Management of Acid Soils for Crop Production

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Land degradation due to soil acidity is one of the most important limitations for optimal use of land resources for higher crop production worldwide. Soil acidity refers to presence of higher concentration of H+ in soil solution and at exchange sites and influenced by edaphic, climatic, and biological factors. Acid soils is defined as soils with pH <6.5 in the top layer. These soils are formed due to weathering caused by hot & humid climate and heavy precipitation. They are characterized by low soil pH and with low base saturation, they are usually more acid near the surface and less acidic or even alkaline at depth/ subsurface where higher quantities of clay and calcium carbonate is present.

Extent and Distribution of Acid Soils

Acid soils occupy a considerable area in world, about 3.95 billion ha which account 30% of the world's ice-free land area (Von Uexkull, H.R. and E. Mutert, 1995). In India out of the 328 million hectares of geographical area nearly about 89.94 m ha area (27.4 per cent) is covered by acid soils (Sharma and Sarkar, 2005) of which 31 m ha area show severe soil acidity problems (pH below 5.5) while 58.94 m ha is slightly acidic with pH between 5.5 and 6.5 (NBSS LUP, Nagpur, 2005). Acid soils are found to occur in the Himalayan region, the eastern and north-eastern plains, peninsular India and the coastal plains under varying environmental conditions of landscape, geology, climate and vegetation. Most of these soils belong to the soil order, Ultisols, Alfisols, Mollisols, Spodosols, Entisols and Inceptisol. The acid soils are mostly distributed in Assam, Manipur, Tripura, Meghalaya, Mizoram, Nagaland, Sikkim, Arunachal Pradesh, West Bengal, Jharkhand, Orissa, Madhya Pradesh, Himachal Pradesh, Jammu & Kashmir, Andhra Pradesh, Karnataka, Kerala, Maharastra and Tamilnadu. Severely acidic soils like acid sulphate soils (pH, 4.5) are found in parts of Kuttanad area of Kerala, Goa, Maharashtra and Andaman and Nicobar Islands (Ganeshamurthy *et al.*, 2000).In Jharkhand out of the 7.9 million hectares of geographical area nearly about 6.7 m ha area (85 per cent) is covered by acid soils of which 1.0 m ha area show severe soil acidity problems (pH < 5.5) while 5.7 m ha is slightly acidic with pH between 5.5 and 6.5 (Maji, *et al.*, 2012).

Table 1. Extent of Acid Soil Region % in different States of India

State	Acid soil regions (ASR) %	State	Acid soil regions (ASR) %	State	Acid soil regions (ASR) %
Andhra Pradesh	10.3	Jharkhand	84.9	Nagaland	100.0
Arunachal Pradesh	81.1	Karnataka	17.3	Orissa	55.7
Assam	59.8	Kerala	94.7	Sikkim	85.3
Bihar	25.1	Madhya Pradesh	38.0	Tamil Nadu	37.7
Chhattisgarh	77.7	Maharashtra	14.9	Tripura	99.5
Goa	83.3	Manipur	98.1	Uttar Pradesh	1.4
Himachal Pradesh	31.9	Meghalaya	99.9	Uttarakhand	65.3
Jammu and Kashmir	7.1	Mizoram	97.0	West Bengal	53.6

Source: (Maji, *et al.*, 2012)

Acid Soils Are Formed Mainly Due To:

- Leaching of bases caused due heavy precipitation.
- Acidic rocks as parent materials e.g. Granite , in the process of soil formation, render the soil acidic
- Use of acid forming fertilizers contributes to soil acidity. Example nitrogenous fertilizers like ammonium sulphate and ammonium nitrate are responsible for creating soil acidity
- Drastic weathering of rocks associated with hot humid climate and heavy rainfall.
- Laterization, podzolisation and accumulation of undecomposed organic matter under marshy conditions contribute to soil acidity.
- Little or no addition of organic matter and continuous removal of crop residue from field.
- Excessive use of water or keeping the field submerged for a long time accompanied by improper drainage may lead to the development of acidity in the soil.
- The normal agricultural practices of fertilization and harvesting of crop, along with increases in leaching of nitrate nitrogen and occasional soil erosion, accelerate the acidification of agricultural lands.

Production Constrains in Acid Soils

- Leaching of bases, fine earth and organic matter.
- Coarse texture soils (high macro pore) and weak soil structure.
- Low moisture holding capacity, High infiltration and permeability rate.
- Formation of soil crust, particularly in red and laterite soils.
- Poor drainage system of soils.
- Low Phosphorus availability and high P-fixation capacity.
- Toxicity of Aluminum, Iron and Manganese.
- Deficiency of secondary nutrients *i.e.* Calcium, Magnesium and micronutrients such as Molybdenum, Boron and Zinc.
- Low in pH, organic matter, base saturation percentage and cation exchange capacity.
- Very slow microbial activity and impairment of nitrogen fixation by legume.
- Decomposition of organic matter is very slow.
- Soil acidity affects enzymatic process in plants as enzymes are sensitive to pH change.
- It causes damage to root tissues and hairs which affects moisture and nutrient uptake by plants.
- Reduction in yield (Table. No. 2), growth and production of crops
- More prevalence of plant diseases.
- Affect nodulation and biological nitrogen fixation in legume crops.
- It affects the microbial population and their activity

Table 2: Expected loss in productivity due to soil acidity

Class	pH	Degree	Loss in productivity
0	>6.5	Nil	Nil
1	5.5-6.5	Sligh	Up to10
2	4.5-5.5	Moderate	10-20
3	3.5-4.5	Strong	25-50
4	3.5	Moderate	>30

Source: (Velayutham and Bhattacharyya, 2000)

Management of Acid soils

Management of acid soils should be directed towards enhanced crop productivity either through addition of amendments to correct the soil abnormalities or by manipulating the agronomic practices depending upon climatic and edaphic conditions.

- Use of liming materials:
- Lime (calcium carbonate) and other liming materials reduce acidity by neutralizing the acid reaction in the soil. The finer liming material with a higher purity and higher neutralizing value (NV) preferably >80% provides a quicker response. Addition of lime helps in neutralizes soil acidity, increases microbial activity & nutrient availability and improves the physical condition of soil. Among the naturally occurring lime sources calcite and dolomite are important.
- **Liming materials:** limestone and dolomite limestone are the most widely used Commercial amendments. Carbonates, oxides and hydroxides of calcium and magnesium are referred to as agricultural lime used as liming material. The other liming material/ sources used are marl, oyster shells and several industrial wastes like steel mill slag, blast furnace slag, lime sludge from paper mills, pressmud from sugar mills, cement wastes, precipitated calcium carbonate, etc are equally effective as ground limestone for acid soils reclamation and also cheaper.
- **Rate of application of lime:** Application of lime is done when soil pH is below 5.5. Its rate of application decided

on its lime requirement (LR) estimated in soil laboratory. The lime requirement is the amount of lime needed to neutralize the hydrogen, as well as the reactive aluminum, associated with organic matter. Based on soil LR application of lime at 1/10th of LR at the time of sowing of crop in furrows each year will help in increasing soil pH and crop productivity. In Jharkhand furrow application of lime, @ of 3 to 4 q/ha depending upon extent of acidity along with type of crops grown is recommended to enhance productivity in acid soil.

2) **Organic Matter:** Organic matter additions as crop residues, organic manures and green manure crops in rotation or as intercrops act as the key components of crop management systems for acid soils. Regular application of well decomposed organic matter in acid soils is essential to prevent sudden fluctuation of soil pH as it improves the buffer capacity of soils. Moreover, it increases the availability of P and reduces the toxicity of Fe and Al in acid soils.

3) **Crop choice:** Selection of crops tolerant to acidity is an effective tool to counter this soil problem and breeding of such varieties is of specific importance for attaining higher productivity particularly in the areas where liming is not economical. From the Table 6, it is evident that rice and tea are most acid tolerant crops and thus can be grown successfully in the areas suffering from acid soils (Mandal et al., 1975). The crops can be grouped on the basis of their performance in different soil pH range such as:

a) **Highly acid tolerant crops:** Rice, potato, sweet potato, oat, castor, etc.

b) **Moderately acid tolerant crops:** Barley, wheat, cowpea, mungbean, pigeonpea, peanuts, etc.

c) **Slightly acid tolerant crops:** Tomato, carrot, red clover, maize, pea, soyabean, brinjal etc.

d) **Acid intolerant crops:** Lucerne, sorghum, berseem, onion, cabbage, cauliflower, etc.

Table 3: Relative tolerance of crops to soil acidity

Crops Optimum	pH range
cereals	
Maize, sorghum, wheat, barley	6.0-7.5
Millets	5.0-6.5
Rice	4.0-6.0
Oats	5.0-7.7
Legumes.	
Field beans, soybeans, pea, lentil etc	5.5-7.5
Berseem	6.0-7.5
Groundnut	5.3-6.6
Miscellaneous crops	
Sugarcane	6.0-7.5
Cotton	5.0-6.5
Potato	.5.0-5.5
Tea	4.0-6.0

Source : Mandal et al. (1975)

4) **Selection of Varieties tolerant to soil Acidity:** The growing of crop genotypes/cultivars tolerant to soil acidity is another strategy to increase productivity of acid soils. The varieties identified for this purpose are given in Table. 4.

Table 4: Crop varieties tolerant to soil acidity

Acid soil region/state	Crop	Varieties
Assam	Rape seed	Varuna, Sonmukhi
	Summer greengram	K851, Sonmugu
Himachal Pradesh	Soyabean	Bragg, Ph1, Harasoya
	Gobhi sarson	ONK1, Hoyala, HPN-3
Jharkhand	Blackgram	KU-301
Kerala	Vegetable cowpea	Bhagyalakshmi
	Cowpea (Bush type)	V-16
Meghalaya	French bean	HUR-15
Orissa	Grondnut	Smruti
	Pigeon pea	UPAs-120
West Bengal	Mustard	Sanjukta, Pusa bold
	Wheat	K9107, PBW 343

Source: ICAR Net Work Project on Acid Soils, 2005

5) **Nutrient Management:** Integrated Application of organic manures in combination with inorganic fertilizers and lime proves to be an excellent package for improving productivity and health of acid soils. Avoid use of ammonium fertilizers as it accelerates acidity, application of nitrogen fertilizer in split doses and use of neem, lac or any other coated urea fertilizers. To avoid p fixation, phosphatic fertilizer should be banded at an appropriate depth, in close proximity of the root zone, to attain higher P utilization.

6) **Flooding:** In lowlands systems, flooding may be an effective technique in raising the pH of the soil. However, this effect is only good for the time for which the soil is flooded. Flooded or paddy mineral soils are called as 'self-liming' soils.

7) **Agro-forestry intervention** with use of horticultural/agro-forestry species including fuel & fodder plantation /multipurpose tree species and hedge row species for stabilization of hilly slopes along with productivity augmentation.

8) **Mechanical measures** such as field bunding, land shaping, construction of field channels/water harvesting structures, etc.

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fig .1 Application of lime in furrow

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