



Agronomic Measures for Enhancing Productivity in Acidic Soils

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Soil acidity is identified as having high acidity content (low pH value <5.5), aluminum, manganese, and phosphorus fixations, which greatly affect roots membrane and development. Soil acidity is 2nd most significant factors that limit agricultural productivity, causing yield reduction after drought. The quality of soil becomes degraded constantly because of soil acidity, aluminum toxicity, and nutrient scarcity, giving rise to wastelands that do not yield anything. These issues affect the maximum area globally and in India, posing serious problems in agricultural activities. Thus, measures like liming, nano-lime, biochar, organic matter, acid-resistant varieties of crops, appropriate nutrient management, biofertilizer application, water management, and conservation tillage should be adopted to manage soil acidity effectively.

Keywords: Acidic soils, soil pH, aluminum toxicity, liming, Phosphorus fixation, Soil Health, Integrated nutrient Management

Introduction

The problem of soil acidity is one of the major constraints to the efficient utilization of lands in several regions around the world. Such soils with a pH level less than 5.5 reduce productivity by restricting nutrient availability in addition to increasing solubility of harmful elements such as aluminum and manganese (Brady and Weil 2016). These elements limit root growth, reduce the effectiveness of fertilizers (nutrient use efficiency) in addition to lowering yield production. In India, about 48 million hectares of land are affected by acidity, specifically in the North-Eastern part of the country, in the eastern states as well as in the hilly regions like Himachal Pradesh (ICAR. 2018).

There are several methods and strategies which can increase soil acidity in order to improve productivity of these soils. Soil liming is the most used method since it helps neutralize soil acidity in addition to increasing nutrient availability. Some of the other methods include balanced fertilization, nutrient management techniques, farmyard manures, cover crops and conservation agriculture (Tisdale et al. 2013). Studies have demonstrated that a combination of using fertilizers with farmyard manure in addition to lime can help increase productivity and soil quality (Dhiman et al. 2019).

Impact of Soil Acidity on Agriculture

Soil acidity may be viewed as one of the significant limiting factors in the agriculture of our planet, particularly in humid tropical and subtropical regions. Soils that have their pH below 5.5 make up between 30-40% of the arable land of the entire globe as well as some areas in India according to Brady and Weil (2016). As per ICAR (2018), there are nearly 48 million hectares of acid soils in India, most of them being found in North-Eastern States, eastern parts of India, and hills of India such as Himachal Pradesh.

It can be noted that the adverse effects of soil acidity arise due to the presence of imbalanced nutrients as well as toxicities. Nutrients such as NPKC and Mg in acid soils

become deficient; however, there is a lot of availability and toxicity of heavy metals like Al and Mn, causing harm to crops (Tisdale et al., 2013). Toxicity of aluminum results in the inhibition of the elongation of roots, damages to root tips and restriction of water and nutrient uptake from the soil by plant roots. Another limitation of acid soils is a lack of phosphorus since it becomes fixed in Fe-Al compounds.

Moreover, acidity in soil impacts biological health of soil because it affects microbial life, decomposition, and nitrogen fixation. Useful microbes like Rhizobium and phosphate solubilising bacteria are less effective under acidic soil condition, which adversely impacts nutrient cycle and fertility of soil. The soil becomes poor in quality, less organic in nature, and highly susceptible to soil erosion under acidic conditions.

Impact of soil acidity is more on some crops than others. Highly sensitive crops like pulses, oilseed crops, vegetables, and wheat are badly affected in case of soil acidity, but tolerant crops like rice, tea, and potato face relatively lesser impacts. Soil acidity causes great financial loss and makes fertilizers ineffective if not taken care of on time.

Global and Indian Scenario of High Temperature stress in food crops

Acidic soil condition is one of the biggest problems that affect agriculture all around the globe. It affects almost 30-40% of the world's arable area, especially in areas with high rainfall as basic elements in the soil become washed away by Brady and Weil (2016). The acidic soil condition occurs in South America, Africa, Southeast Asia, Australia and humid zones of Europe and North America. Such conditions in soil are associated with aluminum toxicity, phosphorus fixation, and nutrient deficiency, leading to poor plant productivity.

The estimated area of land affected by soil acidity condition in India is 48 million hectare (ICAR, 2018). The soils having acidity condition occur in North-Eastern states, Odisha, Jharkhand, West Bengal, Chhattisgarh, Kerala, Karnataka and Himalayan region of Himachal Pradesh.

Management of Acidic Soils

Management of acidic soils is important for improving soil health and sustainable productivity.

Liming is the primitive most effective and widely used practice for correcting soil acidity. Materials such as agricultural lime, dolomite and basic slag neutralize excess acidity, reduce aluminum toxicity and supply calcium and magnesium. Lime will be applied on the basis of soil test.

Balanced fertilization and integrated nutrient management are crucial in acidic soils because nutrient use efficiency is very low. Application of recommended doses of NPK along with farmyard manure, compost, poultry manure, vermicompost and biofertilizers improves soil fertility, microbial activity and crop yields. Phosphorus will be applied in split doses and near root zone because it will be easily fixed in the soil.

Organic amendments such as green manures, crop residues and biochar helps improve soil structure, water holding capacity and nutrient retention for many years.

Biochar can also reduce acidity and immobilize toxic aluminum. Recently, **nano biochar** has gained attention due to its high surface area, better adsorption capacity and enhanced nutrient release efficiency.

Modern technologies such as **nano lime** is essential because nano-sized particles react quickly in soil and require very low doses as compared to conventional lime. Nano lime can improve pH, nutrient availability and root growth more efficiently.

Precision agriculture practices are emerging tools for acidic soil management. Soil pH mapping, GPS-based variable lime application, remote sensing and sensor-based nutrient management helps in applying the nutrient at the where they are required, reducing cost and improving efficiency. Site-specific management is especially useful in fields with variable soil acidity.

Use **acid-tolerant crop varieties**, crop rotation with legumes, conservation agriculture support sustainable productivity in acidic soils. Thus, combining traditional practices with

advanced technologies like nano lime, nano biochar and precision farming offers a promising strategy for future management of acidic soils.

Conservation tillage and conservation farming systems are important in sloped terrain with high rainfall areas. By reducing soil disturbance using reduced or no-till practices the moisture is conserved and erosion is prevented. Crop residue retention on the soil surface provides organic matter and increases the activity of beneficial microorganisms.

Cover crops (e.g., legumes, rye & buckwheat) helps in protecting soil from erosion, control weeds, and provide organic biomass. In addition, legume cover crops helps in atmospheric nitrogen fixation, resulting in improved soil fertility. Crop rotation with legumes and crops that can tolerate acid will help maintain nutrient balance, disrupt pest cycles, and improve soil health.

Water management practices like proper drainage system, use of micro-irrigation system, checking irrigation water quality i.e go with use of alkaline water, raised bed farming and use of intermittent irrigation in rice improves soil conditions.

Conclusion

Soil acidity is a severe limitation to crop output due to nutrient deficits, aluminum toxicity and low soil biological activity. The negative effects of soil acidity can be mitigated through using a variety of methods which include applying lime, applying balanced fertilizers, adding organic matter (animal manure or compost) to the soil, reducing tillage, using cover crops and rotating crops. The use of new technologies such as nano lime, nano biochar, and precision agriculture will result in improved new methods of managing acidic soils at a faster rate, in a more efficient manner and more accurately, improving the health of soils, improving the efficiency at which nutrients are used and consequently, increasing the productivity of crops. As a result, scientific and sustainable management of acid soils is essential to ensuring long term agricultural productivity, profitability and food security, therefore, scientific and sustainable management of acidic soils is crucial in ensuring agricultural production, profitability and food security will occur over the long term.

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