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Research Paper

Effects of pH on plant growth

Jaibir Singh

Department of Chemistry, Government P.G. College, Jhalawar -326001 Rajasthan (India)

Abstract
Depending on the soil pH, nutrients and chemicals will be soluble in the soil water, and are therefore available to plants. Some nutrients are more available under acidic conditions, while others are more available under alkaline conditions. pH affects nutrient availability within the soil, and plants have different nutrient requirements. For example, nitrogen, a very important plant nutrient, is readily available when soil pH is above 5.5.

Key word – Soil pH, Plant Growth, Plants Stability

INTRODUCTION

Using a pH test, you can determine whether soil is naturally acidic or alkaline. The pH of the soil is important for healthy plant growth. Research has shown that some agricultural practices significantly alter soil pH over the long term. The pH of soil is a measure of its acidity or alkalinity. As hydrogen ion concentration varies widely, a logarithmic scale is used to measure the acidity of a soil. For a pH decrease of 1, the acidity increases by a factor of 10.[1]

A very acid soil has a low pH and a high concentration of hydrogen ions, so at high (alkaline) pH values, the hydrogen ion concentration is low. A soil's pH value typically ranges from 3.5 to 10. In areas with higher rainfall, soil pH typically ranges from 5 to 7, while in drier areas, it ranges from 6.5 to 9.[2]

pH values can be used to classify soils:

- Neutral at 6.5 to 7.5
- Over 7.5 is alkaline
- pH less than 6.5 is considered acidic, and pH less than 5.5 is considered strongly acidic.
- The pH value of acid sulfate soils can be extremely acidic (below 4).

[1] "c=AU and o=The State of Queensland. Soil pH. Gov.au. Retrieved January 13, 2023 from https://www.qld.gov.au/environment/land/management/soil/soil-properties/ph-levels"
[2] "c=AU and o=The State of Queensland. Soil pH. Gov.au. Retrieved January 13, 2023 from https://www.qld.gov.au/environment/land/management/soil/soil-properties/ph-levels"

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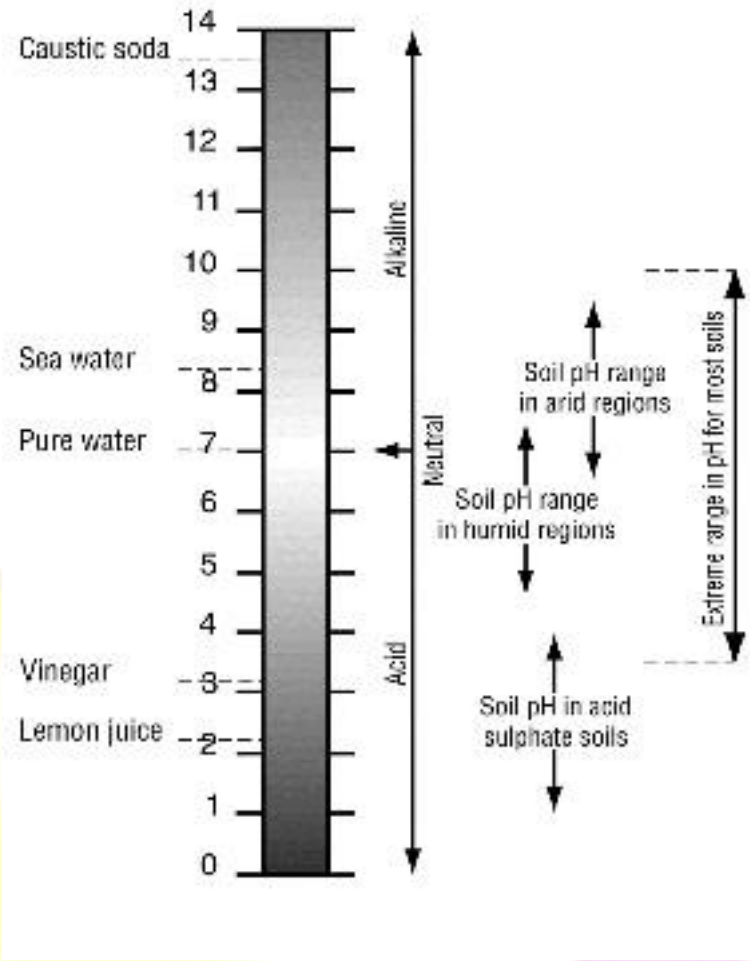

Fig 1. pH Range of Soil

The pH of soil is determined by the rock from which it was formed (parent material) and weathering processes - for example, climate, vegetation, topography, and time. These processes tend to cause a lowering of pH (increase in acidity) over time. Acidification can also be accelerated by some agricultural activities.

Some nutrients are more available under acidic conditions, while others are more available under alkaline conditions. Soil pH affects the amount of nutrients and chemicals soluble in soil water. Soil pH near neutral, however, makes most mineral nutrients readily available to plants.

One or more of the following factors can result in poor plant growth in strongly acidic soils (less than 5.5 pH):

- Toxicology of aluminum
- Toxic effects of manganese
- Deficiency of calcium
- Deficiency of magnesium
- Phosphorus and molybdenum levels are low.

Zinc, copper, boron, and manganese deficiencies can occur in alkaline soils. Soils with an extremely alkaline pH (greater than 9) are likely to have high sodium levels. In order to ensure proper soil pH levels, soil pH levels should be checked regularly. It can be costly and difficult to correct long-term nutrient deficiencies if soil pH levels are not monitored regularly.

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The pH of the soil can be changed by some fertilizers, which may increase or reduce plant nutrient availability. Fertilizers such as crushed sulfur and some ammonium-based nitrogen fertilizers can lower pH and make soil more acidic. They, therefore, are useful for soils with high pH levels.[3]

EFFECT OF PH ON PLANT GROWTHS

A soil's pH is a measure of its acidity (sourness) or alkalinity (sweetness). There are pH levels ranging from 0.0 to 14.0. The most acidic soil is 0.0 and the most alkaline is 14.0. Halfway up the scale, 7.0, is neutral, neither acid nor alkaline. Increasing pH values from 7.0 to 0.0 makes soils more acidic, while increasing pH values from 7.0 to 14.0 makes them more alkaline. Lemon juice, for instance, has a pH value of 2.4, water has a pH value of 7.0, and soap solution has a pH value of 9.3.[4]

Soil pH is an important factor impacting plant growth in many ways. The best range to operate in for bacteria that metabolize organic matter and fertilizers, as well as the availability of nutrients to plants, is around 5.5 - 7.0. If pH levels dip below 5.5, a higher rate of leaching of minerals may occur, with aluminum becoming toxic at below 5.0. In addition, this optimum range affects soil structure--clay soils are more granular and workable within this range than when they become excessively alkaline or acidic and become sticky and difficult to cultivate. pH soil tests determine if your soil is within the optimum pH range or if it needs to be treated to adjust the pH level. Although the optimum pH range is 5.5 to 7.0, some plants can grow in an acid soil and others in an alkaline soil.[5]

It is not a sign of fertility, but it does affect fertilizer availability. The soil may contain adequate nutrients yet plant health may be limited by an unfavorable pH level. The pH of builder's sand, on the other hand, may be optimal for plant growth despite being devoid of nutrients. If an acid soil (5.5 to 0.0) is in need of pH correction, ground limestone or dolomite are the treatments of choice. They are less likely to cause plant root burn than hydrated lime and should be worked into the soil at least six inches for the best results. The amount needed will depend on how much organic matter or clay is present.

Soil that is too alkaline might be due to a natural characteristic, or from lime or dolomite application. To decrease the pH, sulfur can be used, however it should only be applied every two months as it can burn plant roots. Additionally, it takes much less sulfur than limestone to lower the pH by one unit. On Marco Island, due to high sand and shell content, soils are generally alkaline. Utilizing sulfur-coated fertilizers is a great way of adding sulfur in an environmentally friendly way - these are slow-release fertilizers that spread the addition over time to avoid burning plants.[6]

There is a direct correlation between a soil's pH and its concentration of major nutrients, as well as its composition of microelements available to plants. When a soil's pH is too high or too low, plants are likely to suffer from nutrient deficiencies. It is usually possible to correct soil pH imbalances over time by working in particular materials that alter the soil's overall chemical composition. It is common to use lime to treat soils that are too acidic, while gypsum (in conjunction with other measures like planting legumes in crop rotation) is used to treat soils that are too alkaline.

Minerals and trace elements may not be available in sufficient quantities in soils with high acidity or high alkalinity. Plants can be harmed by high concentrations or more accessible forms of minerals, such as aluminum, due to extreme pH levels. A soil's pH levels also affect microbial processes that help decompose organic matter and deliver nutrients. In general, a neutral pH provides the best conditions for microbial action that makes nitrogen, sulfur and phosphorus available in the soil.[7]

[3] "c=AU and o=The State of Queensland. Soil pH. Gov.au. Retrieved January from https://www.qld.gov.au/environment/land/management/soil/soil-properties/ph-levels"
[4] "2021. The effect of soil pH on plants. Southlandorganics.com. Retrieved from https://www.southlandorganics.com/blogs/news/the-effect-of-soil-ph-on-plants"
[5] "2021. The effect of soil pH on plants. Southlandorganics.com. Retrieved January from https://www.southlandorganics.com/blogs/news/the-effect-of-soil-ph-on-plants"
[6] "G. E. CustServ. 2020. Effects of soil pH on plant growth. Garden Express. Retrieved from https://www.gardenexpress.com.au/soil-ph-plant-growth/"
[7] "G. E. CustServ. 2020. Effects of soil pH on plant growth. Garden Express. Retrieved from https://www.gardenexpress.com.au/soil-ph-plant-growth/"

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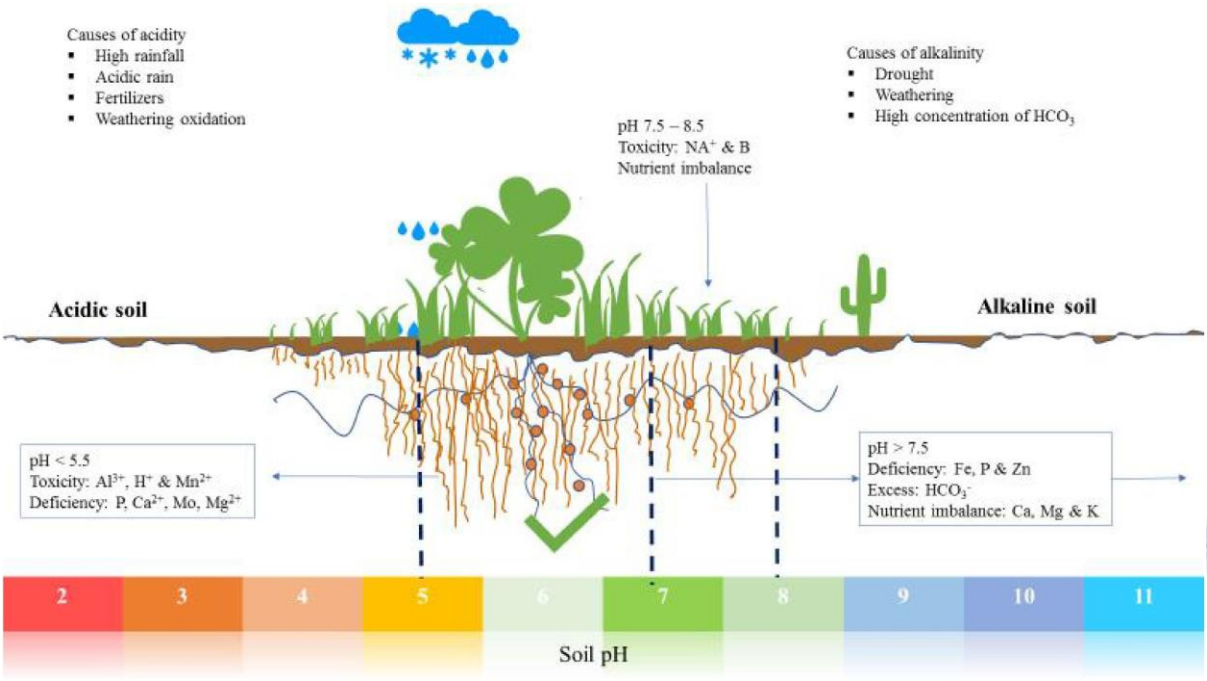

Fig 2. Soil pH and its effects

Some species, depending on their nutritional needs, prefer acidic or alkaline soils, whereas most plants thrive best in neutral soils. For more information, check out our soil pH guide, which outlines the preferred pH range of popular garden plants.

MEASURING SOIL PH

From the local nursery, you can pick up inexpensive soil test kits, digital soil pH meters, or pH testers. The soil test kits are readily available and include a test tube, testing solution, and a colour chart. In order to test your soil sample, simply put it in the test tube, add the recommended amount of solution, shake it, and let it settle for about an hour. Upon changing the color of the solution, the hue could be compared to the colour chart and the pH value of the soil determined. The next steps could be determined based on the outcome.[8]

The pH of soil can be measured in a variety of ways. Some use a saturated paste extract, and others use a 1:5 dilution of soil to water, followed by a pH measurement. Others use the 1:5 dilution, but instead of water they use a dilute Calcium Chloride (CaCl2) solution. It is generally 0.8 pH lower in $CaCl^2$ than in water, but can be as much as 2.0 pH units lower on grey sand. Make sure you are comparing similar methods when you measure soil pH.

Using a dilute $CaCl^2$ solution will likely provide more reliable results than rainwater or plain diluted water. When soil is saturated with water, the majority of H+ ions typically remain firmly bonded to soil particles, rather than being released into the soil solution. Adding a slight quantity of calcium chloride supplies Ca2+ ions that substitute for some of the H+ ions, driving them into the solution and making their concentration similar to what exists in nature.

As H+ concentration in $CaCl^2$ is higher than in water, pH measured in CaCl2 is usually lower than pH of the same soil measured in water. This procedure gives a pH similar to that of natural soil solution since the soil solution also contains dissolved Ca2+ and other ions.

Whenever you need calcium chloride, make up a diluted solution with distilled/deionised water. Ready-made calcium chloride solutions don't usually last very long. Buy $CaCl^2$ and make your own solution. It is usually a dehydrate form of calcium chloride (water is attached to the crystals - it will be noted on the container label - $CaCl^2.2H_2O$).[9]

Approximately 7.5g of the salt should dissolve in 5 litres of distilled/deionised water. If you are using calcium chloride crystals that do not contain water ($CaCl^2$), dissolve about 5.5g of the salt in 5 litres. Small errors in your weighing will not affect your results, so you do not have to be very accurate.[10]

[8] "pH, measurement of pH in soil. Com.au. Retrieved from https://bacto.com.au/measurement-of-ph-in-soil/"
[9] "pH, measurement of pH in soil. Com.au. Retrieved from https://bacto.com.au/measurement-of-ph-in-soil/"

Using a spoon, measure around 10g of your soil into the container, to the nearest half gram. Add 50ml of distilled water to create a 1:5 ratio. Shake the mixture for 2-3 minutes and leave it to settle for another two. If your soil has a high clay content and you need an accurate result, filtering may not be necessary. To get an accurate reading on the digital display, measure the pH value of the water layer above your soil sample. Make sure to clean out your containers before taking any further measurements.

The relative availability of soil nutrients is influenced by the pH of soil. Growth will be curtailed and erosion is increased if the pH does not fall within an acceptable range. A soil's ability to provide adequate nutrition to a plant depends on four factors:

The amount of different elements present in the soil depends on the nature of the soil and on its organic matter content since it is a source of several nutrient elements. Plants are able to access soil nutrients both as complex, insoluble compounds and as simple compounds, usually soluble in soil water. In order to benefit a plant, the complex forms need to be broken down into simpler, more available forms through decomposition.[11]

CONCLUSION

Soil pH affects the availability of the nutrients and chemicals found in soil water, as well as the interaction between them. Generally, most plants thrive best in soil that is slightly acidic to slightly alkaline. However, extreme pH can have detrimental effects on nutrient availability: phosphorus and molybdenum become less soluble in acidic conditions, while zinc is affected when the soil is too alkaline. On top of this, excessive acidity or alkalinity may also lead to higher solubility for elements toxic to plants, such as aluminum and manganese at low pH. Consequently, soil pH has far-reaching consequences both for how much of certain nutrients will be accessible to plants, as well as how those nutrients interact with each other.

[10] "pH, measurement of pH in soil. Com.au. Retrieved from https://bacto.com.au/measurement-of-ph-in-soil/"

[11] "pH, measurement of pH in soil. Com.au. Retrieved from https://bacto.com.au/measurement-of-ph-in-soil/"

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