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Soil pH and their Effect on Nutrient Availability

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Introduction

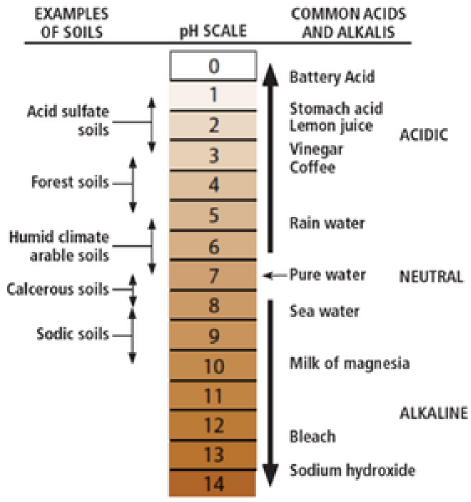
The concept of pH was introduced by Srensen. pH is the abbreviation for Latin "*pondus hydrogenii*"; pondus stands for power, and hydrogenii stands for hydrogen. In chemistry, the pH scale is a numeric index used to specify acidity and alkalinity of aqueous solutions. The term pH is defined as the logarithm of the hydrogen ion concentration or activity in solution expressed in equivalents per liter. It is a measure of the acidity or alkalinity in soils. The range of the pH scale is 0–14. A solution with a pH of 7 is neutral; one with a pH of less than 7 is acidic. A solution is basic if its pH is higher than 7.

pH= – log10 [H+] where [H+] – Hydrogen ion concentration

There is an inverse relationship between pH and [H+]: the greater the [H+], the lower the pH.

pH Meter:

A pH meter consists of a pair of electrodes, a glass electrode and a suitable reference electrode known as calomel electrode connected to a meter capable of measuring small voltages- in the order of millivolts. The voltage (electrical potential) produced by the solution is measured and compared with the voltage of a known standard solution. The difference in voltage (the potential difference) between them is used to calculate the pH. As temperature affects chemical activity, most measurements of pH include a temperature correction to a standard temperature of 25 °C so it is made inbuilt auto tempreture probe.



Procedure (pH measurement through pH Meter):

- Allow the pH meter to warm up & then Calibrate the pH meter.
- For calibration pour the buffer solutions into the beakers, appropriately labeled buffer 4.0, 7.0, and 10.0.
- Insert the electrode into the beaker corresponding to pH 7.0 and adjust the reading to the exact value of the buffer solution measured. Rinse the electrode with water and gently blot using soft, standard lab tissue paper. Proceed in the same way with pH 4.0 or 10.0.
- Weight 10.0 g of soil sample into 100-mL beakers and add 25 mL of water (soil to water ratio 1:2.5 w/v).
- Shake the soil–water mixture or carefully stir or swirl the suspension intermittently and thoroughly until complete homogenization. Let the mixture stand for 60 min.
- Stir the suspension again with a stirring stick for 10 seconds before taking the pH measurement.
- Place the electrode into the partially settled suspension to mitigate the suspension effect. Read the pH in the suspension when the pH value is stable and record results to 2 decimal places on an air dried soil basis.

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The desirable soil pH range for optimum plant growth varies among crops. Generally, From the attached diagram, soil pH 6.0-7.5 is acceptable for most plants as most nutrients become available in this pH range. Acid soils with a pH of less than 6 commonly have deficiencies in calcium, magnesium, phosphorus, potassium, molybdenum. Iron, manganese, zinc, copper and boron are commonly unavailable in alkaline soils with a pH of more than 7. Lets discuss about nutrients one by one.

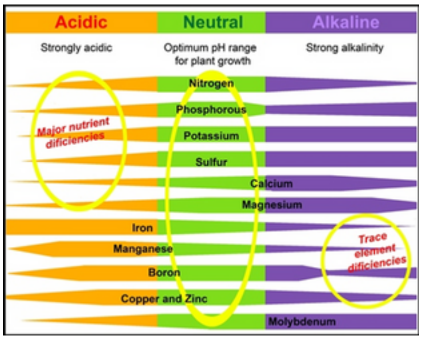

Fig: Soil pH & Nutrient availability
(Source: Bluedale: http://bluedale.com.au)

Soil pH affect the availability of Nitrogen & Phosphorous

Nitrogen is more readily available in slightly acidic to neutral soils (pH 6.0–7.5). Uptake of nitrate (NO3-) by plants is best at a lower pH, while NH4+ is absorbed more efficiently at a neutral pH. Phosphorus availability is optimal in slightly acidic soils (pH 6.0–7.0). In order for P to be available to plants, soils pH needs to be in the range of 6 to 7. If pH is lower than 6.0, P starts forming insoluble compound with Fe and Al, and if pH is higher than 7.5 P starts forming insoluble compounds with calcium.

Potassium (K), Calcium (Ca) and Magnesium (Mg) are Indirectly Affected by pH -

Potassium, Ca and Mg are less available in acid soils because they have been leached out, not necessarily due to solubility issues but also due to precipitation or adsorption onto soil particles. Potassium availability remains relatively consistent across a broad pH range. Uptake of potassium is therefore favored by high pH. Al can also dominate the CEC, limiting the soil's ability to absorb and hold K. Compared to K, Ca and Mg are more competitive with Al for CEC sites. In addition, toxic levels of Mn and Al may damage plants roots, preventing uptake of Ca, Mg and K.

Sulfur is Available in Soils as the ion SO_4^- over a Wide Range of pH -

The ion SO_4^- form of sulfur is negatively charged and is retained better by acidic soils. It is important to remember that when elemental sulfur (S) is added to soil, it creates sulfuric acid (lowering pH).

Micronutrients and their availability related to soil pH -

Micronutrients	Their availability in pH range.
Boron	Acidic
Zinc	Acidic
Manganese	Acidic
copper	Acidic
Iron	Acidic
Molybdenum	Alkaline
Chlorine	N/A

With the exception of molybdenum (Mo), all known micronutrients become less available when pH increases. For every unit increase in pH, the concentration of zinc (Zn), copper, and magnesium (Mn) decreases 100 times. Instead of being wasted, these nutrients preferentially sorb to soil surfaces, where plants cannot access them. They will precipitate as solid minerals at high quantities (iron, for example). Deficits will manifest in the field as noticeable symptoms when they are severe. Lower concentrations and the leached character of the soil are likely to be the cause of any micronutrient deficiencies found in acidic soil. As pH Rises, Micronutrients Bond to the Soil or Become Insoluble Minerals and Cannot be Taken up by Plants.

Strategies for managing Soil pH:

In order to maximise nutrient availability and support plant health, soil pH management is essential. Depending on whether the soil is excessively alkaline or too acidic, different techniques can be used to change its pH. To improve the pH of acidic soils, lime (calcium carbonate) is frequently used. Lime reacts with hydrogen ions to produce carbon dioxide and water, which balances the acidity of the soil. In addition to raising the pH of the soil, this process provides calcium and magnesium, which are vital elements for plant growth.

The kind of soil, the initial pH of the soil, and the quality of the lime all affect how effective liming is. By keeping soil pH within the ideal range, regular liming can improve crop yields and nutrient availability. Acidifying ingredients like sulphur, ammonium sulphate, or organic matter can be utilised to reduce the pH of overly alkaline soils. Alkalinity is neutralised by sulphuric acid, which is created when sulphur is oxidised by soil microorganisms. Because soil microorganisms convert ammonium to nitrate, which releases hydrogen ions, ammonium-based fertilisers also cause the soil to become more acidic. By improving soil structure and boosting microbial activity, adding organic matter—such as compost or manure—can assist to progressively lower soil pH. To monitor soil pH and make well-informed decisions regarding pH management, routine soil testing is necessary. Farmers can apply the right amendments in the right amounts thanks to soil testing, which offer useful information on the soil's current pH levels and nutrient status. In order to maintain ideal conditions for crop growth, it is helpful to track variations in soil pH over time and modify management techniques accordingly. A greater range of soil pH levels can be tolerated by some crops than by others. One tactic to control soil pH and nutrient availability is crop rotation and selection. Legumes like lucerne and clover, for instance, can raise the amount of organic matter in the soil and enhance its structure, which can help buffer its pH. Maintaining soil health and production can also be achieved by rotating crops that favour neutral pH with others that can withstand acidity.

Conclusion

Soil pH is considered to be the "master variable" of soil chemistry due to its profound impact on countless chemical reactions involving essential plant nutrients. Among essential plant, in general. nutrients nitrogen, potassium, calcium, magnesium and sulfur are more available within soil pH 6.5 to 8, while boron (B), copper, iron, manganese, nickel (Ni), and zinc are more available within soil pH 5 to 7. At pH less than 5.5, high concentrations of H+, aluminum and manganese in soil solution can reach toxic levels and limit crop production. Phosphorus is most available within soil pH 5.5 to 7.5. In order to maximise nutrient availability and support plant health, soil pH management is essential. To improve the pH of acidic soils, lime (calcium carbonate) and in alkaline soil gypsum is frequently used. Beside chemical ingredients organic matter, green manure, crop rotation, legume crops etc. are also control pH and maintain soil health and production

References

- Barrow, N.J. and Hartemink, A.E. (2023). *The effects of pH on nutrient availability depend on both soils and plants*. Plant Soil, 487, 21–37. https://doi.org/10.1007/s11104-023-05960-5.
- Changing the pH of your Soil. Clemson University Cooperative Extension. www.clemenson.edu
- Hartemink AE and Barrow NJ (2023). Soil pH – nutrient relationships: the diagram. Plant Soil. https://doi.org/10.1007/s11104-022-05861-z.
- Miller, Jarrod. (2016). Soil pH Affects Nutrient Availability. University of Maryland Extension.
- US Environmental Protection Agency Method 9045D (2004) Soil and Waste pH, 4 (11).