

Soil acidity management

in NEH region of India for doubling farmers income

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Out of 25 m/ha of problematic acid soils of India with pH below 5.5, NEH region represents 54% of the total area whereas it occupies only 8% of the total geographical area. Soil pH has major influence on the availability of elements, including essential nutrients, as well as secondary, micronutrients, and potentially toxic elements like aluminum. In acid soil crop production is less though sufficient nutrients are available in soil. If the nutrients can get converted into available form, mainly at neutral pH range, crop yield will automatically increase. At low pH, high aluminum availability can severely restrict root growth and thus, uptake of nutrients and water. Under acidic condition most of the soil beneficial microbes are absent and which functions their activities at near neutral pH. Thus increasing soil pH will automatically increase nutrient availability and ultimately crop production which may fulfill our objective of doubling farmer's income.

Keywords: Agro-forestry, Biochar, NEH region, Organic farming, Problematic soils, Soil acidity

MANY technologies to make acid infertile soils productive and profitable on a long-term sustainable basis are available, but they need to be adapted and applied locally. Every soil ameliorating method has its own merit and demerits, but among the soil acidity correction technology mostly available are ready reckoners for acid soils to raise soil pH to 5.5 by liming application in furrows to each crop, tolerant plants: rice, pigeonpea, finger millet, buckwheat, rice bean, colocasia, pineapple, sweet potato, potato, ginger, turmeric, tea, rubber, etc. Some technologies are described herewith for management of soil acidity for doubling farmer's income.

Application of agricultural limestone

Soil acidity can be corrected easily by liming the soil, or adding basic materials such as lime, biochar *etc.* to neutralize the acid present. The most commonly used liming material is agricultural limestone, the most economical and relatively easy to

manage source (Fig. 1). Liming is the most desirable practice of amelioration of acidic soils having pH of less than 5.5. Lime requirement of soils of North Eastern Regions of the country is generally calculated using the data on pH, organic carbon, clay content, and CEC of soils. Cost effective liming

materials are available in north eastern states of the country as paper mill by products like lime sludge, basic slag, paper mill sludge, etc. with cheap prices. Lime rates based on exchangeable aluminium have been found adequate for maize production and considerably less than those required bringing the soil pH to 6.5.



Fig. 1. Application of agricultural Lime stone

The amount of liming material required is crop specific and is calculated by estimation of lime potential and lime requirement of soils and neutralizing values (CaCO_3 equivalent). Application of lime stone @ 4 t/ha resulted optimum yield for wheat and maize in a sequence in the state. It is therefore, recommended that half the amount of limestone (2 t/ha) is needed for sustained production of wheat-maize cropping system. Application of liming materials in furrows is always preferred than broadcast in terms of unnecessary wastage of liming materials. Significant increase in maize yield (11.3% increase) has been observed by furrow application of limestone by applying only 250 kg/ha per year, whereas broadcast application of limestone requires higher doses.

Biochar application

Biochar is carbon rich charcoal-like substance created by heating biomass in limited oxygen condition through a process known as pyrolysis. Locally available weed biomass which are not economically important and cause considerable crop loss can be used as an important source of biomass for preparation of biochar. The cost of biochar produced by farmers using the biomass created during/after harvest and/or from other economical sources comes to around ₹ 3-5/ kg. If anyone wishes to prepare commercially from woody substances, it is also available for ₹ 9-12/kg. But, biochar prepared from locally available weed biomass will be available at zero cost. Apart from this, low-cost portable biochar kiln along with smoke-free stove costing ₹ 500-550, that produces biochar during cooking and smoke is reduced by 75% as against the traditional chullah. Fuel energy produced during burning of biomass used for cooking and cost of fuel energy nullified by labour cost and thus production cost of biochar depends on only biomass cost. Thus, from weeds its zero cost, from crop residue ₹ 3-5 and woody substance 9-12. Biochar is basic in nature ($\text{pH} > 7.0$). It can react similarly as agricultural lime does *i.e.*, by increasing soil pH (upto 1 point



Fig. 2. Biochar applications

increase in pH). Biochar should be applied along with other inputs like compost or manure at the same rate every year to realize the actual benefits. Application rates of these organic inputs can be reduced as biochar also contains some nutrients. It was found that rates between 5-10 t/ha (0.5-1 kg sqm) have beneficial effect on soil properties and crop yield (Fig. 2). A study has proved that biochar increases/improves soil moisture retention upto 20%, nutrient use efficiency upto 15%, CEC upto 35% and crop productivity upto 30%. Biochar increases grain yields ($>15\%$) by decreasing leaf SPAD value at sites with low P availability in upland rice.

Conservation agriculture

Conservation tillage systems often increase surface residue and limit incorporation and mixing of organic matter and nutrients, resulting in reduced soil erosion, accumulation of organic matter near the soil surface, lower soil temperature, increased water infiltration, decreased water runoff, higher soil moisture, stratification of nutrients and soil pH, and changes in the rooting pattern of crops. Description of the C cycle starts in the plant leaves with the creation of sugars from carbon dioxide (CO_2) and water using the energy of the sun through photosynthesis. These sugars are converted in part to organic acids that dissociate into H^+ ions and organic anions. The negative charge on the anions is balanced by the

“base” cations, Ca^{2+} , Mg^{2+} , K^+ and Na^+ to form salts of organic. As the alkali is accumulated in the above ground biomass, an equal amount of acid is added to the soil. The return of biomass to the soil neutralises the acid as it breaks down. Some acid will be utilised in the weathering process otherwise the ecosystem will retain an alkali/acid balance that, if the system was totally closed, would continue indefinitely. In conservation agriculture, soil is minimum disturbed, ground cover and residue recycling, somewhat follow the principles of closed ecosystems and reduces the chances of soil acidity. In contrast, conventional agriculture practices follow the clean cultivation concept and plant material is removed from the eco-system as in the harvest of grain or the making of hay then the eco-system is left more acid. Cultivation of upland rice using no-till along with brown manuring mulching enhanced productivity and profitability of rice cultivation in NER of India. Adopting rice-rice system under reduced tillage/no-till with INM/IPNM and effective residue recycling is recommended for enhancing the system productivity, carbon and nitrogen sequestration in paddy soils of the NER of India.

Organic manures as amendments

Most people recognize the value of animal waste as a plant nutrient source or soil amendment, but the potential of manure, especially poultry litter, to neutralize soil acidity and raise soil pH is less known. The

organic matter added with manure acts as pH buffer, releasing H^+ in response to the addition of alkaline materials and accepting H^+ in response to the addition of acidic materials. Application of solid cattle manure moves soil pH towards neutrality in acidic and thus improving nutrient availability. This move towards neutrality is also favourable for plant growth and a variety of beneficial microbial processes. Therefore, solid manure should be regarded not only as a source of nutrients, but also as a beneficial soil conditioner. Poultry manure is as effective as lime in raising soil pH and in reducing aluminum toxicity. Application of large amounts of vermicompost and cow manure increased the availability of soil nutrients (N, P, K and micronutrients) and also enhanced the biodiversity of soil bacterial communities in *L. chinensis* grasslands along with enhanced soil enzyme activity, which will contribute to the sustainable development of agro-ecosystems. Addition of organic matter is a viable option to manage problems associated with soil acidity. Organic matter increases the cation exchange capacity (CEC) of the soil. As the base saturation increases, the relative amount of “acid cations” decreases. During the decomposition of organic matter, there is a release and synthesis of organic compounds which forms strong bonds, known as “chelates,” with aluminum. Chelation reduces the solubility of aluminum and soil acidity. Again, if your soil is prone to manganese toxicity, it is not suggested that you add organic matter.

Method of raising plant

Germinating seeds are severely affected by soil acidity, resulting in higher mortality and thus poor crop stand; the crop should be raised by transplanting seedlings. For this, older seedlings raised in nursery on good soil should be used. Planting of 45 days old seedling of rice showed higher degree of resistance to survive under acidic soil over the 25 and 30 days old seedlings of rice. At lower pH, rice plants are basically very susceptible and due to this sometimes

after transplanting they are not able to survive. Therefore it is essential to transplant rice at slightly mature stage under high acidic soil condition.

Mulching

The addition of organic matter improves physical conditions of soil and more water holding capacity keeps acids in diluted form. Study conducted at ICAR Sikkim Centre showed that after three years of fixed plot experiments receiving 5 t/ha weed biomass and crop residue, marginal improvements in soil pH (5.75) were noticed over the initial values of 5.5.

Crop rotation

Using crop rotations can lead to dramatic increases in soil fertility in general and maintaining the soil pH towards the neutrality in particular, help to optimize nutrient and water use by crops, and improve our soil resources. It has been found that most of the soil nutrients are available (except some micronutrients) in the neutral pH range and thus, such neutral pH can be a game changer for increasing soil nutrients availability for increasing crop production and productivity under changing climate.

Crop diversification

Inclusion of legume in cropping system not only economizes nitrogen requirement of cropping system but also helps in efficient utilization of native phosphorus due to secretion of certain acids (oxalic acid; 0.01 ppm) that helps in solubilization of various forms of phosphorus. This capacity of legumes makes them efficient in native utilization of phosphorus present in different forms. Increased available P is a result of P acquisition from insoluble phosphates through root exudates.

Reducing the leaching of NO_3-N

Nitrate nitrogen (NO_3-N) is easily leached, as it is highly soluble than other N compounds, when NO_3-N is leached away it leaves that part of the soil more acidic. If the NO_3-N is taken up further down the profile there can be an increase in pH_{Ca} at the point of uptake. However, when

the NO_3-N is leached below the root zone it leaves the soil profile more acidic. It qualifies the effect of each factor and indicates how the effect can be influenced. The absolute effect of each factor will increase with higher rainfall.

Agro-forestry

Agro-forestry can play in improving acid soils but the processes through which this role is realized have not yet been treated. However, in the case of agriculture in the hills, it became clear that increased agricultural exports and elimination of woody components from the production system lead to decreased SOM, increased nitrate leaching and acidification. More than 8.8 kmol/ha of H^+ are lost annually from the first 1 m of the soil profile, at 2,200 mm/year of rainfall, under high-input intensive agriculture. The opposite takes place under peach palm agro forestry, with rice and legumes as undergrowth: the acidification rate is negative ; < -4.0 kmol/ha of H^+ . Shifting cultivation, low input agriculture without external input all show acidification, but much lower than in the case of intensive agriculture. In hilly area, large cardamom based agroforestry system have wide scope for enhancement of income as well as build up of soil fertility. Besides, some nitrogen fixing trees like *Alnus*, *Ficus* may also play a vital role.

Preventing erosion of topsoil

A build-up of soil organic matter and/or increasing the biomass, both dead and alive, has the same effect on soil acidity as removing produce from the soil. The increase in soil organic matter or biomass will stabilise at a new level over time and can be reversed if the biomass is reduced and the organic matter mineralised. However, if the topsoil is removed by erosion, the increase in the acidity of the soil is permanent. Similarly, if the biomass is burned and the ash is washed or blown away then soil is left a little more acidic. Higher organic matter levels often mean higher levels of available nitrate nitrogen and the potential for further acidification due to leaching.



Fig. 3. Monitoring subsurface pH

Monitor subsurface pH

On heavy soils, monitor the 10-20 cm soil layer. On lighter textured soils include the 20-30 cm layer. This is because the most acidic layer and consequently the most aluminium toxic layer for lighter textured soils are often between 15-25 cm. The

surface pH_{Ca} needs to be above 5.5 to achieve adequate downward alkalinity into subsurface. For this, regular soil sampling collection and analysis is necessary.

Conclusion

Soil acidity decreases the

availability of most of the plant nutrients. It also affects adversely the important microbiological processes. Several technologies such as conservation agriculture, organic manures, method of raising plant, locally available biomass material as mulches, crop choice, varieties tolerant to soil acidity, crop diversification and intensification, minimising product removal effects, agro-forestry etc. are available to make acid infertile soils productive and profitable on a long-term sustainable basis, but it needs to be adapted and applied locally. Thus if all the scientific community can spread the technology for management of soil acidity, automatically crop yield will be increase which will aid in achieving the objective of doubling farmer's income.

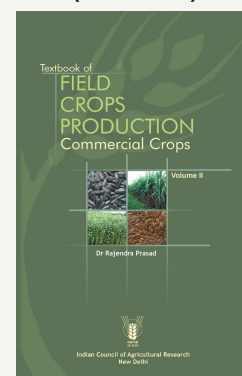
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