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Exploring Untapped Potential of Acid Soils of India

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Exploring Untapped Potential of Acid Soils of India

1. PREAMBLE

There are about 90 million hectares of acid soils in India, of which about 31 million hectares show pH below 5.5 while about 59 million hectares have pH between 5.6 and 6.5 (Fig. 1). Very low pH (4 or less) soils, though important and present mostly in Kerala, are not very extensive. The acid soils are found extensively in north-eastern, eastern, peninsular (including Bihar plateau, sub-plateau region of West Bengal and major parts of Orissa), north-east Himalayan regions, north-west (comprising Jammu & Kashmir, Himachal Pradesh) and central (Uttarakhand) Himalayan regions. There are large areas of acid soils in Assam, Manipur, and Tripura in the north-eastern India. The cultivated area identified for amelioration of acid soils in different states is given in Table 1.

Acid soils and poor farmers with little or no resources go together in a large part of the acid soil region (ASR). The major crops grown in the ASR are rice, jute, wheat, potato, pulses, and oilseeds. The productivity of these crops is low, even below the national average. Rice is the predominant crop, which in some regions is grown in both *kharif* and *rabi* seasons. Maize is grown in valley areas of H.P., J&K and Uttarakhand, where farmers get good yields with appropriate management practices. In NE states, horticultural and plantation crops (tea and rubber) are grown and forestry is practiced with good returns.

Soil acidity, however, is a major problem in field crop production, particularly in the high rainfall regions, and in the areas where low input agriculture is practiced. Poor crop growth in acid soils can be correlated directly with Al saturation. Except for extreme situations, pH *per se* rarely has a direct effect on plant growth. At very low pH 4.2, however, the hydrogen ion concentration may hinder, or even reverse cation uptake by plant roots. The poor fertility of acid soils is due to a combination of Al, Mn and Fe toxicity, and deficiency of P, Ca, Mg and K and some micronutrients like B, Mo, and Zn.The crops grown on these soils consequently contain low/high amount of these elements. Some relationships exist between the consumption of the crops grown on these soils and the occurrence of malnutrition/imbalance of micronutrients in some species of animals and also human beings resulting in their health problems. Besides increasing their productivity, ameliorating these soils to have crops containing adequate/balanced micronutrients for alleviating micronutrient malnutrition of animal and human is a big challenge.

Realizing the importance of the subject, the National Academy of Agricultural Sciences organized a Brainstorming Session on 22-23 July 2010 in its premises at New Delhi to identify various issues related to the theme. Dr C.L. Acharya, former Director, Indian Institute of Soil Science, Bhopal, convened it. A total of 31 participants comprising subject matter specialists from different acid soil regions of the country and representing the disciplines of Soil Science, Agronomy, Soil-Water Engineering, Microbiology, Plant Physiology and Plant Breeding and representatives of the industry took part in the deliberations.

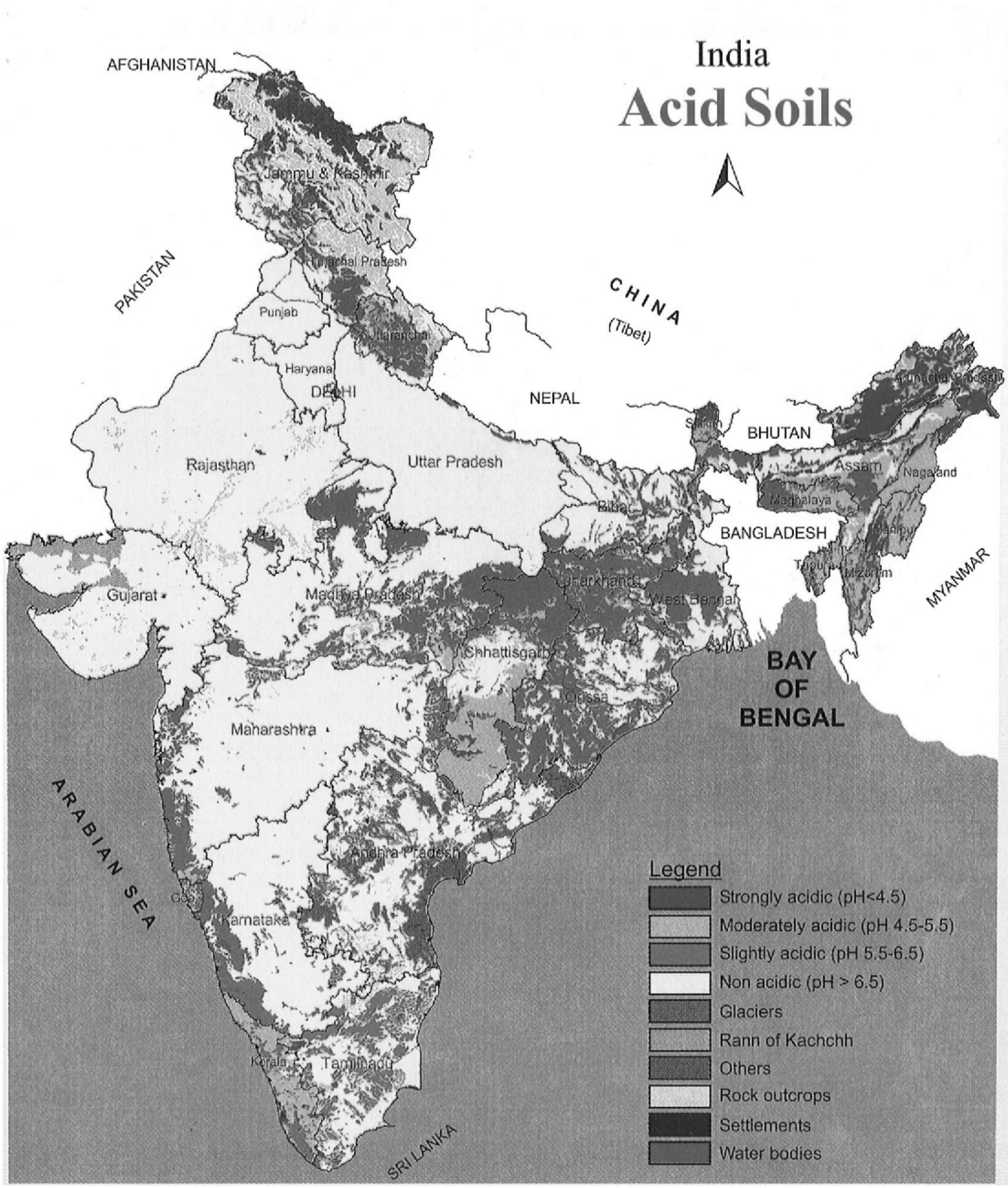

Fig. 1: Acid soils of India

(Source: Sharma, P.D. and Sarkar, A.K. 2005. Managing Acid Soils for Enhancing Productivity – Technical Bulletin, ICAR, New Delhi)

Table 1 Cultivated acid soil areas identified for amelioration in different states

State	Area (million ha)	Districts
Assam	1.5	Dibrugarh, Sibsagar, Lakhimpur, Bongaigaon, Nagaon, Kamrup, Darrang, Colpara, Cachar, Jorhat, Golaghat, Tinsukia, Soniput etc.
Himachal Pradesh	0.1	Kangra, Kullu, Mandi, Simla, Solan
Jharkhand	0.4	Dumka, Jamtara, East Singhbhum, Ranchi, Gumla, Garhwa
Kerala	2.1	Trivandram, Alleppey, Ernakulam, Trichur, Palghar, Connanory
Maharashtra	0.3	Ratnagiri, Thane
North-Eastern Hill Region	2.0	Lower Subansiri, West Siang (Arunachalam Pradesh); East Khasi Hills, West Khasi Hills (Meghalaya); Churachandpur, Tamenlong (Manipur); Aizwal (Mizoram); Mokokchung, Mon (Nagaland); West District, South Districts (Tripura); North Sikkim, West Sikkim (Sikkim)
Orissa	1.8	Cuttack, Kendrapara, Jagarsinghpur, Jaipur, Dhenkanal, Anugul, Koraput, Nawarangpur, Khurda, Nayagarh, Puri, Mayurbhanj
West Bengal	2.0	Bankura, Medinapur, Purulia, Birbhum, West Dinajpur, Jalpaiguri, Murshidabad, Burdwan, Cooch behar, Malda
All regions	10.2	

(Source: Sharma, P.D. and Sarkar, A.K. 2005. Managing Acid Soils for Enhancing Productivity – Technical Bulletin, ICAR, New Delhi)

2. MAJOR ISSUES AND CHALLENGES

2.1 Soil acidity

Soil acidity is a problem for sustainable crop production. Oxisols, Ultisols and many Alfisols in their natural state are acidic and have a large proportion of their active cation exchange sites occupied by Al^{3+}. Without liming to neutralize Al and adequate supply of Ca and Mg, efficient and economic crop production is not possible. The yield increase with lime application in furrows at the time of sowing has been shown to the extent of 19 to 32 per cent in soybean and from 21 to 48 per cent in groundnut in acid sandy loam soil (pH 5.6) of Ranchi. In Kangra district of H. P. (pH around 5.5) the B:C ratio worked out to be 1.76 in maize-wheat system with the use of recommended doses of mineral fertilizers and lime underlining the economic advantage of ameliorating acid soils.

The crops require lime at different levels depending on soil texture, clay mineral composition, environment and overall level of soil fertility. Part of this problem may be the way in which the pH is measured. Traditional methods of determining lime requirement of acid soils are based on the relationship between soil pH and per cent base saturation and knowledge of CEC of the soil and use of buffers such as Woodruff's or Shoemaker, Mclean and Pratt (SMP) etc. These methods target liming soils to pH 7 or above. Since acid soils with pH values less than 5.5 generally contain exchangeable Al, a number of researchers have suggested that the lime requirement be based on exchangeable Al. Lime requirement determined on the basis of exchangeable Al results in much lower lime rates and is generally targeted to pH 6.5. Experiments at Ranchi have shown that best response to liming is obtained with one-tenth of the lime requirement determined by using buffer methods.

In some soils, there is a problem of **sub-soil acidity**, which affects the plant root growth, and nutrient and water availability. In such soils the application of lime rate may be higher than that determined for surface soils. This will also require suitable equipment to place lime in sub-soil. In soils having calcareous layer at depth the effects of liming can be achieved by deep ploughing.

2.2 Specific ion toxicity and phosphate deficiency

Aluminium toxicity is an important growth limiting factor in acid soils. It limits both rooting depth and degree of root branching and thus increases susceptibility to drought. Water potential of plants increases when root growth is reduced by Al toxicity. Al precipitates native soil and applied P and interferes with the uptake and translocation of phosphate. Excess Mn inhibits Ca transport into the leaves of plants and induces typical Ca deficiency symptoms. Manganese toxicity generally occurs in soils containing sufficient total Mn. Unlike Al, excess Mn affects plant tops more directly than roots. Hydrogen ions penetrate plant tissues in large quantities and acidulate the cell sap because of highly acidic soil solution. The solubility of ferrous iron, may increase considerably to cause toxicity under reduced (sub-merged) conditions. Young plants are more susceptible to iron toxicity. One major problem with increase in iron concentration is the fixation of native soil and applied P, which creates phosphate deficiency. Phosphate fertilizers containing less water soluble P or ground rock phosphate would do better on acid soils.

2.3 Reduced biological activity

Generally, soil fauna can tolerate the soil acidity to cope with large changes in soil pH. However, most macro-fauna including deep burrowing species such as earthworms and termites tend to decrease in abundance in acidic soil conditions. The populations of bacteria and actinomycetes in acid soils have been reported to be lower than those in neutral soils in the red soil region of Ranchi. *Azotobacter* is almost absent in these soils, whereas the fungal population has been reported to be fairly high.

2.4 Liming materials

The use and popularity of liming material will depend on its availability at a reasonable price and profitability. Market lime (burnt lime-stone) containing both Ca and Mg, is efficient in enhancing the yield of crops. Other sources such as industrial wastes like basic slag, blast furnace slag, lime sludge from paper mills, pressmud from sugar factories and powdered stromatolitic limestone have been found beneficial. Pressmud, a waste product of sugarcane mill possessing 13.1% organic matter, 41.7% Ca, 0.66% N, 0.37% P_2O_5, 0.36% K_2O, 228 ppm Zn, 3640 ppm Fe, 344 ppm Mn and 69 ppm Cu was found to be an effective source for ameliorating soils acidity. Information on the availability of liming materials in different states and their tentative cost is given in Table 2.

Table 2 Availability of liming materials in different regions/states

Region/State	Liming Material	Quantity available (million tonnes)	Cost/tonnes (Rs.)
Assam	Limestone	15.0	4,000
Himachal Pradesh	Marketable lime	-	4,000
Jharkhand	Limestone / Basic slag	1.0	1,000
Kerala	Lime shells	4.0	6,000
Maharashtra	Marketable lime	0.2	2,000
North-Eastern Hill Region	Limestone	14.0	1,000
Orissa	Paper mill sludge	0.2	500
West Bengal	Basic slag	0.3	1,000
Others	Basic slag	3.0	1,000

(Source: Sharma, P.D. and Sarkar, A.K. 2005. Managing Acid Soils for Enhancing Productivity – Technical Bulletin, ICAR, New Delhi)

2.5 Water management

Acid soils of Eastern region pose typical water management problems, which are mostly associated with physical and chemical properties of soils. Kaolinite dominated light textured acid soils have very high saturated hydraulic conductivity leading to heavy percolation losses. This can be controlled by compaction. Light and frequent irrigations help in enhancing water and nutrient-use efficiency on these soils. Problems of high evaporative demands on crusting soils can be managed by mulching the crop lands with available paddy straw. Mulching not only lowers evapotranspiration of the crops but also saves irrigation water to the tune of 15-20 % in different crops. Hardening of red loamy soils can be avoided by incorporating paddy husk and powdered groundnut shells into soils followed by light irrigation. This technique helps in enhancing moisture recharging in the profile and carry-over enough moisture for subsequent rabi crops. Poor aggregate stability is also one of the major constraints responsible for poor water-use efficiency. Stability of aggregates can be achieved by application of compost, paddy straw, green manuring etc. Liming followed by light irrigation is the most effective technique, which helps improve the chemical and biological properties of acid soils and increase water-use efficiency.

The presentations by the lead speakers and deliberations by the eminent scientists representing different fields of specializations in the Brainstorming Session led to the following recommendations:

3. RECOMMENDATIONS

Research

- There is a need to revalidate methods for determination of lime requirement.
- There is a need to develop fertilizer recommendations for conservation tillage based crop production.
- Exploration and utilization of microbial diversity in acid soils.
- Increasing efficiency of lime and plant nutrient sources through nanotechnology.
- Delineation of extent and severity of subsoil acidity and development of suitable corrective measures.
- Constraint analysis in adoption of recommended technologies for acid soil amelioration by the farmers.
- Phosphate management on acid soils.
- Emphasis to be laid in the breeding programmes to modify root characteristics for mitigating the problem of Al-toxicity and nutrient deficiencies in acid soils.
- Physiological and molecular interventions to explore and develop plants high tolerance to Al-toxicity.
- Research on crop diversification and integrated farming systems for income enhancement and employment generation.

Development

- The harmonized district-wise database on type and degree of soil acidity and acreage available with National Agricultural Research System (NARS) should be used by State Governments for planning amelioration strategies.
- Publications in regional languages on Best Management Practices (BMP) for acid soils to be brought out and distributed among farmers.

- Development and promotion of use of organic manures enriched with bio-fertilizers/ fertilizers to improve soil health and crop productivity.

Policy

- A National Acid Soil Management Authority (NASMA) as a nodal agency to coordinate and to implement various acid soil management programs in the country needs to be established.

- A supply chain mechanism needs to be developed for use of phosphate rock in acid soil regions (ASR).

- Conservation irrigation systems need to be promoted for enhancing water and nutrient use efficiencies and crop productivity in ASR.

- There is a need for strict enforcement of quality control measures in value chain of low cost liming materials (dolomite, calcite, basic slag, paper mills sludge).

- The Govt. and the steel industry should develop an assured supply chain of basic slag, a low cost liming material for acid soils with the specifications such as minimum 30% CaO, less than 1% free iron and 80 mesh size of material.

- Policy needs to be framed for judicious utilization of large lime reserves available in NEH region for agricultural use.

NAAS Documents on Policy Issues*

1.	Agricultural Scientist's Perceptions on National Water Policy	- 1995
2.	Fertilizer Policy Issues (2000-2025)	- 1997
3.	Harnessing and Management of Water Resources for Enhancing Agricultural Production in the Eastern Region	- 1998
4.	Conservation, Management and use of Agro-biodiversity	- 1998
5.	Sustainable Agricultural Export	- 1999
6.	Reorienting Land Grant System of Agricultural Education in India	- 1999
7.	Diversification of Agriculture for Human Nutrition	- 2001
8.	Sustainable Fisheries and Aquaculture for Nutritional Security	- 2001
9.	Strategies for Agricultural Research in the North-East	- 2001
10.	Globalization of Agriculture: R & D in India	- 2001
11.	Empowerment of Women in Agriculture	- 2001
12.	Sanitary and Phytosanitary Agreement of the World Trade Organization – Advantage India	- 2001
13.	Hi-Tech Horticulture in India	- 2001
14.	Conservation and Management of Genetic Resources of Livestock	- 2001
15.	Prioritization of Agricultural Research	- 2001
16.	Agriculture-Industry Interface: Value Added Farm Products	- 2002
17.	Scientists' Views on Good Governance of An Agricultural Research Organization	- 2002
18.	Agricultural Policy: Redesigning R & D to Achieve It's Objectives	- 2002
19.	Intellectual Property Rights in Agriculture	- 2003
20.	Dichotomy Between Grain Surplus and Widespread Endemic Hunger	- 2003
21.	Priorities of Research and Human Resource Development in Fisheries Biotechnology	- 2003
22.	Seaweed Cultivation and Utilization	- 2003
23.	Export Potential of Dairy Products	- 2003
24.	Biosafety of Transgenic Rice	- 2003
25.	Stakeholders' Perceptions On Employment Oriented Agricultural Education	- 2004
26.	Peri-Urban Vegetable Cultivation in the NCR Delhi	- 2004
27.	Disaster Management in Agriculture	- 2004
28.	Impact of Inter River Basin Linkages on Fisheries	- 2004
29.	Transgenic Crops and Biosafety Issues Related to Their Commercialization In India	- 2004
30.	Organic Farming: Approaches and Possibilities in the Context of Indian Agriculture	- 2005
31.	Redefining Agricultural Education and Extension System in Changed Scenario	- 2005
32.	Emerging Issues in Water Management – The Question of Ownership	- 2005
33.	Policy Options for Efficient Nitrogen Use	- 2005
34.	Guidelines for Improving the Quality of Indian Journals & Professional Societies in Agriculture and Allied Sciences	- 2006
35.	Low and Declining Crop Response to Fertilizers	- 2006
36.	Belowground Biodiversity in Relation to Cropping Systems	- 2006
37.	Employment Opportunities in Farm and Non-Farm Sectors Through Technological Interventions with Emphasis on Primary Value Addition	- 2006
38.	WTO and Indian Agriculture: Implications for Policy and R&D	- 2006
39.	Innovations in Rural Institutions: Driver for Agricultural Prosperity	- 2007
40.	High Value Agriculture in India: Prospects and Policies	- 2008
41.	Sustainable Energy for Rural India	- 2008
42.	Crop Response and Nutrient Ratio	- 2009
43.	Antibiotics in Manure and Soil – A Grave Threat to Human and Animal Health	- 2010
44.	Plant Quarantine including Internal Quarantine Strategies in View of Onslaught of Diseases and Insect Pests	- 2010
45.	Agrochemicals Management: Issues and Strategies	- 2010
46.	Veterinary Vaccines and Diagnostics	- 2010
47.	Protected Agriculture in North-West Himalayas	- 2010

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