

# Management of acid soil for sustainable agriculture in hilly ecosystems of eastern Himalaya

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*Soil acidity in hill ecosystems is one of the major constraints affecting crop productivity. It is developed due to the leaching of basic cations in the high rainfall receiving areas. More than 80% of soils in north eastern region are acidic. In hilly areas, low agricultural production is owing to low soil fertility due to soil acidity, erosion, continuous cropping, and inadequate sustainable soil fertility management. Acid soils are devoid of phosphorus, calcium, magnesium, boron and molybdenum while aluminium and iron are in toxic concentration. Crop production is significantly affected by soil acidity because of lack basic cations, poor microbial activity and toxicity of few micronutrients. There are several organic and inorganic management practices namely agricultural lime application, acid-tolerant crops, balanced fertilizer use, improved agronomic, cultural, and biological methods such as crop residue management, green manuring, agroforestry, integrated nutrient management, etc. For resilient, environmentally sensitive farming and long-term food security in India, especially in northeast India, these sustainable acid soil management strategies could be cost-effective, environment friendly solutions that improve crop yields while enhancing soil health.*

**Keywords:** Balanced fertilizer use, Environment friendly, Soil acidity

**H**EALTHY soil is the cornerstone of lucrative, and ecologically sustainable agriculture systems. By comprehending the impact of management methods on soil processes that facilitate plant growth and govern environmental quality, one can devise a crop and soil management strategy that enhances and sustains soil health over time. Soil is an essential resource; its management can enhance or diminish its quality. Soil is a multifaceted environment in which living microorganisms and plant roots aggregate mineral particles and organic materials into a dynamic structure that governs water, air, and nutrient availability. In agriculture, soil health primarily denotes the soil's capacity to maintain agricultural productivity and safeguard environmental resources. Healthy soil performs numerous tasks that facilitate plant growth, including nutrient cycling, biological pest management, and regulation of water and air supply. These functions are affected by the interconnected physical, chemical, and biological characteristics of soil, many of which are responsive to soil management approaches.

Soil health management is crucial to long-term

agricultural production. Healthy soil improves plant productivity, health, water and air quality, water and nutrient retention and release, erosion and nutrient loss resistance, soil biodiversity, and soil management techniques. The north eastern region soils are mostly acidic (>80%) and have many soil-related constraints, including soil acidity-induced soil health problems (physical, chemical, and biological), soil crusting, soil erosion and nutrient losses, waterlogging and nutrient leaching, and organic matter loss. Undulating geography and mountainous terrain threaten viable agriculture in the region. Soil acidity reduces availability of phosphorus, zinc, boron, and molybdenum and increases iron and aluminium toxicity. All plant species require 17 elements to complete their life cycle. These elements are essential for plant metabolism and cannot be replaced. Farmyard manure, composts, green manures, green leaf manures, intercropping, and other methods supplemented major nutrients (nitrogen, phosphorus, and potassium), secondary nutrients (calcium, magnesium, and sulphur), and micronutrients like boron, chlorine, copper, iron, manganese, sodium,



(A) Mulching and (B) Green manure crop (*Crotalaria juncea*)

zinc, molybdenum, and nickel in ancient agriculture. Micronutrients are deemed vital trace elements because their requirement is modest. Despite their minimal demand, plants cannot complete their life cycle without these micronutrients. Farmers often overlook nutrient supplementation in modern agricultural production systems. The northeastern region's strong rains and acidic soil exacerbate crop nutrient deficiencies. To maximize productivity sustainably, soil health management is crucial. Crop rotation, intercropping, green manuring, green leaf manuring, organic manure, lime treatment, etc. assist maintain soil health. Soil testing is one of the most significant tools for recommending and applying the proper quantity of customized fertilizers, organic manure, and micronutrients to crop plants.

**Table 1.** Distribution of acid soils in north eastern India

States	pH <5.5 (m ha)	pH 5.5–6.5 (m ha)	Total acid soil (m ha)	Geographical Area	% Geographical area under acid soil
Arunachal Pradesh	6.52	0.27	6.79	8.347	81.08
Assam	2.33	2.33	4.66	7.844	59.41
Manipur	1.87	0.32	2.19	2.233	98.07
Meghalaya	1.19	1.05	2.24	2.243	99.87
Mizoram	1.27	0.78	2.05	2.208	97.20
Nagaland	1.60	0.05	1.64	1.658	99.50
Sikkim	0.60	-	0.60	0.710	84.51
Tripura	0.81	0.24	1.05	1.049	100.00
Total NER	16.19	5.04	21.23	26.29	80.79

Source: Annual Reports of AICRPDA

### Acid soil health management practices

**Crop residues management:** crop plants need several macro and micro-nutrients for growth and development. Beyond the economic parts (grain, fruits, vegetables, etc.), crop leftovers (straw, stalks, leaves, etc.) contain most of the nutrients crop plants need. Using crop remains as mulch on succeeding crops reduces the nutrients taken from the land. Mulching

the soil's open surface with straw, stalks, grass cuttings, bark chips, plastic, etc. is one of the easiest and most effective soil health management strategies. Mulching retains soil moisture and conserves water, regulates soil temperature, protects the soil from erosion, heavy wind, and intense sunlight, reduces weed growth, and protects crops from pests and diseases. It improves plant health and growth by reducing weed growth and maintaining soil moisture and temperature, improving soil structure by reducing soil compaction from heavy rainfall, and improving soil fertility by decomposing crop residues by microorganisms to release nutrients.

**Green manuring:** Green manuring improves soil physical, chemical, and biological health. It involves ploughing undecomposed green plant materials into the soil. Undecomposed green plant materials can be grown in the field (green manure crops like *Sesbania rostrata*, *Crotalaria juncea*, dhaincha, cowpea, cluster bean, black gram, ricebean, soybean, lentil, pea, etc.) or collected from outside and used there. Green manuring prevents nutrient leaching, increases water holding capacity, adds organic matter, extracts nutrients from deeper soil layers, improves microorganisms activity, fixes biological nitrogen, prevents soil erosion, reduces pest and disease incidence, improves soil structure, and releases nutrients during decomposition. Intercropping (growing two or more crops in a row) is another significant soil health management method. By efficiently using resources that would otherwise be consumed by a single crop, intercropping increases yield on a given amount of land.

**Bulky organic manures:** Bulky organic manures are made from animal and plant leftovers that contain less quantity of plant nutrients in complex form and are applied in huge volumes. When microbes degrade organic manures, plants can uptake their nutrients. Organic manures provide plant nutrients and sustain acid soil health, where the north eastern state governments promote organic farming. Organic produce is higher-quality and more expensive than inorganic. Since farmers cannot afford inorganic fertilisers due to their exorbitant pricing, it is a great alternative. Organic manures include farmyard manure



(A) FYM and (B) Vermicompost

(FYM), compost, vermicompost, poultry, and pig manures. While decomposing, it gives nutrients to crop plants, improves soil physical, chemical, and biological qualities, and increases soil plant nutrient availability by reacting organic acids generated by organic manures with soil nutrients comprising minerals. Besides being eco-friendly, it boosts soil microbial activity, which recycles nutrients. As mulch, it reduces soil moisture loss through evaporation. FYM, the decomposed mixture of farm animal excrement, urine, litter, and residual roughages or fodder provided to cattle, is the most frequent organic manure source to boost production and soil health. It contains a lot of plant nutrients that slowly feed agricultural plants. Unlike FYM, vermicompost is earthworm casts rich in macro and micronutrients, enzymes, and growth regulators. It is ideal for growing free-living and symbiotic bacteria that indirectly boost plant development and productivity.

**Chemical fertilisers and liming:** The soil is fertilized with natural or synthetic materials to provide plants with nutrients required for plant growth and development. It might be powder, crystal, granule, or liquid. urea, SSP, DAP, and MOP are the main solid fertilizers used in India including northeast region for nutrient control. Liquid fertilizer is usually applied by drip irrigation. Some north eastern states like Sikkim, Meghalaya, etc. consume no fertiliser in most crops, including fruits and vegetables. Applying fertilizer according to soil test results, crop needs, soil condition, etc. helps give nutrients without degrading the soil. Acid soil amelioration is crucial for maximum productivity and soil health in north eastern states, where over 80% of soils are acidic. Lime is used worldwide to improve acid soils, and north eastern farmers apply lime regardless of crop. Applying 500 kg of lime per hectare to furrows raises soil pH to neutral, enhancing nutrient availability and minimising nutrient toxicity. Lime is affordable, so farmers can afford it. Limestone reacts with soil to neutralize acidity, depending on particle size. Smaller particles have a larger surface area to react, modifying soil pH to promote crop plant nutrient uptake. The fundamental difficulty of phosphorus fixation can be minimized to enhance plant phosphorus availability.

**Agroforestry and alley cropping:** In agroforestry, crops are cultivated on the same land management unit as woody perennials like trees, bushes, bamboo, palms, etc., in specific or chronological configurations. Alongside tree species such as Khasi pine, alder, areca nut, pear, peach, etc., north eastern region is home to a variety of crops, including pineapple, coffee, turmeric, ginger, vegetable crops, and coffee. The economic significance of the species and the local climate dictate crop and tree species selection processes. Soil nitrogen fixation by leguminous trees, erosion management by cover and barrier effects nutrient loss prevention are all parts of the agroforestry system that work together to keep soil healthy. Increased nutrient availability through nutrient cycling, decreased insect and disease incidence, improved biological activity of the soil, and preservation of good soil physical conditions are all outcomes. Agroforestry also has the potential to diversify farm economies, which means farmers can expect more consistent revenue. The practice of planting tree rows with a greater spacing and then growing agricultural products in the spaces between them is known as alley cropping. In addition to increasing or diversifying farm income, alley cropping has many other uses, such as reducing wind erosion, improving nutrient utilisation, improving wildlife habitat, protecting crops from erosion, improving the microclimate for improved crop production, and improving the area's aesthetics.

**Integrated nutrient management:** Increasing agricultural output while protecting the environment for the next generation is the goal of integrated nutrient management (INM). Soil health and plant nutrient supply are two aspects of INM or integrated plant nutrition management (IPNM) that aim to maximise the advantages from all potential sources in order to preserve the desired production. The system of land use and ecological, social, and economic conditions should be considered while determining the appropriate combination of chemical fertilisers, organic manures, green manures, crop residues, N<sub>2</sub>-fixing crops (rice bean, black gram, soybean and groundnut), crop rotations, and biofertilizers. The cropping system rather than an individual crop, and farming system rather than an

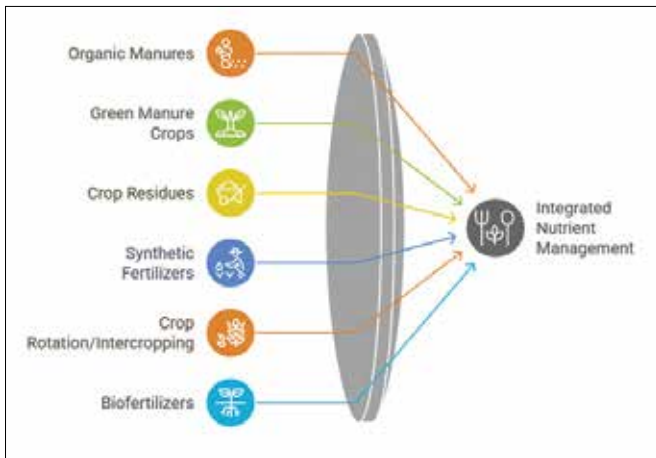


(A) Furrow liming and (B) Agroforestry system

individual field, is the focus of attention in this approach for development of INM practices for various categories. Nutrient conservation and application, technological advancements that make nutrients more available to plants, and information sharing between researchers and farmers are the pillars upon which it rests. INM has several benefits, including making more applied and in-soil nutrients available, ensuring balanced crop nutrition, improving soil physical, chemical, and biological properties, and reducing soil and water erosion by increasing soil organic carbon and decreasing nutrient losses.

### SUMMARY

The eastern Himalayan region faces significant agricultural challenges due to widespread soil acidity, affecting more than 80% of arable land. Acidic soils reduce nutrient availability, hinder microbial activity, and lower crop productivity. Various challenges still persist which hinder the continuous efforts of management of soil acidity. The absence of an umbrella policy to subsidize and promote ecological fertilization practices, high cost of bulky organic manures like vermicompost, shortage and low availability of FYM and seeds of green manure crops has hindered widespread adoption of acid soil management practices among the farming community of NEH region. To address this, sustainable soil management strategies have been developed by ICAR and agricultural universities. By choosing alternate approaches like *in situ* residue management, vermicomposting, biochar production, agroforestry systems, promotion of mechanised residue management and INM farmers in the eastern Himalayas can sustainably manage acid soils, improve crop productivity, and support long-term environmental and economic resilience. These integrated approaches ensure food security while conserving the fragile hilly ecosystems in a more sustainable way.



Components of integrated nutrient management (INM)

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Plant trees, Conserve water,  
Protect environment.

