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pH

INTRODUCTION: Sometimes when a plant doesn't look good, the grower may think the plant has a disease, needs water, or needs fertilizer. This may be true in terms of fertilizer need; however, simply adding fertilizer may not be the cure. There are several factors that must be considered. One of them is soil or planting media chemistry. For a plant to absorb the nutrients from a fertilizer, the soil media chemistry has to be suitable for the plant to absorb nutrients. From an agricultural point of view, the soil condition is referred to as pH, whereas, the letters "p" and "H" represent the "**p**otential **h**ydrogen" in the soil. By definition, the term is that pH is the 'negative logarithm of the hydrogen ion concentration [H+]', i.e., pH = -log [H+]. Through a soil testing procedure, a system of measurement is used to distinguish what type of soil you may have. In simple agricultural terms, pH is typically referred to as soils being either acid, neutral, or alkaline; depending on the pH range of 0 to 14. Neutral soils have a pH of 7, and below 7 are considered acidic, and above 7 are considered alkaline or basic. Some common slang that is referred to soil pH is sour [acidic] or sweet [alkaline].

CEC relationship with sandy to organic soils: You may have a question on how does pH affect the nutrient availability of a plant. The answer is the degree in which nutrients are absorbed by the soil and are available to the plant is termed cation exchange capacity (CEC). CEC is directly affected by soil pH. The CEC is referred to as the capability to which a soil can absorb and exchange nutrients (i.e cations). A few examples of cations, positively charged particles, are nitrogen (NH_4^+), potassium (K^+), calcium (Ca^{2+}), and iron (Fe^{2+}). Organic matter and soil particles have negative charges on their surfaces and attract positive charged particles (i.e. NH_4^+, K^+, Ca^{2+}, Fe^{2+}). When negative charged particles of soil particles and plant roots attract positively charged particles of nutrients, this is one of the basic fundamentals of simple soil chemistry. Once the minerals or cations are absorbed, the minerals are not easily lost when the soil is leached by water; however, they will provide a nutrient reserve available to plant roots. In addition, plant roots themselves, exhibit cation exchange capacity as well. Sandy soils normally exhibit low CEC while clay and organic soils exhibit high CEC (see Table 1). The high CEC clay and organic type soils also possess a higher buffering ability compared to sandy type soil where this increases the soils ability to resist change in pH.[1] [2]

Table 1

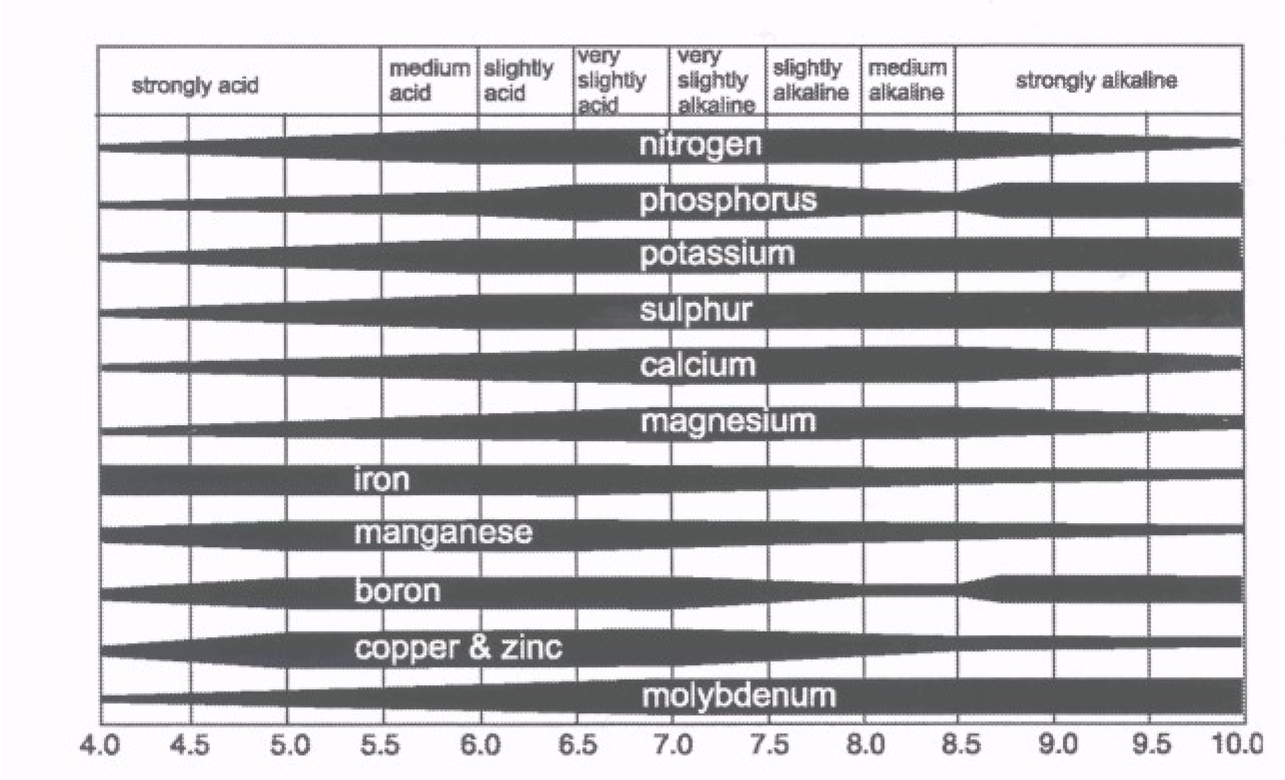
Soil texture	CEC (meq/100g soil)
Sands (light-colored)	3-5
Sands (dark-colored)	10-20
Loams	10-15
Silt loams	15-25
Clay and clay loams	20-50
Organic soils	50-100[3]

pH and nutrient availability: Still, what does this have to do with the relationship of absorbing nutrients you may ask. Once again, the availability of nutrients is directly influenced by soil pH. It is the controlling factor for nutrient uptake. For instance, some nutrients become insoluble if the soil pH is too high or too low, limiting the availability of these nutrients to the plant root system. For instance, Iron (Fe) is readily available in acidic soil, where its optimum range is pH 4.0 – 6.5; whereas, it is very limited in alkaline soils. Potassium is most available from slight acidic to alkaline soils that are above 6.0 and tapers off in its availability below pH 6.0. Nitrogen is readily available in a soil pH mid-range of 6.0 to 8.0, then below 6.0 and above 8.0, nitrogen becomes less available. Finally, molybdenum is readily available in higher pH (i.e. above pH 7) and limited in acidic (i.e. below pH 7), (see Chart 1).

pH and the availability of specific nutrients: Soil chemistry and pH is quite challenging. Landscape plants may exhibit nutrient deficiency or toxicity symptoms as a result of highly acidic or alkaline soil pH. In acidic soils, the availability of plant nutrients such as potassium (K), calcium (Ca), and magnesium (Mg) is reduced, while availability of potentially toxic elements such as aluminum (Al), iron (Fe), and zinc (Zn) are increased. In alkaline soils, iron, manganese (Mn), zinc, and boron (B) are commonly deficient.

Chart 1

Chart of the effect of soil pH on nutrient availability[4]



Plants and their optimum pH and problems associated with pH: Each plant has an ideal pH range it best performs at. Some plants can tolerate a wide range. Optimal ornamental ranges can vary from 4.5 to 8.0 (see Chart 2). For instance, azaleas require a specific pH range of 4.5 to 6.0, citrus needs 5.5 to 6.5, in contrast, verbena prefer a range of 6.0 to 8.0. Leatherleaf fern is one plant that is tolerant of a wide range of soil pH. It can grow and look great in soil having a pH range of 4.0 to 6.5. If the pH range does not match the plant requirements, although there may be ample nutrients in the soil, the plant simply cannot and will not be able to absorb them. There are varying degrees of pH and growth responses (see Table 2).

A pH scale is logarithmic: In a case where an individual may wonder why his/her verbena may be declining with yellow foliage when the soil pH is 5.8., remember that the ideal pH range for verbena is 6.0 to 8.0. The situation is that there is only 0.2 difference from its ideal range. The fact is, the pH scale is a logarithmic scale. A change of one unit in the pH scale represents a ten-fold change in acidity or alkalinity. A soil with a pH of 5.0 is ten times more acidic than a soil with a pH of 6.0 and 100 times more acidic than a soil with a pH of 7.0. This is one good reason to be very careful in trying to increase or lower soil pH. In this case with the verbena, the soil pH is two times more acidic than the minimum requirements. In this case the individual may want to increase his/her soil pH with the use of lime.

Altering pH: To alter the soil pH takes time. In short, you can raise or increase the soil pH with the use of agricultural limestone. If you wish to lower the soil pH, sulfur is normally used. This process may take up to four to six months or even longer depending on the soil or media type. As a rule, the heavier the soil (i.e. more clay or organic matter) the longer the process of change.

Alkaline soils: The common materials used to lower the soil pH is with the use of elemental sulfur (S), microbes oxidized the elemental sulfur into a sulfate (SO_4) and H^+ resulting in the lowering pH. Hydrogen (H^+) ions also are produced with the use of ammonium (NH_4) based fertilizer and soil organic matter (SOM). This also will lower the pH of your soil.

Acidic soils: Depending where you live, over time, with rain in our humid climate, soils become acidic due to the leaching. In addition, with the addition of fertilizers and organic matter, the acidulation process is enhanced. Monitoring of soil pH is important, for the fact if the pH becomes very acidic, (below pH 5.4); some minerals such as aluminum and manganese become very soluble and often are toxic to plants. Leaf yellowing, puckering, and burning symptoms may appear. Plant nutrients such as calcium and magnesium often are deficient in acidic soils. For legumes, beneficial soil bacteria that fix nitrogen on the roots of legumes such as beans and peas will not survive in acidic soils, and then those crops will suffer.

The common material used in raising soil pH is with the use of lime. Lime comes in many forms such as $CaCO_3$, $CaMg (CO_3)_2$, CaO, or $Ca (OH)_2$ to name a few. In the soil, the lime reacts with carbon dioxide and water yielding bicarbonate (HCO_3-), thus displacing or removing (H^+) ions and raising the pH in the process.

Other contributing factors: Organic matter (OM) also has an effect on soil pH. As a result of microbes' decomposition process, carbonic acid is produced dissolving nutrients and organic and inorganic acids that also provide (H^+) ions, thus aiding in lowering the pH as well. Soil pH also can affect soil bacterial and fungal activity, enhancing or inhibiting the development of soil-borne plant diseases or how efficiently microbes function as decomposing organisms.

Various fertilizers have different reactions with the soil, some alter pH to acidic and some to alkaline spectrums (see Chart 3). It's always wise to consult with your local Extension agent prior to any application of amendment.

BLUEBERRIES: Blueberries require an acid, well-drained soil. The soil pH maximum range should be 4.2 to 5.5. Adjust soils with a pH above 6.0 in the direction of pH 5.4 with the addition of sulfur. Sandy soils can be slightly acid in the top 6 inches because of previous nitrogen fertilization, but still have an alkaline reaction in the subsurface depths. Avoid sites where brush and timber have been burned. The basic minerals of ash will raise the soil pH above the range for best plant growth. Avoid recently limed land unless the lime was applied to raise the soil pH into the favorable range for blueberries. In fertilizing blueberries, the use of nitrogen fertilization should be with ammoniac nitrogen, not nitrate nitrogen.[5]

CITRUS: The optimal soil pH for citrus should be maintained at a pH range of 6.0 – 6.5. To prevent any trace element toxicity, particularly copper, soil pH management is essential.

LEATHERLEAF FERN: Leatherleaf fern is one plant that is tolerant of a wide range of soil pH. It can grow and look great in soil having a pH range of 4.0 to 6.5.

PITTOSPORUM: The optimal soil pH for pittosporum should be maintained at a pH range of 6.2 – 6.8. Magnesium (Mg) should be applied in sufficient quantities to meet crop needs. The most frequently used Mg sources are MgSO4 (Epsom salts) and dolomite (dolomitic limestone containing both calcium and Mg). Growers should be aware that dolomite can cause the soil pH to rise, i.e., become more alkaline.

Chart 2

Commonly used landscape plants and their preferred pH ranges[6]

Commonly used landscape plants and their preferred pH ranges

Shrubs	Preferred pH
Azalea	4.5 - 6.0
Barberry	6.0 - 7.5
Buddleia (Butterfly Bush)	6.0 - 7.5
Camellia	4.5 - 5.5
Crapemyrtle	5.0 - 6.0
Deutzia	6.0 - 7.5
Euonymus	6.5 - 7.0
Flowering Almond	6.0 - 7.0
Gardenia5	.0 - 6.0
Hibiscus	6.0 - 8.0
Holly	5.0 - 6.0
Huckleberry	5.0 - 5.5
Hydrangea (blue)	4.5 - 5.0
Hydrangea (pink)	6.0 - 7.0
Japanese Quince (flowering quince)	6.0 - 7.0
Ligustrum	6.0 - 7.0
Lilac	6.0 - 7.5
Oleander	5.0 - 7.5
Philadelphus (English Dogwood)	6.0 - 8.0
Pyracantha (Firethorn)	6.0 - 7.0
Spiraea Spp.	6.0 - 7.0
Tea Roses	5.5 - 7.0
Viburnum	6.5 - 7.5
Weigela	6.0 - 7.0

Trees	Preferred pH
Apple, Peach, Pear, Cherry	6.5 - 7.0
Dogwood	5.0 - 7.0

Trees	Preferred pH
Elm	6.0 - 7.5
Flowering Crab Apple	5.0 - 6.5
Holly	5.0 - 6.0
Magnolia	5.0 - 6.0
Maple	6.0 - 7.5
Oak Group	
Pin Oak	5.0 - 6.5
Scarlet Oak	6.0 - 7.0
Red Oak	5.0 - 7.5
Pine	5.0 - 6.0
Redbud	5.5 - 6.5
Vitex	6.0 - 7.0
Weeping Willow	5.0 - 6.0

Garden Flowers	Preferred pH
Amaryllis	5.5 - 6.5
Baby's Breath	6.5 - 7.0
Balsam (Touch-Me-Not)	6.5 - 7.0
Begonia	5.5 - 7.5
Caladium	6.0 - 7.0
Candytuft	6.5 - 7.0
Canna	6.0 - 7.0
Carnation	6.5 - 7.0
Chrysanthemum	6.0 - 8.0
Cockscomb (Celosia)	6.0 - 7.5
Coleus	6.0 - 7.0
Cornflower	6.0 - 7.5
Cosmos	6.5 - 7.0
Daffodil	6.0 - 7.5

Garden Flowers	Preferred pH
Dahlia	6.5 - 7.0
Day Lily	6.0 - 8.0
Easter Lily	6.0 - 7.5
Four-O-Clock	6.0 - 7.5
Foxglove	6.5 - 7.0
Geranium	6.0 - 8.0
Gladiolus	6.5 - 7.0
Hollyhock	6.0 - 8.0
Iris	6.5 - 7.0
Larkspur	6.5 - 7.0
Lupine	6.5 - 7.0
Marigold	6.0 - 7.5
Nasturtium	6.5 - 7.0
Narcissus	6.0 - 7.5
Pansy	5.0 - 6.0
Periwinkle	6.5 - 7.0
Petunia	6.5 - 7.0
Phlox	5.0 - 6.0
Poppy	6.5 - 7.0
Salvia	6.0 - 7.0
Shasta Daisy	6.0 - 8.0
Snapdragon	6.0 - 7.5
Sweet Alyssum	6.5 - 7.0
Sweetpea	6.5 - 7.0
Sweet William	6.5 - 7.0
Tuberose	6.0 - 7.0
Tulip	6.0 - 7.0
Verbena	6.0 - 8.0
Zinnia	5.5 - 7.5

Table 2

Varying degrees of pH and growth responses[7]

	Soil pH	Effect
Extremely acid	below 4.5	Few crops survive. Aluminum/manganese toxicity.
Very acid	4.5-5.0	Only acid-tolerant plants such as azaleas, carpet grass and blueberries do well.
Very acid	5.0-5.5	Some aluminum and manganese toxicity. Some nutrient deficiencies. Mid-5 is good pH for Irish potatoes, because scab bacteria don't survive well at this pH. Most crop yields slightly reduced, especially legumes.
Moderately acid	5.5-6.0	No visible problems with most crops. Yields of crops requiring high calcium and magnesium may be reduced (for example, tomatoes and peppers). Good for centipede and carpet grasses.
Slightly acid	6.0-7.0	Ideal for most crops. Best for soil bacteria/nitrogen fixation. Optimum nutrient availability. St. Augustine, Bermuda, and zoysia.
Slightly alkaline	7.0-8.0	Micronutrient deficiencies of iron, zinc, and manganese may occur. Too high for acid plants.
Alkaline	8.0+	Severe micronutrient deficiencies. Few garden crops do well. Acidulate your soil.

Chart 3
Various fertilizers have different pH eactions with the soil[8]

Material	Analysis N-P-K	Rate of application per 100 square feet Dry	Liquid	Speed of Reaction	Effect on pH
Ammonium Sulfate	20-0-0	½-1 lb	1 oz per 2-3 gal	Rapid	Very acid
Sodium Nitrate	15-0-0	¾-1¼ lb	1 oz per 2 gal	Rapid	Basic
Calcium Nitrate	15-0-0	¾-1½ lb	1 oz per 2 gal	Rapid	Basic
Potassium Nitrate	13-0-44	½-1 lb	1 oz per 3 gal	Rapid	Neutral
Ammonium Nitrate	34-0-0	¼-½ lb	1 oz per 5 gal	Rapid	Acid
Urea	45-0-0	¼-½ lb	1 oz per 5-7 gal	Rapid	Sl. acid
Mono-ammonium Phosphate	11-48-0	1 lb	1 oz per 3 gal	Rapid	Acid
Di-ammonium Phosphate	18-46-0	½-¾ lb	1 oz per 4-5 gal	Rapid	Acid
Triple Superphosphate	0-46-0	1-2½ lb	Insoluble	Medium	Neutral
Superphosphate	40-20-0	3-5 lb	Insoluble	Medium	Neutral
Potassium Chloride	0-0-60	½-¾ lb	1 oz per 4-5 gal	Rapid	Neutral
Potassium Sulfate	0-0-50	½-1 lb	Not advisable	Rapid	Neutral
Complete Soluble (mixtures)	20-20-20 20-5-30 12-12-12	Not advisable	1 oz per 3-5 gal	Rapid	Various
Complete Dry (mixtures)	10-10-10 5-10-10	2 lb 2-3 lb	Relatively insoluble	Various Various	Various Various
Limestone	None	5-20 lb	Insoluble	Slow	Basic
Hydrated Lime	None	2 lb	Relatively insoluble	Rapid	Basic
Gypsum (calcium sulfate)	None	2-5 lb	Insoluble	Medium	Neutral
Sulfur	None	1-2 lb	Insoluble	Slow	Acid
Epsom Salts (magnesium sulfate)	None	8-12 oz	1 oz per 5 gal	Rapid	Neutral
Aluminum Sulfate	None	(not advisable)	1 oz per 5 gal	Rapid	Very acid
Urea Formaldehyde	38-0-0	3-5 lb	-	Slow	Sl. acid
Magnesium Ammonium Phosphate	7-40-6	Variable	-	Slow	Neutral
Dried Blood	12-0-0	2-3 lb	-	Medium	Acid
Steamed Bone Meal	Usually	5 lb	-	Slow	Basic
Castor Pumice	5-1-1	3-5 lb	-	Slow	-
Cottonseed Meal	7-2-2	3-4 lb	-	Slow	Acid
Hardwood Ashes	0-1-5	3-10 lb	-	Medium	Basic
Hoof and Horn Meal	13-0-0	2-3 lb	-	Slow	-
Seaweed (Kelp)	Usually	2-3 lb	-	Slow	-
Linseed meal	5-1-1	3-5 lb	-	Slow	Acid
Soybean Meal	6-0-0	3-5 lb	-	Slow	-
Trace Elements	-	3-6 oz	-	0	-
Iron Sulfate	-	8-12 oz	1 oz per gal	-	-
Chelated Iron	-	1-2 oz	1 oz per 25 gal	-	-
Borax	-	½ oz	-	-	-
Copper Sulfate	-	1-2 oz	-	-	-

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