Organic manure as an amendment

Farmers in Sikkim commonly use cattle manure for maize production. Benefit of organic fertilizers could be increased by continuous application of FYM to each crop on aluminium toxic soil. However, higher yield can be achieved by the application of 1 t/ha limestone or dolomite with 10 t FYM/ha by increasing base status and surface charge of soil where it is possible.

Effects of lime on soil properties

Concentration of hydrogen and hydroxyl ion, solubility of iron, aluminium and manganese will decline. The availability of phosphates and molybdates will increase. Toxicity effect of aluminium can be reduced. Reduced uptake of calcium and magnesium in soil solution can be alleviated. Nitrification is enhanced by liming to a pH of 5.5-6.5. Nitrogen fixation both symbiotic and non-symbiotic is favoured by adequate liming. Club root disease of cole crops can be reduced with liming. Liming decreases bulk density of soils, increases infiltration and percolation rate of water.

Crop responses to lime application

Most of the agricultural crops grow well in between pH range 6.0-7.0. On the basis of experiments carried out in different parts of India and differential responses of crops to liming, upland crops are grouped as- i) high response groups- pigeon pea, soybean; ii) medium response groups- maize, gram, lentil, peas, groundnut; iii) low/no response groups-rice, millets, potato, buckwheat.

With Dolomite Application

Without Dolomite Application

Effect of overliming

Deficiency of iron, copper, boron and zinc will occur. P and K availability will be reduced. Incidence of scab in root crops will be increased. Root development will be inhibited in association with tip swelling brought about by hydration.

Published by:

Dr. R. K. Avasthe, Joint Director
ICAR Research Complex for NEH Region
Sikkim Centre, Tadong, Gangtok-737 102, Sikkim

For further details please contact to:

Dr. S. V. Ngachan, Director
ICAR Research Complex for NEH Region
Umiam - 793 103, Meghalaya

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SOIL ACIDITY MANAGEMENT IN SIKKIM

NICRA
National Initiative on Climate Resilient Agriculture

Authors

Shaon Kumar Das, R. K. Avasthe, R. Singh, S. Babu C. Kapoor, A. Yadag, R. Gopi and H. Kalita

ICAR Research Complex for NEH Region
Sikkim Centre, Tadong, Gangtok-737 102

E-mail:jdsikkim.icar@gmail.com

Soil acidity and sources

Soil acidity may be defined as soil system's proton donating capacity (H^+ ions) during its transition from a given state to a reference state. Acid soil is base unsaturated soil which has got enough of adsorbed exchangeable H^+ ions to give a pH lower than 7.0. There are five major reasons for soils to become acidic: leaching due to heavy rainfall, acidic parent material, organic matter decay and release of organic acids, harvest of high-yielding crops and presence of aluminosilicate minerals.

Nutrient imbalance in acid soil

Iron, aluminium and manganese are usually present in higher concentrations under moderate to strong acid soils. Phosphorus reacts with these ions and produces insoluble P-complex and hence, rendering availability to plants. Al, Fe, Mn and Cu are abundant, but N, P, S, Mo and B are very limited and become less available in an acid soil having pH less than 5.5.

Objectives of acid soil management

Maintain appropriate soil pH in order to assure multi condition favorable to plants. Increase availability of plant essential nutrients. Increase activity of favorable microorganisms in soils.

Management practices

There are two approaches: (1) plants can be selected that grow well at the existing soil pH, or (2) the pH of the soil can be altered to suit the needs of the plants. The former practice is rather risky than latter. As most soil pH changes are directed towards reduced soil acidity and increased pH by liming and intensive cropping system without liming in humid regions increase soil acidity, judicious use of organic fertilizers and liming in combination is the best practice. Application of liming materials cause reduced exchangeable aluminium in soil solution, increased soil pH. Application of organic matter improves buffer capacity of soil and reduces Al toxicity. Fresh mulches (weed biomass) reduce the adverse effect of soil acidity substantially. Location specific crop diversification with acid tolerant crops should be followed. Cultivation of highly sensitive (towards soil acidity) crops like soybean, French bean, pigeon pea etc. should be tuned accurately to liming. Wood ash can also be used to increase soil pH.

Lime requirement

Lime requirement of an acid soil may be defined as amount of liming material that must be added to raise pH to some prescribed value. Although harvested crops remove copious lime-like elements each year, the soil pH does not change much from year to year, meaning the soil is buffered, or resistant to change. The greater the amount of moisture are, more rapid is the rate of reaction. Lime and liming materials react more rapidly at high than that at low temperature. The correct pH depends on the crop being produced. Grasses tend to tolerate acidic soils better than legumes.

Field crops	Preferred pH range	Field crops	Preferred pH range
Maize	5.0-6.5	Pea	5.5-7.0
Rice	4.0-6.5	Lentil, gram	5.5-7.0
Soybean	5.5-7.0	French bean	5.5-7.0
Millets	4.0-6.0	Cowpea	5.0-6.5
Potato	5.0-5.5	Oats	5.0-7.5

Lime requirement of an acid soil

The desirable soil pH range for most of the field crop is 6.0-7.0. SMP buffer method is used for determination of lime requirement of an acid soil. Lime requirement in terms of pure calcium carbonate can be observed from the following table:

pH of soil buffer suspension (field soil sample)	Lime required to bring soil to indicated pH (tonnes of $CaCO_3$ per acre)		
	pH 6.0	pH 6.4	pH 6.8
6.7	1.0	1.2	1.4
6.6	1.4	1.7	1.9
6.5	1.8	2.2	2.5
6.4	2.3	2.7	3.1
6.3	2.7	3.2	3.7
6.2	3.1	3.7	4.2
6.1	3.5	4.2	4.8
6.0	3.9	4.7	5.4

Efficiency of liming materials

Efficiency of liming materials can be judged by calcium carbonate equivalent (CCE) or neutralizing value (NV), purity and degree of fineness of liming materials. The more pure the liming material, the higher will be its effectiveness for amelioration. If the liming materials are finer, the effectiveness will be higher (materials passing through 60 mesh sieve is called as 100 percent efficiency rating). Higher CCE/NV value indicates higher effectiveness of liming materials. CCE/NV values of some liming materials are:

Liming materials	CCE (%)
Calcium oxide/burned lime (CaO)	179
Calcium hydroxide/slaked lime [$Ca(OH)_2$]	136
Dolomite [$CaMg(CO_3)_2$]	109
Calcite/limestone ($CaCO_3$)	100
Basic slag ($CaSiO_3$)	86

Furrow application of limestone

The limestone rates based on exchangeable aluminium cannot become popular in the hilly terrain of the state, because here inputs are carried manually to the distant fields. This problem can be overcome by furrow application (require less amount and very effective) of small doses of limestone every year to achieve optimum productivity than a relatively higher dose once in three to four years. Furrow application of lime (80 mesh size) @ 250-400 kg/ha every year to maize and soybean is economical than a relatively higher dose based on exchangeable Al.

Response of maize to liming

Lime rates based on exchangeable aluminium have been found adequate for maize production and considerably less than those required to bring the soil pH to 6.5. Depending on soil characteristics maize responded well to dolomitic limestone, when lime doses were 1 to 2 equivalent of exchangeable aluminium (2 to 4 t limestone/ha) and pH raised to around 5.5. The application of limestone equivalent to 2 exchangeable aluminium (4 t limestone/ha) gave the optimum yield of wheat and maize in a sequence for two years and thereafter half the amount of limestone is needed for sustained crop production.