Eco. Env. & Cons. 29 (April Suppl. Issue) : 2023; pp. (S131-S136)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i02s.025

Dynamics of Acidity Component of the Soils as Influenced by Liming in Upper Brahmaputra Valley Zone of Assam, India

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(Received 14 September, 2022; Accepted 7 November, 2022)

ABSTRACT

An incubation study was conducted to investigate the effect of lime ($CaCO_3$)on the acidity components in Upper Brahmaputra Valley Zone (UBVZ) of Assam. Fourteen(14) geo-referenced soil samples were collected from Sibsagar and Jorhat districts of Assam. Soils were treated with 3 different doses of lime viz. 10 per cent Lime Requirement (LR10), 25 per cent Lime Requirement (LR25) and 50 per cent of Lime Requirement (LR50) and initial properties were recorded before liming. Samples were incubated in laboratory at different period of time viz. 15, 30, 60 and 90 days after liming (DAL) with moisture content at Field Capacity (0.33 bar). At four different intervals, soils were analysed for soil acidity components viz. total acidity, exchange acidity, exchangeable Al^{3+} and exchangeable H^+. The soil of Upper Brahmaputra Valley Zone (UBVZ) of Assam were highly acidic to moderately acidic, sandy loam to silt loam in texture with high OC content ranged from 0.72 to 2.59%. The Cation Exchange Capacity (CEC) value ranged from 7.8 to 14.2 cmol (p^+)/kg. Application of lime brought about mark decreased in acidity components viz. total acidity, exchange acidity, exchangeable aluminium and exchangeable hydrogen. Soil acidity components recorded highest decreased at 90 DAL @ LR50 and decreased started from 15 days onwards. The findings of the investigation showed that liming @ LR10 was found effective in reducing soil acidity. The residual effect of lime was found persisting till 90 days. However, the magnitude of lime was increasing with increase in application of lime@ from LR10 to LR25 and to LR50.

Key words : *Incubation, Liming, Dose, Acidity and nutrient*

Introduction

Soil acidity is a major constraint for crop production in temperate and tropical region of the world. It has been identified as an important agricultural problem for enhancing production potential of crops (Mansingh *et al*., 2018). Considering the different factors causing acidities, Al toxicity is the major constraint for crop production on 67 per cent of the total acid area (Eswaran *et al*., 1997). Soil acidity is partitioned into exchangeable (chiefly monomeric Al^{3+}) and non-exchangeable (pH-dependent) acidity. The lime requirements and production potential of soil is determined by the production of exchangeable and pH dependent acidity (Kumar *et al*., 1995). Management of such type of soils for agriculture is the national priority (Bhattacharyya *et al*., 2015).

In India, approximately $1/3^{rd}$ of the arable land is affected by soil acidity (Mandal, 1997). North-eastern regions of India occupies the majority of the area under acid soils with nearly 65 per cent of the lands are in extreme forms of soil acidity with pH of <5.5

(Sharma and Singh, 2002). Around 15 mha of NE region is acidic (pH 4.0-6.3) and acid soil with pH below 5.5 occupy 54 per cent of the total area of country (Bhatt *et al*., 2014). Assam is an agriculturally important state where 90 per cent of the production depends on agriculture for their socio-economic development and livelihood (Upadhai and Nayak, 2017). Assam occupies a landmass of 78,523 sq. km of which 19 per cent area is hilly. The Brahmaputra valley of Assam constitutes more than 50 per cent of the geographical area of Assam and covers an area of 56,000sq.km. The pH status of the soils of Assam ranged from extremely acidic to strongly acidic.

Soil acidity plays a major role in determining the plant nutrient availability. Liming is the most common ameliorative measures used for neutralizing soil acidity and overcoming soil acidity constraints. Liming acid soils increases use efficiency of phosphorus and other micronutrients by upland plants (Fageria and Baligar, 2008). Liming improves the chemical, physical and biological properties of soils through its direct and indirect effects on biological N-fixation and mineralization of N, P and S in soil (Haynes and Naidu, 1998; Bolan *et al*., 1999a) plant nutrient mobilization and thereby improvement in soil structure and its hydraulic conductivity.

The present research is aimed at reducing the quantity of lime application in soils where the quantity of lime required to increase the pH of the soil to 6.5 is considered as 100 per cent of Lime Requirement (LR). The present laboratory incubation study was undertaken for evaluating the changes in forms of acidity in acid soils of Upper Brahmaputra Valley Zone (UBVZ) of Assam with lime after treating the soils with different doses of lime viz. 10, 25 and 50 per cent of LR of the respective soils.

Materials and Methods

Study Area: The present study was carried out in Upper Brahmaputra Valley Zone of Assam. It has geographical area of 22,400 sq. km which is 20.40 per cent of the total area of Assam. It is located between latitude of 25°13'24"N and longitude of 89°41'41"E.

Soil Sampling: The experiment was carried out in UBVZ of Assam using samples collected from the surface soils (0-15 cm) depth. 14 geo-referenced soil samples from Sibsagar and Jorhat districts of Assam were collected and air dried, crushed, homogenized and passed through 2 mm sieve and stored in polythene bags for physical and chemical analysis.

Soil Analysis: The initial soil samples were analysed as per the standard methods for soil texture, pH, EC, OC, CEC, moisture content, and Lime Requirement. Available N, P and K were determined by alkaline $KMnO_4$ (Subhiha and Asija, 1956), Bray's I method (Brays and Kurtz, 1945) and Neutral normal NH_4OAc (Jackson, 1973) respectively.

Soil acidity components were characterized as follows: total acidity was determined by 1N NaOAc solution. The exchange acidity and exchangeable Al were extracted by 1N KCl solution and determined by titration of 0.1N NaOH using phenolphthalein as indictor and by back titration after acidification with 40g/l NaF with 0.1N HCl solution respectively. Exchangeable H^+ was determined by substracting exchangeable Al from exchangeable acidity i.e., Exchangeable H^+ = Exchangeable acidity - Exchangeable Al

Incubation Study: An incubation study was conducted with 14 surface soil (0-15cm) samples with three different doses of lime @10 per cent LR(LR10), 25 per cent of LR(LR25) and 50 per cent of LR(LR50) applied as pure $CaCO_3$ on 70g of air dried soil taking duplicates samples and maintaining moisture content at F.C (0.3 bar) throughout the process in polythene bag to monitor the dynamics of the soils after 15, 30, 60 and 90 days after application of lime (DAL). After the completion of each incubation period the different forms of acidity of the soils were determined following the procedures mentioned above. Factorial CRD was undertaken to evaluate the significance effects.

Statistical Analysis: Factorial CRD was undertaken to evaluate the effect of days after liming (DAL) and different doses of lime requirement (LR). Statistical analysis of the experimental data was done in CoStat Professional, Version 6.311.

Results

Initial soil physico-chemical properties

In the present findings, the texture of the soils of UVBZ of Assam was found to vary from loamy sand (LS) to silty clay loam (SCL). The pH status of the soils was extremely acidic to moderately acidic (4.27 to 5.34 pH) as shown in Table 1. The electrical conductivity (EC) of the soils varied from 0.49 to 2.01 dSm^{-1}. The organic carbon content of the soil ranged from 0.72 to 2.59 per cent.

The CEC of the soil ranged from 7.80 to 14.20 cmol(p+)kg^{-1}. Soil moisture at field capacity (0.3 bar) of the soil varied from 16.08 to 32.79 per cent (Table 1). Magnitude of Lime Requirement of the soil of UVBZ of Assam ranged between 0.56 to 11.42 tha^{-1}. Available nitrogen content of the soil ranged from low (100.80 kgha^{-1}) to medium (260.22 kgha^{-1}). Available phosphorus (P_2O_5) content of the soils was low (20.91 kgha^{-1}). Exchangeable potassium (K_2O) content of the soils varied from 40.86 kgha^{-1} to 90.01 kgha^{-1} as showed in Table 1. The results on forms of total acidity, exchange acidity, exchangeable Al and exchangeable hydrogen content were 2.41 cmol(p+)kg^{-1}, 1.86 cmol(p+) kg^{-1}, 1.05 cmol(p+)kg^{-1}and 0.82 cmol (p+)kg^{-1}, respectively (Table 1).

The findings of laboratory Incubation study to determine the effect of different doses of LR and the days after liming (DAL) on acidity components

The results of the laboratory experiment conducted to determine effect of three different doses of lime *viz*., 10(LR10), 25 (LR25) and 50 (LR50) percent of LR applied as pure $CaCO_3$ on dynamics of components of soil acidity at 15, 30, 60 and 90 days after liming (DAL) in acid soils of UBVZ of Assam are presented in Table 2 and Fig. 1 to 4.

Total Acidity

The initial mean total acidity 2.41 cmol(p$^+$)kg^{-1} of the soils of UBVZ of Assam was reduced by about 40 per cent at 15 DAL. The results also indicated that total acidity of the soils remain more or less constant with increase in DAL *viz*., at 15, 30, 60 and 90 DAL in respect of the soils where lime was applied @ LR10, LR25 and LR50, respectively (Table 2 and Fig. 1). When soils are treated with LR10 the total acidity varied from 1.41 cmol(p$^+$)kg^{-1}at 15 DAL to 1.02 cmol(p$^+$)kg^{-1}at 90 DAL, respectively. With application of lime @ LR25 it varied from 0.72 cmol(p$^+$)kg^{-1}at 15 DAL to 0.75 cmol(p$^+$)kg^{-1}at 90 DAL. At with the highest quantity of application of lime i.e. liming @ LR50 the total acidity of the soils were found to be 0.77 cmol(p$^+$) kg^{-1}at 15 DAL and 0.63 cmol(p$^+$)kg^{-1}at 90 DAL.

Exchange Acidity

It is evident from Fig. 2 that there was a progressive decrease of the initial exchange acidity (1.87 cmol(p$^+$)kg^{-1}) from 0 to 30 DAL in all doses of application of lime. Then, from 60 to 90 DAL the magnitudes of exchange acidity of the soils became more or less flattened in respective doses of application of lime, i.e. LR10, LR25 and LR50 (Fig. 2). Within the whole incubation period i.e. 15, 30, 60 and 90 DAL

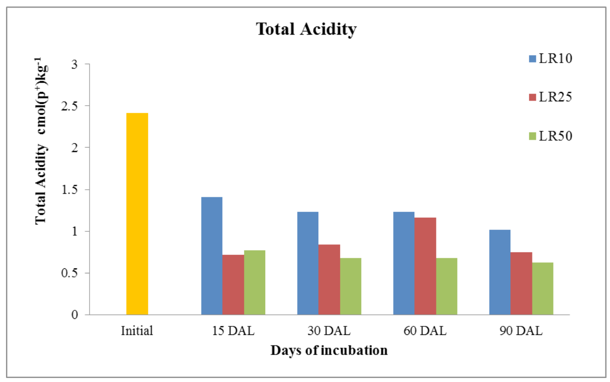

Fig. 1. Mean total acidity of the soils at different doses of LR and at different days after liming (DAL)

Table 1. Physico-chemical characteristics of the soils of UBVZ of Assam

Soil characteristics	Mean	Range
Soil texture	-	Loamy sand to silty clay loam
pH	4.96	4.27 - 5.34
EC (dSm^{-1})	0.97	0.49 - 2.01
Organic carbon (%)	1.61	0.72 - 2.59
CEC (cmol (p+) kg^{-1})	10.99	7.80 - 14.20
Moisture Content (%)	21.79	16.08 - 32.79
Lime requirement (tha^{-1})	7.52	0.56 - 11.52
Available N (kgha^{-1})	189.22	100.80-260.22
Available P_2O_5(kgha^{-1})	20.91	12.73-29.80
Available K_2O (kgha^{-1})	76.50	40.86-90.01
Total Acidity (cmol (p+) kg^{-1})	2.41	1.38 – 3.75
Exchange Acidity (cmol (p+) kg^{-1})	1.86	0.88-2.63
Exchangeable Al^{3+}(cmo l(p+) kg^{-1})	1.05	0.63-1.50
Exchangeable H^+ (cmol (p+) kg^{-1})	0.82	0.10-1.50

Table 2. Effect of DAL on the availability of acidity components at 10(LR10), 25(LR25) and 50(LR50) percent of LR in soils of UBVZ of Assam

	15 DAYS			30 DAYS			60 DAYS			90 DAYS		
	LR10	LR25	LR50	LR10	LR25	LR50	LR10	LR25	LR50	LR10	LR25	LR50
Total acidity (cmol(p$^+$)kg^{-1})												
Mean	1.41	0.72	0.77	1.23	0.84	0.68	1.23	1.16	0.68	1.02	0.75	0.63
Range	0.75-2.00	0.25-1.50	0.50-1.25	0.75-1.75	0.50-1.25	0.50-1.00	1.00-1.50	0.50-1.25	0.50-1.25	0.75-1.50	0.50-1.25	0.50-0.75
SD	0.41	0.37	0.21	0.30	0.23	0.21	0.18	0.32	0.21	0.21	0.22	0.13
Exchange acidity (cmol(p$^+$)kg^{-1})												
Mean	1.18	0.97	0.58	0.72	0.56	0.49	0.60	0.55	0.48	0.52	0.44	0.40
Range	0.50-2.50	0.63-1.63	0.38-0.75	0.50-1.00	0.50-0.75	0.38-0.63	0.38-1.00	0.25-1.25	0.25-1.00	0.38-0.75	0.25-0.63	0.25-0.75
SD	0.52	0.26	0.14	0.16	0.08	0.09	0.20	0.25	0.20	0.13	0.16	0.16
Exchangeable aluminium (cmol (p$^+$)kg^{-1})												
Mean	0.55	0.45	0.25	0.53	0.46	0.32	0.51	0.45	0.38	0.43	0.32	0.30
Range	0.25-1.13	0.25-0.88	0.13-0.38	0.38-0.63	0.38-0.50	0.25-0.38	0.38-0.63	0.25-0.63	0.25-0.50	0.25-0.63	0.13-0.38	0.25-0.50
SD	0.31	0.18	0.13	0.08	0.06	0.06	0.10	0.11	0.09	0.10	0.08	0.08
Exchangeable hydrogen (cmol (p$^+$)kg^{-1})												
Mean	0.63	0.53	0.32	0.18	0.09	0.18	0.09	0.13	0.11	0.09	0.11	0.10
Range	0.25-1.50	0.13-1.13	0.13-0.50	0-0.50	0-0.25	0-0.38	0-0.38	0-0.63	0-0.50	0-0.25	0-0.50	0-0.38
SD	0.35	0.18	0.13	0.19	0.10	0.12	0.14	0.19	0.16	0.10	0.16	0.12

reduction of initial exchange acidity was the highest with liming @ LR50, intermediate with LR25 and lowest with liming @ LR10 (Fig. 2). The magnitude of exchange acidity of the soils treated with lime @ 10, 25 and 50 percent of LR was 1.18, 0.97 and 0.58 cmol(p$^+$)kg^{-1}, respectively at 15 DAL and 0.52, 0.44 and 0.40 cmol(p$^+$)kg^{-1}, respectively at 90 DAL (Table 2).

Exchangeable Aluminium (Ex. Al^{3+})

The exchangeable aluminium (Al^{3+}) content of soils (1.05 cmol(p$^+$)kg^{-1}) of the Upper Brahmaputra Valley Zone of Assam before liming was found to be reduced sharply to lower than half (0.55 to 0.25 cmol(p$^+$)kg^{-1}) with liming @ LR10 to LR50 at 15 DAL (Table 2 and Fig. 3). After that exchangeable Al^{3+} content of the soils were found to be reduced with very small magnitudes from 30 DAL and reached its lowest value at 90 DAL (Fig. 3). The decrease in exchangeable Al^{3+}content of the soils with increase in quantity of liming @ LR 10, LR25 and LR50 was very prominent at 15, 30, 60 and 90 DAL. The exchangeable Al^{3+} content of the soils were 0.55, 0.45 and 0.25 cmol(p$^+$)kg^{-1}at 15 DAL, 0.53, 0.46 and 0.32 at 30 DAL, 0.51, 0.45 and 0.38 at 60 DAL and 0.43, 0.32 and 0.30 cmol(p$^+$)kg^{-1}at 90 DAL with application of lime @ LR10, LR25 and LR50, respectively (Table 2).

Exchangeable Hydrogen (Ex. H^+)

The effect of different doses of lime on exchangeable hydrogen (H^+) content of the soils of UBVZ of Assam was most prominent at 15 DAL (Fig. 4). At 15 DAL, the exchangeable H^+ content of the soils with lime treatment @ LR10, LR25 and LR50 were 0.63, 0.53 and 0.32 cmol(p$^+$)kg^{-1}, respectively. Hence, the exchangeable H+ content of the soils reduce to half with LR50 than the soils with LR10. It was also prominent from the data that the initial exchangeable H+ content of the soils decreased almost linearly and steeply till 30 DAL. Then the magnitude of decreased almost become same irrespective of quantity of application of lime @ 10, 25 and 50 per cent of LR at 60 and 90 DAL (Fig. 4). The exchangeable H+ content of the soils at 60 and 90 DAL became about 0.10 cmol(p$^+$)kg^{-1} irrespective of dose of LR. The magnitude of exchangeable H^+ at 60 to 90 DAL becomes about eight time lower than its content before application of lime (0.82 cmol(p^+)kg^{-1}).

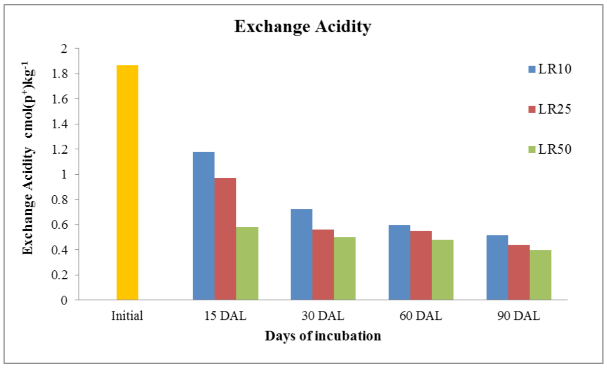

Fig. 2. Mean exchange acidity of the soils at different doses of LR and at different days after liming (DAL)

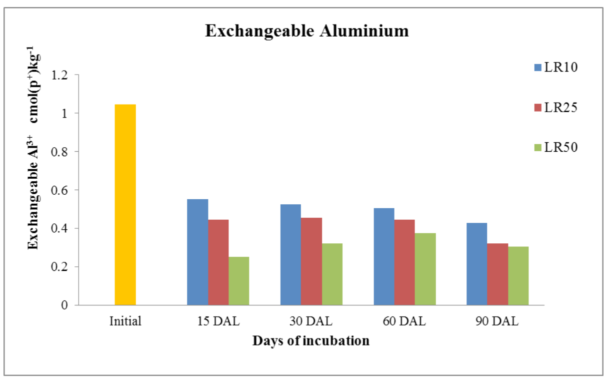

Fig. 3. Mean exchangeable aluminium of the soils at different doses of LR and at different days after liming (DAL)

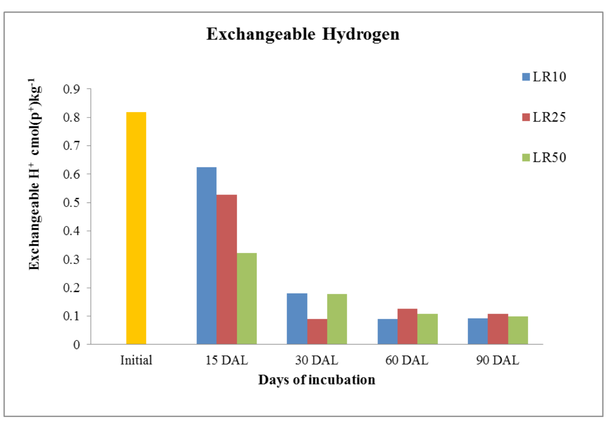

Fig. 4. Mean exchangeable hydrogen of the soils at different doses of LR and at different days after liming (DAL)

Discussion

Incubation study to determine the dynamics of different doses of LR and the days after liming (DAL) on Total acidity

The initial mean total acidity of the soil was 2.41 cmol(p^+)kg^{-1}which was reduced by about 40 per cent at 15 DAL (Fig. 1). When soils were treated with LR10, the total acidity varied from 1.41 cmol(p^+)kg^{-1}at 15 DAL to 1.02 cmol(p^+)kg^{-1}at 90 DAL, respectively. With the highest quantity of application of lime @ LR50, the total acidity of the soil were found to be 0.77 cmol(p^+)kg^{-1}at 15 DAL and 0.63 cmol(p^+)kg^{-1}at 90 DAL (Table 2). The decrease of initial total acidity with liming might be resulted due to neutralization of hydroxyl Fe and Al polymers in the soils (Mclean*et al.*, 1964). Thakuria*et al.* (2001) also observed that initial total acidity of soils decreased 39.17 to 49.55 per cent 90 days after liming.

Incubation study to determine the dynamics of different doses of LR and the days after liming (DAL) on exchange acidity

Initial exchange acidity 1.87 cmol(p^+)kg^{-1}decreased progressively from 0 to 30 DAL in all doses of application of lime. Then, from 60 to 90 DAL, the magnitude of exchange acidity become more or less flattered in respect of doses of lime @ LR10 , LR 25 and LR50 (Fig. 2). Within the whole incubation period, reduction in initial exchange acidity was highest with LR50, intermediate LR25 and lowest LR10. This might be attributed to suppression in the activity of Al^{3+} and H^+ by calcium (Dixit and Sharma, 1993).

Incubation study to determine the dynamics of different doses of LR and the days after liming (DAL) on exchangeable aluminium (Exch. Al^{3+})

The exchangeable aluminium content of the soils (1.05 cmol(p^+)kg^{-1}) before liming was reduce sharply to lower than half (0.55 to 0.25 cmol(p^+)kg^{-1}) with liming @ LR10 to LR50 at 15 DAL (Fig. 3). After that exchangeable aluminium content of the soils were found to be reduced with very small magnitude from 30 DAL and reached its lowest value at 90 DAL. The decreased in exchangeable Al^{3+} content of the soils with liming @ LR10, LR25 and LR50 was very prominent at 15, 30, 60 and 90 DAL. The reduction of exch. Al^{3+} on application of lime might be attributed to precipitation of trivalent Al^{3+} on $Al(OH)_3$ in the presence of high concentration of OH^- ion (Makaya and Bishnoi, 1990).

Incubation study to determine the dynamics of different doses of LR and the days after liming (DAL) on exchangeable hydrogen (Exch. H^+)

The effect of different doses of lime on exchangeable H^+ content of the soil of UBVZ of Assam was most prominent at 15 DAL (Fig. 4). It showed declining trend from its initial value of 0.82 cmol(p^+)kg^{-1} to 0.63 (LR10), 0.53 (LR25) and 0.32 (LR50) cmol(p^+) kg^{-1} after 15 DAL. The declining pattern in exchangeable H^+ was continued till 90 DAL. The highest decline was recorded with application of lime@ LR50. Badole *et al.* (2015) also reported reduction of electro statistically bound hydrogen on application of lime.

Conclusion

The findings of the present laboratory incubation study leads to the conclusion that in soils of UBVZ of Assam having wide range of soil physical and chemical characteristics and values of soil acidity components, the application of lime as low as 10 percent of LR (LR10) was found effective in reducing the soil acidity viz., total acidity, exchange acidity, exchangeable aluminium and exchangeable hydrogen. The residual effect of lime was found to persist till 90 days after the liming. However, magnitude of this effect was increasing with increase in application of lime@ from LR10 to LR25 and to LR50.

Acknowledgement

The authors thank faculties of Department of Soil Science, College of Agriculture, Assam Agricultural University, Jorhat, Assam for their assistance and guidance. The work was made possible through the technical support of National Bureau of Soil Survey and Land Use Planning, Jorhat, Assam and financial support of AAU, Jorhat, Assam.

References

Badole, S., Datta, A., Basak, N., Seth, A., Padhan, D. and Mandal, B. 2015. Liming influences forms of acidity in soils belonging to different orders under subtropical India. *Commun. Soil Sci. Plant Anal.* 46(16) : 2079-2094.

Bhatt, C.M., Rao, G.S., Begum, A. and Sree, M. 2014. Satellite images for extraction of flood disaster footprints and assessing the disaster impact: Brahmaputra floods of June-July 2012, Assam, India. *Current Sci.* 104: 1692-1700.

Bhattacharyya, R., Gosh, B. N., Mishra, P. K., Mandal, B., Rao, C. S., Sarkar, D., Das, K., Anil, K. S., Lalitha, M., Hati, K. M. and Franzluebbers, A.J. 2015. Soil degradation in India: Challenges and Potential Solutions. *Sustainability.* 7 : 3528-3570.

Bolan, N.S., Naidu, R., Syers, J.K. and Tillman, R.W. 1999a. Surface charge and solute interactions in soils. *Adv. Agron.* 67: 88-141.

Bray, R.H. and Kurtz, L.T. 1945. Determination of total, organic and available forms of phosphorus in soils. *Soil Sci.* 59(1) : 39-46.

Dixit, S.P. and Sharma, P.K. 1993. Effect of lime and potassium on soil acidity, form of Aluminium and Iron and yield of crops in sequence. *J. Indian Soc. Soil Sci.* 41 : 522-526.

Eswaran, H., Almaraz, R., Berg, E.V.D. and Reich, P. 1997. An assessment of the soil resources of Africa in relation to productivity. *Geoderma.* 77: 1-18.

Fageria, N.K. and Baligar, V.C. 2008. Ameliorating soil acidity of tropical Oxisols by liming for sustainable crop production. *Adv. Agron.* 99 : 345-431.

Jackson, M.L. 1973. *Soil Chemical Analysis.* Prentice Hall of India, New Delhi.

Haynes, R.J. and Naidu, R. 1998. Influence of lime, fertilizer and manure applications on soil organic matter content and soil physical conditions: A review. *Nutr. Cycl. Agroecosyst.* 51: 123-137.

Kumar, K., Rao, K.V.P. and Singh, L.J. 1995. Forms of acidity in some acid Inceptisols under different land uses in Manipur. *J. Indian Soc. Soil Sci.* 43 : 338-342.

Makaya, A.S. and Bishnoi, S.K. 1990. Effect of lime and phosphorus application on some chemical properties of an Alfisol. *J. Indian Soc. Soil Sci.* 38: 154-157.

Mandal, S.C. 1997. Introduction and historical overview. In: Acidic Soils of India. ICAR, New Delhi 1, 3-24.

Mansingh, M.D.I., Suresh, S., Arunkumar, V. and Velayutham, A. 2018. Influence of liming on Yield of Rice and Soil Properties in Acidic Soils of High Rainfall Zone. *Intern. J. Adv. Agril. Sci. Technology* 5: 84-94.

McLean, E.D., Hourigan, W.R., Shoemaker, H.E. and Bhumbia, D.R. 1964. Aluminium in soils: V. Form of aluminium as a cause of soil acidity and a complication in its measurement. *Soil Sci.* 97: 119-127.

Sharma, U.C. and Singh, R.P. 2002. Acid soils of India: their distribution, management and future strategies for higher productivity. *Fert. News.* 47: 45-52.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for the determination of available nitrogen in soils. *Curr. Sci.* 25: 259-260.

Thakuria, P., Bordoloi, P.K. and Borah, D.K.2001.Effect of different sources and levels of lime on acidity components in Haplaquept of Assam. *Indian J. Hill Frm.* 14: 48-55.

Upadhai, K.V. and Nayak, B.D. 2017. Problems and prospects of agriculture development in upper Assam: a case study of Sadiya Block of Tinsukia District. *Intern. J. Scientific Res. Mngmt.* 5 : 6248-6256.