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SOIL REACTION AND ITS INFLUENCE ON AVAILABILITY OF PLANTS NUTRIENTS

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Introduction: -

Soil reaction is one of the most important physiological characteristics of the soil solution.The presence and development of micro-organism and higher plant depend upon the chemical environment of soil. Therefore, study of soil reaction is important in soil science. There are three types of soil reactions.

1.Acidic

2.Alkaline

3.Neutral

1. Acidic: - It is common in region where precipitation is high. The high precipitation leaches appreciable amount of exchangeable base from the surface, layers of the soil, so that the exchange complex is dominated by H^+ ions. Acid soils therefore occur widely in humid regions and affect the growth of plants markedly.

2.Alkaline: - Alkali soil occur when there is comparatively high degree of base saturation. Salts like carbonates of calcium, magnesium and sodium also give a preponderance of OH^- ions over H^+ ions in the soil solution. When salt of strong base such as sodium carbonate go into soil solution and hydrolyse, consequently they give rise to alkalinity.

The reaction is as follow: -

$$Na_2CO_3 \longrightarrow 2Na^+ + Co_3^-$$
$$2Na^+ + CO_3^- + 2HOH \longrightarrow 2Na^+ + 2OH^- + H_2CO_3$$

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Since sodium hydroxide dissociates to a greater degree than the carbonic acid, OH^- ion dominate and give rise to alkalinity. This may be as high as 9 or 10. These soils most commonly occur in arid and semi - arid regions.

3.Neutral: - Neutral soils occur in regions where H^+ ions just balance OH^- ions.

<u>SOIL pH</u>

Soil reaction is measured by pH of a suspension of soil in water. The concept of pH may be explained with reference to pure water, which is amphoteric and in which hydrogen and hydroxyl ions are in equilibrium with undissociated water molecules.

Definition of pH: -

" pH may be defined as the log of reciprocal (or negative logarithm) of the hydrogen ion activity."

" pH may be defined as the negative logarithm of the active hydrogen ions in gram / Littre."

$pH = \log_{10} [1/H^+]$

At neutrality, the hydrogen ion concentration is 0.0000001.

or $1x10^{-7}$gms of hydrogen /Littre of solution

pH = log 1 / 0.0000001 pH = log 10000000 = 7.0

At pH of 6.0 there is 0.0000001 gm of active hydrogen or 10 time more the concentration of H^+ than at a pH of 7.0. At each smaller pH unit, The H^+ increase by 10 time in concentration.

Concept of H^+ ion Concentration

The acidity or alkalinity of a solution can be expressed on the scale of acidity and alkalinity in the same way as temperature is expressed on a thermometer scale. The scale of acidity or alkalinity is called pH scale. The unit of this scale is called pH Value. This scale runs from 0 to 14 values. The neutral point in this scale is at pH 7.0. All the values above pH 7.0 represent alkalinity and below 7.0 denote acidity. The degree of alkalinity increases as values go above pH 7.0 and the degree of acidity increase as the pH decreases below 7.0

------------ Acidity--------------------------------Neutral ---------------Alkalinity ------------------

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14

p^Hrange for most mineral soils

According to the theory of electrolytic dissociation, when liquids have number of H^+ ions just equal the number of OH^- ions, the solution is neutral. While, H^+ ions exceed OH^- ions the solution is acidic. Conversely, if OH^- ions are in excess the solution is alkaline.

Pure water ionized to a very small degree, though to a measurable extent according to following equation:

$$H_2O \text{ -------------------- } \rightarrow H^+ + OH^-$$

According to the law of mass action

$$\frac{\text{Concentration of H ions X concentration of OH ions}}{\text{Concentration of undissociated } H_20} = \text{K (constant)}$$

INFLUENCE OF SOIL REACTION ON AVAILABILITY OF NUTRIENTS

The main effect of soil reaction is on the availability of plants nutrients in the soil. The unproductiveness of acid and alkali soil is very often due to the lack of available plant nutrients. In highly acid soils (< pH), the availability of same of the nutrients such as Al, Fe and Mn etc., is increased to a point when they become toxic to the plant. At the same time, supply of available calcium, nitrogen, phosphorus etc., are reduced to starvation level. The same is the case at high pH (alkaline condition), plant growth suffers due to the unavailability of nutrients like nitrogen, phosphorus and some minor elements (e.g., iron, manganese, boron etc.).

Another indirect effect occurs through the activity of microorganisms. Most microorganisms function at their best within a pH range 6.0 to 7.5. If soil reaction is changed beyond this range, the microorganisms become functionless. Consequently, the supply of some of the essential plant nutrients like nitrogen is considerably reduced.

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1.Nitrogen- Plant absorbs most of their nitrogen in the form of nitrate whose availability depends on the activity of nitrifying bacteria. The microorganisms responsible for nitrification are most active when the pH is between 6.5 and 7.5. They are adversely affected if the pH falls below 5.5 and greater than 9.0. Nitrogen-fixing bacteria (like Azatobactor) also fails to function below pH 6.0. The decomposition of organic matter which is the primary source of nitrogen also slows down under acidic condition.

2.Phosphorus: - Its availability is highest when the reaction is between 6.5 and 7.5. When the reaction is above or below this range, availability is reduced. In the strongly acidic soil (pH 5.0 or less), iron, aluminium, manganese and other bases are present in a soluble state and in more quantity. The phosphate ions react with these bases (iron, aluminium etc.) and insoluble phosphates of these elements are formed and become unavailable.

Example:

$Al^{+++} + H_2PO_4^- + 2H_2O$ ⇄ $2H^+ + Al(OH)_2.H_2PO_4$ (soluble) (Insoluble)

The phosphates react with hydrated oxides of iron and aluminium and form insoluble hydroxy-phosphates of iron and aluminium. Unavailability of phosphorus is called phosphorus-fixation. Fixation of phosphate takes place even when the soil is alkaline (high pH). Phosphate ion combines with calcium ion and calcium (or magnesium) carbonates and form insoluble calcium (or magnesium) phosphate.

The reaction is as follows:-

$Ca(H_2PO_4)_2 + 2Ca^{++}$ ⇄ $Ca_3(PO_4)_2 + 4H^+$

(Soluble) (Absorbed) (Insoluble)

$Ca(HPO_4)_2 + 2CaCO_3$ ⇄ $Ca_3(PO_4)_2 + 2CO_2 + 2H_2O$

(Soluble) (Insoluble)

The availability of phosphorus at different pH is linked with the ionic form in which it is present in soil solution. The monovalent $H_2PO_4^-$ ions predominate in highly acid (at pH 4.0-5.0) solutions. With decreasing acidity, the divalent HPO_4^{--} ions begin to appear. In alkaline

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soil the trivalent PO_4^{--} ions are present in extremely small quantity. At pH 9.0 and above PO_4^{--} is available to plants.

3. Potassium: - The availability of potassium does not influence by soil reaction to any great extent. In acid soil, potassium is lost through leaching. The unavailability of K is due to the conversion of exchangeable to non-exchangeable potassium. In alkaline soil, particularly if the alkalinity is due to $CaCO_3$ (or is brought about by over liming in acid soil), the solubility of soil potassium is depressed (results in non-availability).

4.Calcium and Magnesium: - Acid Soils (base unsaturated) are poor in available calcium and Magnesium. In alkaline soil (pH not exceeding 8.5) availability of Ca and Mg nutrients is always high. When the pH is above 8.5, the availability of these nutrients again decreases.

5.Iron, Aluminium and Manganese: - When the pH is low the solubility of iron, aluminium and manganese compounds is increased, and hence, they are readily available in acid soils. At the pH range 5.5 to 7.0, iron and manganese are present in the soluble ferrous (Fe^{++}) and manganous (Mn^{++}) forms. At pH below 5.5, the solubility of these compounds is considerably increased with the result that they have a toxic influence on plant growth. Under neutral and alkaline conditions, iron and manganese are usually present in ferric (Fe^{+++}) and magnaic (Mn^{++++}) states. Hence, the soils with pH 7.5 and above, they become unavailable and sometimes produce deficiency disease like chlorosis in plants.

6. Sulphur: - The availability of sulphur is not affected by soil reaction as sulphur compounds are soluble in the whole pH range. However, it is more soluble in acid soil and lost in leaching. Acid conditions which retard the decomposition of organic matter, therefore, retard the release of available sulphur. The availability of sulphur present in organic matter depends upon the decomposition of organic matter.

7. Micronutrients: - In general, the availability of boron, copper and zinc is reduced in alkaline soils and that of molybdenum in acid soils. The availability of boron, copper and zinc progressively decreases as the soil pH increases. Their availability also decreases under highly acid condition when the pH is below 5.0. Zinc availability in alkaline soils form insoluble zinc salts (calcium zincate) Which reduces its availability, zinc and copper adsorbed on the clay colloids and are not easily displaced and hence, not available for plant growth. The availability of molybdenum is reduced acid soil. It is more available in Neutral and alkaline soils.

Plant Growth and Soil Reaction

A large proportion of crop plants can tolerate slight to moderate acidity. A few can tolerate slightly alkaline soils, but very few are able to tolerate moderately alkaline soil conditions. There are some plants that require strongly acid soils, but all plants of agricultural value fail to grow and die in strongly alkaline soils. The preference of plants for soil pH seems to be linked with the type of buffering system present in the cell sap.