetative growth at the expense of fruit set, and cause potential health hazards for man and animal due to nitrate accumulation in leafy vegetable or forage crops.

Nitrogen is an indispensable nutrient element but it must be utilized properly to reap maximum benefit.

Phosphorus:

Phosphorus (P) is necessary for the hardy growth of the plant and activity of the cells. It encourages root development and by hastening the maturity of the plant, it increases the ratio of grain to straw, as well as the total yield. It plays an important part in increasing the palatability of plants and stimulates the formation of fats, convertible starches and healthy seed. By stimulating rapid cell development in the plant, phosphorus naturally increases the resistance to disease. An excess of phosphorus does not cause the harmful effects of excessive nitrogen and has an important balancing effect upon the plant.

Potassium:

Potassium (K) is a positively charged basic metal cation whose total content in most mineral soil, except sandy natured soils, is greater than most other major nutrient elements. It is estimated that 2.3% of the Earths surface is potassium. However most of this potassium is not available to plants because it is either bound in primary minerals or is fixed in the interlayer of clay minerals.

Since clay soils develop from the decomposition of potassium rich primary minerals, it follows that soils high in clay content usually have a relatively high potassium content.

As potassium in the soil solution is diminished by plant uptake it is replenished by exchangeable potassium from soil colloids. Potassium fixed in the interlayer of clay minerals also contributes to the soil potassium supply even though it is not considered as readily available.

Depending on the type of clay mineral and its resistance to weathering actions, the potassium supply may or may not be adequate for maximum crop production. This evaluation of supply can be made with the Milwaukee NPK soil test, since exchangeable colloids and potassium in the soil solution are the forms of potassium measured by the soil test. In this light the soil test for potassium content reflects that portion of soil potassium which is readily available to plants, and depending on the soil test level may or may not be an adequate supply for good crop yields.

Soils which fix potassium serve as a bank which safeguards against leaching and ultimately, in time, returns potassium to the exchangeable form which can be withdrawn and utilized by plants.

Soils which are predominantly sand with little or no clay have extremely low levels of native potassium and are subject to sever leaching. In most cases annual potassium applications are required to grow satisfactory crops. Soils of this nature are common thought the Southeastern region of the United States.

Potassium in plant nutrition enhances disease resistance by strengthen stalks and stems. It activates various enzyme systems within plants. Potassium contributes to a thicker cuticle which guards against disease and water loss. It controls the turgor pressure within plants to prevent wilting. Potassium enhances fruit size, flavor texture and development and it is involved in the production of amino acids, chlorophyll formation, starch formation, and sugar transport form leaves to roots.

Relative Nitrogen, Phosphorus and Potassium Requirements for Common Crops and Plants

{ VH = Very High }   { H = High }   { M = Medium }   { L = Low }

L * = Nitrogen supplied by legume organisms

Plant	N	P	K
Alfalfa	L *	H	H
Apples	M	L	L
Asparagus	VH	H	M
Barley	M	H	M
Beans, Lima or String	L	M	M
Beets, Early	VH	VH	VH
Beets, Late	H	VH	H
Bent Grass	M	L	L
Blackberries	L	L	L
Blue Grass, Kentucky	M	M	L
Broccoli	H	H	H
Brussels Sprouts	H	H	H
Buck Wheat	M	L	L
Cabbage, Early	VH	VH	VH
Cabbage, Late	H	H	H
Carrots, Early	H	H	H
Carrots, Late	M	M	M
Cauliflower, Early	VH	VH	VH
Cauliflower, Late	H	H	VH
Celery, Early	VH	VH	VH
Celery, Late	H	VH	VH
Clover, Alsike	L *	M	M
Clover, Ladino	L *	M	M
Clover, Red	L *	H	H

Plant	N	P	K
Clover, Wild White	L *	M	M
Corn, Field	M	M	M
Corn, Sweet, Early	H	H	H
Corn, Sweet, Late	M	M	M
Cotton	H	M	M
Cucumbers	H	H	H
Deciduous Plants	M	L	L
Deciduous Shrubs	M	M	L
Deciduous Trees	M	L	L
Egg Plant	H	H	H
Evergreen Plants	L	L	L
Evergreen Trees	L	L	L
Flowers, Annual	H	H	H
Flowers, Perennials & Bulbs	M	M	M
Grapes	M	M	M
Grasses, Mixed	M	L	L
Grasses, Fairways & Lawns	M	M	L
Grasses, Putting Greens	H	L	L
Lettuce, Head	VH	VH	VH
Lettuce, Leaf	H	VH	VH
Millet	M	L	M
Muskmelons	H	H	H
Oats	H	M	M
Onions	H	H	H
Orchard Grass	M	M	M
Parsnips	M	M	M
Peaches	M	L	M
Pears	M	L	L
Peas, Early	M	H	H
Peas, Field, Canada	L *	M	M

Plant	N	P	K
Potatoes, Early	VH	VH	VH
Potatoes, Late	H	VH	VH
Potatoes, Sweet	L	M	H
Pumpkins	M	M	M
Radishes	H	VH	VH
Raspberries	L	L	L
Rhubarb	H	H	H
Rutabagas	M	H	M
Rye	M	L	L
Rye Grass	M	L	L
Soybeans	L *	M	M
Spinach	VH	VH	VH
Squash, Early	H	H	H
Squash, Late	M	M	M
Strawberries	M	M	L
Timothy	M	L	M
Tobacco	VH	M	VH
Tomatoes, Early	M	H	H
Tomatoes	H	H	H
Turnips	L	M	M
Vetch, Hairy	L *	M	M
Watermelons	M	M	M

Soil Test Form

Sample #, Grid #, or Location Reference of Test Sample:	
Date This Sample Taken: / /	Date This Sample Tested: / /
Past Management at this location – Last Action Taken: *(fertilization, sub-soiling, liming, irrigation, etc)*	
Well Water pH Test Results:	Soil pH Test Results:
Conductivity (EC) General Nutrients Reading Results:	
Comments / Action Taken:	

NPK Soil Test Kit Results

Test For	Test Results	**Comments or Action To Be Taken**
Nitrate Nitrogen (N)		
Phosphorus (P)		
Potassium (K)		
Schedule of Next Test Date: / /		

General Comments:

Into Metric

If you know	Multiply by	To Get
Length		
inches	2.54	centimeters
foot	30	centimeters
yards	0.91	meters
miles	1.6	kilometers
Area		
sq. inches	6.5	sq. centimeters
sq. feet	0.09	sq. meters
sq. yards	0.8	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.4	hectares
Mass (Weight)		
ounces	28	grams
pounds	0.45	kilograms
short ton	0.9	metric ton
Volume		
teaspoons	5	milliliters
tablespoons	15	milliliters
fluid ounces	30	milliliters
cups	0.24	liters
pints	0.47	liters
quarts	0.95	liters
gallons	3.8	liters
cubic feet	0.03	cubic meters
cubic yards	0.76	cubic meters
Temperature		
Fahrenheit	Subtract 32, then multiply by 5/9ths	Celsius

Out of Metric

If you know	Multiply by	To Get
Length		
millimeters	0.04	inches
centimeters	0.4	inches
meters	3.3	feet
kilometers	0.62	miles
Area		
sq. centimeters	0.16	sq. inches
sq. meters	1.2	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (Weight)		
grams	0.035	ounces
kilograms	2.2	pounds
metric tons	1.1	short tons
Volume		
milliliters	0.03	fluid ounces
liters	2.1	pints
liters	1.06	quarts
liters	0.26	gallons
cubic meters	35	cubic feet
cubic meters	1.3	cubic yards
Temperature		
Celsius	Multiply by 9/5ths, then add 32	Fahrenheit

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