ACIDIFICATION OF SOILS AND AMELIORATION

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The problem of soil acidification limiting crop production is mainly occurring in the highly weathered and leached soils of the humid tropics. Several climatic, biological and edaphic factors lead to acidification of soils. The hydrogen ion (H+) activity in soil solution determines the soil acidity and soils with lower pH, particularly with values lesser than 7 are classified under acidic soils. The solubility as well as the availability of nutrients to plants is related to soil pH. These soils are poor in their fertility status either due to the toxic effects of aluminium, manganese and a few micronutrients or due to the deficiencies of nutrients like P, Ca, Mg and Mo (Carver and Ownby, 1995; Jayasundara et al., 1998). However, the major problem in acidic soils is Al toxicity. This happens when the pH lowers below 4.5. These nutrient disorders arising out of lower pH limits the crop production due to the prevailing infertility conditions in the soil.

REASONS BEHIND SOIL ACIDIFICATION

Heavy rainfall and parent material: Heavy rainfall leaches bases from the surface and leads to the development of acid soils. The areas where rainfall exceeds evapotranspiration, acidification occurs as a natural process. Soils developed from acidic parent material usually turn acidic much faster than the soils from calcareous parent materials. The soils with fewer clay particles and more of sand acidify more rapidly as a result of their smaller reservoir of alkaline cations and increased leaching potential (Reynolds et al., 2001).

Plant roots: During respiration, plants release carbon-dioxide to the atmosphere. The roots, during active growth stages, release carbon-dioxide to soil which thereby increases the amount of carbon-dioxide dissolved in the soil water. This results in the formation of carbonic acid leading to lowering of soil pH and thereby soil acidification.

Acid producing fertilizers: Applications of acid producing fertilizers like ammoniacal or phosphatic fertilizers or urea result in release of hydrogen ions which increases soil acidity. When ammoniacal fertilizers are applied to soil, for every ammonium converted to nitrate, two H^+ ions are released. In the case of application of urea, two ammoniacal ions are released contributing to four hydrogen ions. These H^+ ions contribute to acidification of soil. Fertilizers containing monocalcium phosphate on application combines with water to form dicalcium phosphate and phosphoric acid which contributes to H^+ ions and thereby acidity. Thus repeated application of such fertilizers intensifies soil acidification (Adams, 1984).

Decomposition of organic residues: Organic residues on decomposition release organic acids, contributing towards soil acidity. Carbonic acid and other weaker acids produced during the decay of organic matter intensifies soil acidification (Carver and Ownby, 1995)

Plant growth: Nutrient uptake during plant growth may contribute to soil acidity as a result of hydrogen ion exchange process for basic cations like Ca, Mg and K. Legumes take up more cations than non legumes and are more acidifying in nature. By harvesting the crops, cations are removed from the soil and this accelerates the process of soil acidification (Ulrich et al., 1980).

Acid rain: Acid rain occurs as a result of emission of sulfur and nitrogen oxides gases, which reacts with water molecules in atmosphere to produce acids. Such rain water entry into soil system also results in soil acidification.

LIMITATIONS TO CROP PRODUCTION

Aluminium toxicity is one of the important reasons that hinder crop production in acidic soils. Roots are seriously affected due to Al toxicity. Roots turn brownish, stubby and brittle and growth gets restricted. Fine branching doesn’t occur causing difficulty in water and nutrient uptake by roots (Foy et al., 1978). The main symptom of Al toxicity is rapid inhibition of root growth. Availability of plant nutrients is impaired with strong and extreme soil acidity. Bacteria are responsible for many microbial processes like N mineralization, fixation etc. These processes will be hindered in case of lower pH as bacteria can't survive in acidic conditions. Thus, bacterial activity is less in acidic soils. Beneficial microbes are normally not present when the pH values are below 4.5. Fungus strives in acidic soils; hence some fungi may be present in acid soils. Pathogenic fungi, responsible for diseases in crops are usually seen under such circumstances.

AMELIORATION OF ACIDIC SOIL

Liming: The well known method to ameliorate surface soil acidity and Al toxicity is the practice of liming i.e. application of liming materials to soils to improve the pH. Liming is carried out using any liming material capable of neutralizing soil acidity and these materials are usually Ca or Mg compounds, viz. oxides, hydroxides and carbonates of Ca and Mg. Examples: CaO, Agricultural Lime ($CaCO_3$), Dolomite ($CaMg(CO_3)_2$) or the combination of both. By-products from a few industries like press mud from sugarcane industry, basic slags from iron and steel industries, flue dust from cement plants *etc*., phosphogypsum from phosphate industry, are examples of other liming materials (Thomas and Hargrove, 1984). These liming materials on application to acidic soils replace hydrogen and aluminium ions in the colloidal phase to soil solution and thereby ameliorate soil acidity. Usually lime is broadcasted on the surface and incorporated well during tillage operations. The lime should be applied more in smaller doses than one time full dose application. For successful liming and amelioration of soil acidity, easy availability of cheap liming materials (burnt lime, finely powdered limestone, dolomite, slags etc.) must be ensured. The target pH levels of 5.5 and 4.8 in the surface and subsoil are recommended. Hence a regular application of liming materials to raise the pH to safe levels (pH >5.5) is recommended to overcome soil acidity. This will ensure to treat both surfaces as well as subsoil acidification. This will allow sufficient alkalinity to move down and treat subsoil acidity. The effects of aluminium toxicity in the subsurface are minimised if the pH is above 4.8. The application rates of lime will depend on the soil pH profile, soil type, farming system, rainfall and lime quality.

Other methods: The use of Al tolerant varieties to overcome the problems due to Al toxicity in acid soils could be thought of as an effective amelioration mechanism. To serve this purpose genotypes should be developed with enhanced tolerance to acid soils and extreme levels of Al. This along with the practice of liming could improve the crop production in acid soils. Application of gypsum along with lime could help in ameliorating subsoil acidity problems.

CONCLUSION

Acidification affects the transformation and the biogeochemical cycling of nutrients due to the infertile conditions in the soil thereby hindering the crop growth and production. This is because of lowering the values of soil pH which is considered as the master variable controlling the availability of nutrients in the soil for plant uptake. The ideal pH where maximum availability of nutrients happens is 6.0 to 7.5 with better microbial activity. Hence, bringing the soil to an ideal pH range by liming improves the availability of nutrients to soil and favours microbial activity. Liming is the most commonly practiced amelioration measure in acid soils, however an integrated measure of liming, along with growing tolerant varieties of crops could be a better approach in overcoming the problem of soil acidification.

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