Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

June 2017, Volume 30, Issue 1, Page 144-148

Monitoring Soil pH and Exchangeable Ca Status in Groundnut–Rapeseed Cropping System as Influenced by Direct and Residual Effect of Micronutrients and Liming

S. Das[1] • A. Das[2*] • G.I. Ramkrushna[2] • J. Layek[2] • S. Chowdhury[3]

[1]College of Post Graduate Studies, Central Agricultural University, Umiam

[2]ICAR Research Complex for NEH Region, Umiam, Meghalaya

[3]ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram

ARTICLE INFO

Article history:
Received 16 July 2016
Revision Received 26 September 2016
Accepted 8 November 2016

Key words:
Soil acidity, Exchangeable Ca, nutrient status, liming, micronutrient, oilseed crops

ABSTRACT

Soil acidity associated problems are the major bottleneck in realizing yield potential of most of the crops in north eastern hill region. The field experiment was conducted in ICAR Research complex for North Eastern Hill (NEH) Region, Umiam, Meghalaya (980 m above mean sea level) in groundnut with six micronutrient treatments *viz.* control (no micronutrient), Zn @ 5 kg/ha, B @ 1 kg/ha, Mo @ 0.5 kg/ha, Zn + Mo, Zn + B + Mo (all the micronutrients were applied through soil application) and two acid soil amendment practices *viz.* lime @ 500 kg/ha (furrow application) and no lime application. The residual effect of treatments applied to groundnut were assessed on soils under succeeding rapeseed. The objectives were to monitor the soil pH and exchangeable Ca during the crop growth period at 15 days interval as influenced by direct and residual effect of micronutrient application and liming. At 0-15 and 15-30 cm soil depth, soil pH remained non-significant due to either sole or combined application of micronutrients, whereas, application of lime significantly influenced soil pH at both the soil depth than no lime application in different growing stages of groundnut. Soil pH status at different growing stages of rapeseed did not vary significantly due to residual effect of micronutrients, whereas, residual effect of liming increased soil pH of rapeseed crop significantly at all the growing stages of succeeding rapeseed in 0-15 cm and 15-30 cm of soil layers. At different growing stages of groundnut, soil exchangeable Ca did not vary significantly due to sole or combined application of micronutrients at 0-15 and 15-30 cm soil depth, whereas, application of lime significantly improved exchangeable Ca at both soil depth over no lime application. Residual effect of lime increased soil exchangeable Ca significantly in both the soil depth at different growing stages of rapeseed crop. Thus, liming increased soil pH and exchangeable Ca with direct effect in groundnut and residual effect in succeeding rapeseed crop in acid soils of NEH Region.

1. Introduction

Acid soil is a base unsaturated soil which has got enough of adsorbed exchangeable H^+ ions so as to give soil a pH lower than 7.0 (Das 1996). In India, approximately one-third of the cultivated land is affected by soil acidity (Mandal 1997). Majority of these soils are concentrated in north-eastern region of India (NER), where about 65% of soils are highly acidic in nature (pH below 5.5) (Sharma and Singh 2002). Soil acidity occurs due to the accompanying effects of Al and Mn toxicity and nutrient deficiencies and their consequential detrimental effects on crop growth and yield. Acid soils are not suitable for the cultivation of agricultural crops due to the absence or low level of availability of the macronutrients.

*Corresponding author:anup_icar@yahoo.com

Phosphorus (P), Calcium (Ca) and Magnesium (Mg) and some micronutrients most notably molybdenum (Mo), zinc (Zn) and boron (B) as induced by increased levels of hydrogen ions (Kaiser et al. 2005). Various soil amendments are used as liming materials to neutralize the soil acidity. One of the most important liming material is calcium carbonate ($CaCO_3$), usually known as agricultural lime. Groundnut (*Arachis hypogea* L.) is a non-conventional crop of NER and cultivated in an area of about 4,000 ha with a productivity of 1,000 kg/ha which is higher compare to the national average (Munda et al. 2006). The major constraint for improving groundnut productivity in North Eastern Region (NER) of India is soil acidity. Lime is the most commonly used material for acidity correction due to its capacity to increase fertilizer efficiency. It supplies Ca to plants which is component of cell wall and helps in improving peg development in groundnut. Lime application at 2, 4 and 6 tonnes/ha reported to maintain soil pH $\geq$ 5.5 for 2-4 years, respectively for acid soils with pH less than 5.5 (Kisinyo et al. 2014). Furrow application of lime @ 500 kg/ha is a feasible economical option. Substantial increase in crop yields due to furrow liming has been reported (Manoj-kumar et al. 2012). Micronutrients are very essential for plant growth, but are required in much smaller amounts than those of the primary nutrients; nitrogen (N), phosphorus (P) and potassium (K). Micronutrients are elements with specific and essential physiological functions in plant metabolism and important for oilseed crops such as groundnut and rapeseed (Epstein 1965). Rapeseed (*Brassica campestris* var. toria) which is a major oil-yielding crop grown in winter season is a very good catch crop. Rapeseed is mostly cultivated with residual moisture in rice or maize fallow (Tuti et al. 2012). There is also good opportunity to cultivate rapeseed and mustard after groundnut with residual nutrients in NER for enhancing cropping intensity, productivity and income. There is little information on the effect of micronutrients and soil amendments on soil pH and exchangeable Ca in groundnut-rapeseed cropping system under acid soil conditions.

Table 1. Effect of micronutrients and lime on soil pH status of groundnut at 0-15 cm depth

Treatments	**15 DAS**	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**90 DAS**	**At harvest**
Micronutrient							
Control	4.55	4.57	4.59	4.59	4.61	4.67	4.68
Zinc (Zn)	4.61	4.61	4.68	4.70	4.72	4.73	4.76
Boron (B)	4.63	4.63	4.68	4.71	4.70	4.73	4.76
Molybdenum (Mo)	4.61	4.62	4.69	4.72	4.75	4.79	4.82
Zn + Mo	4.64	4.65	4.71	4.73	4.76	4.79	4.83
Zn + B + Mo	4.65	4.66	4.75	4.79	4.80	4.81	4.85
S.Em±	0.03	0.07	0.03	0.05	0.06	0.06	0.04
C.D. (*P=0.05*)	NS	NS	NS	NS	NS	NS	NS
Soil amendment							
Lime	4.72	4.77	4.84	4.90	4.94	4.96	5.00
No Lime	4.51	4.48	4.52	4.52	4.51	4.54	4.56
S.Em±	0.01	0.02	0.01	0.02	0.02	0.02	0.01
C.D. (*P=0.05*)	0.03	0.06	0.03	0.05	0.06	0.06	0.04

DAS- days after sowing

Table 2. Effect of micronutrients and lime on soil pH status of groundnut at 15-30 cm depth

Treatments	**15 DAS**	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**90 DAS**	**At harvest**
Micronutrient							
Control	4.49	4.51	4.55	4.56	4.56	4.57	4.59
Zinc (Zn)	4.53	4.56	4.57	4.57	4.58	4.59	4.60
Boron (B)	4.55	4.55	4.56	4.58	4.61	4.63	4.66
Molybdenum (Mo)	4.58	4.60	4.61	4.63	4.64	4.66	4.67
Zn + Mo	4.59	4.61	4.62	4.63	4.64	4.67	4.69
Zn + B + Mo	4.59	4.61	4.61	4.61	4.62	4.63	4.65
S.Em±	0.03	0.05	0.03	0.05	0.05	0.08	0.06
C.D. (*P=0.05*)	NS	NS	NS	NS	NS	NS	NS
Soil amendment							
Lime	4.64	4.69	4.69	4.71	4.71	4.72	4.73
No Lime	4.47	4.46	4.48	4.48	4.52	4.53	4.55
S.Em±	0.01	0.02	0.01	0.02	0.02	0.03	0.02
C.D. (*P=0.05*)	0.02	0.04	0.03	0.05	0.05	0.07	0.06

Keeping these points in view, the present study was undertaken to monitor the effect of micronutrients and liming on soil pH and exchangeable Ca at regular interval in groundnut–rapeseed cropping system.

2. Materials and Methods

The field experiment was conducted on Agronomy experimental field, ICAR Research complex for NEH Region, Umiam, Meghalaya during *kharif* and *rabi* season of 2013. The region receives high rainfall (long term annual rainfall average 2450 mm). The site was previously under rice + groundnut intercropping system for two consecutive years under uniform package of practices. The soil pH and exchangeable Ca (meq/100g soil) prior to initiation of the experiment were 4.5 and 4.4 and 0.85 and 0.80 at 0-15 cm and 150-30 cm soil depths, respectively. The experiment was laid out in factorial randomized block design (FRBD) with six micronutrients treatment *viz*. control (no micronutrient), Zn @ 5 kg/ha, B @ 1 kg/ha, Mo @ 0.5 kg/ha, Zn + Mo, Zn + B + Mo (all the micronutrients were applied through soil application) and two soil amendment practices *viz.* lime @ 500 kg/ha (furrow application) and no lime application. The fertilizers used as a micronutrient sources were zinc sulphate (22% Zn), borax (11% B) and ammonium molybdate (56% Mo). The net plot size was 4m × 3m (12 m^2) with adequate drainage facility. Groundnut (var: ICGS-76) were sown at a spacing of 30 × 10 cm^2. The N, P and K ($N:P_2O_5:K_20$ @ 30:60:40 kg/ha) were applied through urea, single super phosphate and muriate of potash, respectively. Lime @500 kg/ha was applied in furrows seven days before groundnut sowing and properly mixed with the soil. In succeeding season in the same plots rapeseed was sown at 30 cm row to row spacing to evaluate the residual effect of treatments applied to groundnut on performance of rapeseed.

Table 3. Effect of micronutrients and lime on soil exchangeable calcium status of groundnut

Treatments	0-15 cm				15-30 cm			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Micronutrient								
Control	0.89	0.97	1.06	1.03	0.95	0.97	1.01	0.99
Zinc (Zn)	1.02	1.08	1.18	1.15	1.05	1.09	1.10	1.11
Boron (B)	1.09	1.08	1.15	1.06	1.00	1.06	1.10	1.09
Molybdenum (Mo)	1.05	1.09	1.16	1.07	1.03	1.02	1.09	1.08
Zn + Mo	1.03	1.13	1.17	1.11	1.01	1.06	1.11	1.06
Zn + B + Mo	1.01	1.11	1.18	1.18	1.04	1.06	1.11	1.08
S.Em±	0.06	0.06	0.07	0.06	0.06	0.06	0.06	0.06
C.D. (*P=0.05*)	NS	NS	NS	NS	NS	NS	NS	NS
Soil amendment								
Lime	1.04	1.15	1.35	1.25	1.08	1.10	1.15	1.15
No Lime	0.99	1.01	0.93	0.96	0.94	0.98	1.03	0.99
S.Em±	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
C.D. (*P=0.05*)	NS	0.06	0.06	0.06	0.06	0.06	0.06	0.06

Table 4. Residual effect of treatments on soil pH status of rapeseed at 0-15 cm soil depth

Treatments	15 DAS	30 DAS	45 DAS	At harvest
Micronutrient				
Control	4.69	4.71	4.74	4.77
Zinc (Zn)	4.80	4.80	4.82	4.83
Boron (B)	4.78	4.80	4.83	4.84
Molybdenum (Mo)	4.84	4.84	4.86	4.87
Zn + Mo	4.85	4.86	4.87	4.90
Zn + B + Mo	4.85	4.87	4.88	4.89
S.Em±	0.05	0.05	0.05	0.05
C.D. (*P=0.05*)	NS	NS	NS	NS
Soil amendment				
Lime	5.01	5.04	5.05	5.08
No Lime	4.59	4.59	4.61	4.62
S.Em±	0.02	0.02	0.01	0.02
C.D. (*P=0.05*)	0.06	0.06	0.03	0.06

The rapeseed was grown with recommended dose of $N:P_2O_5:K_20$ (50:60:40 kg/ha). All recommended agronomic practices such as weed management, pest and disease management were followed for groundnut and succeeding rapeseed crop. Soil samples from each plot at 0-15cm and 15-30 cm depth were collected following standard procedure at 15 days interval during the growing period of groundnut and succeeding rapeseed crops. Soil samples were analyzed for pH using pH meter (1:2.5) (Mclean 1982) and exchangeable calcium by complex metric titration method described by Schwartzenbach et al. (1946). Data obtained from the study were statistically analyzed in FRBD using the technique of Analysis of Variance (ANOVA). The difference between the treatments means were tested as to their statistical significance with appropriate critical difference (C.D.) value at 5 percent level of probability(P=0.05). The treatment means were compared by employing Least Significant Difference (LSD) test at *P= 0.05*.

3. Results and Discussion

At 0-15 and 15-30 cm soil depth, soil pH remained non-significant due to either sole or combined application of micronutrients. Whereas, application of lime significantly influenced soil pH at both the soil in different growing stages of groundnut (Table 1 & 2). Increase in soil pH upon limning due to displacement of Al^{3+}, Fe^{2+} and H^{+} ions from the soil sorption sites by Ca^{2+} and Mg^{2+} has been reported by earlier researcher (Kamprath 1984). At different growing stages of groundnut, soil exchangeable Ca did not vary significantly due to sole or combined application of micronutrients at 0-15 and 15-30cm soil depth, whereas, application of lime

Table 5. Residual effect of treatments on soil pH status of rapeseed at 15-30 cm soil depth

Treatments	15 DAS	30 DAS	45 DAS	At harvest
Micronutrient				
Control	4.59	4.60	4.64	4.67
Zinc (Zn)	4.62	4.64	4.67	4.70
Boron (B)	4.68	4.71	4.73	4.74
Molybdenum (Mo)	4.68	4.71	4.74	4.74
Zn + Mo	4.70	4.72	4.74	4.75
Zn + B + Mo	4.68	4.71	4.72	4.75
S.Em±	0.05	0.05	0.03	0.05
C.D. (*P=0.05*)	NS	NS	NS	NS
Soil amendment				
Lime	4.76	4.78	4.81	4.85
No Lime	4.56	4.58	4.60	4.60
S.Em±	0.02	0.02	0.01	0.02
C.D. (*P=0.05*)	0.06	0.06	0.03	0.06

Table 6. Residual effect of treatments on soil exchangeable Ca (meq/100g) status of rapeseed

Treatments	0-15 cm		15-30 cm	
	30 DAS	At harvest	30 DAS	At harvest
Micronutrient				
Control	1.10	0.97	0.99	0.98
Zinc (Zn)	1.13	1.15	1.05	1.03
Boron (B)	1.12	1.12	1.07	1.03
Molybdenum (Mo)	1.11	1.06	1.07	1.02
Zn + Mo	1.13	1.06	1.04	1.03
Zn + B + Mo	1.12	1.09	1.05	1.02
S.Em±	0.07	0.07	0.06	0.06
C.D. (*P=0.05*)	NS	NS	NS	NS
Soil amendment				
Lime	1.22	1.20	1.11	1.08
No Lime	1.02	0.99	0.98	0.96
S.Em±	0.02	0.02	0.02	0.02
C.D. (*P=0.05*)	0.06	0.06	0.06	0.06

significantly increased exchangeable Ca at both the soil depth over no lime application except at 30 DAS (Table 3). Smith (1995) reported that lime is a suitable source of Ca for groundnut grown on light textured acid soils because of the slow release of Ca. Cox et al. (1982) reported that incorporating lime to a depth of 10 cm ensures availability of Ca in the podding zone. Soil pH status at different growing stages of rapeseed did not vary significantly due to residual effect of micronutrients, whereas, residual effect of liming increased soil pH under rapeseed crop significantly at all the growing stages in 0-15 cm and 15-30 cm of soil depth (Table 4&5). Soil exchangeable Ca did not differ significantly due to the residual effect of micronutrients at 0-15 and 15-30 cm soil depth. Residual effect of lime increased soil exchangeable Ca significantly in both the soil depth at different growing stages of rapeseed crop. Exchangeable Ca found higher at 0-15 cm death as compared to 15 -30 cm soil depth (Table 6). Soil pH and Ca influenced due to neutralizing effect of lime on pH that varied with the length of time after application. Soil pH remained higher for longer periods of time in the upper horizons with relatively heavier applications of lime (Pawluk and Arneman, 1957). Similar result was also reported by Cifu et al. (2004). Thus, it can be concluded that soil application of micronutrients does not have any impact on soil pH and soil exchangeable Ca. However, furrow application of lime @ 500 kg/ha significantly influenced soil pH and exchangeable Ca due to direct effect in first crop groundnut and residual effect in succeeding crop rapeseed.

Acknowledgement

The first author is thankful to College of post Graduate Studies, Central Agricultural University, Umiam and ICAR Research Complex for NEH Region, Umiam, Meghalaya for providing necessary financial, lab and field support to conduct the study.

References

Cifu M, Xiaonan L, Zhihong C, Zhengyi H, Wanzhu M (2004). Long-term effects of lime application on soil acidity and crop yields on a red soil in Central Zhejiang. Plant Soil 265(1-2): 101-109

Das DK (1996). Soil Acidity. In: Introductory Soil Sci, 1st. edn. Kalyani Publishers, Ludhiana. pp. 184-212

Cox FR, Adams F, Tucker BB (1982). Liming, fertilization and mineral nutrition. In: Pattee H, Young C (eds.), Peanut Science and Technology. American Peanut Res Edu Soc. pp. 138–159

Kaiser NB, Gridler KL, Ngaire BJ, Phillips T, Tyerman SD (2005). The role of molybdenum in agricultural plant production. Ann Bot 96: 745-754.

Kamprath EJ (1984). Crop response to lime in the tropics. In: Adams F (ed.). Soil acidity and liming. 2nd ed. Agronomy Monograph 12. Agronomy and Soil Science Society of America. Madison, Wis. pp 349-368

Kisinyo PO, Othieno CO, Gudu SO, Okalebo JR, Opala PA, Ngetich WK, Opile WR (2014). Immediate and residual effects of lime and phosphorus fertilizer on soil acidity and maize production in western Kenya. Experimental Agri 50(1): 128-143

Mandal SC (1997). Introduction and historical overview. In: Mahapatra IC, Mandal SC, Misra C, Mitra GN, Panda N.) (Eds). Acidic Soils of India ICAR, New Delhi, pp 3-24

Manoj Kumar, Hazarika S, Choudhury BU, Ramesh T, Verma BC, Bordoloi LJ (2012). Liming and Integrated Nutrient Management for Enhancing Maize Productivity on Acidic Soils of Northeast India. Ind J Hill Farming 25(1): 35-37

Munda GC, Bujarbaruah KM, Hazarika UK, Panwar AS, Patel DP, Kumar R, Das A, Singh IM, Vishwakarma AK, Mitra J (2006). Technology for oilseeds in NEH region, ICAR Research Complex for NEH Region. Technical Bulletin No. 25, pp. 1-35

Pawluk S, Arneman HF (1957). The residual effects of lime added for the growth of various conifers in Minnesota. Soil Sci Soc Am J 21(6): 653-655

Sharma UC, Singh RP (2002). Acid soils of India: their distribution, management and future strategies for higher productivity. Fertilizer News 47: 45–52

Smith WC (1995). Crop Production: Evolution, History and Technology. John Wiley & Sons, INC, Pp. 408-457.

Tuti MD, Mahanta D, Mina BL, Bhattacharyya R, Bisht JK, Bhatt JC (2012). Performance of lentil (*Lens culinaris*) and toria (Brassica campestris) intercropping with wheat (T*riticum aestivum*) under rainfed conditions of north-west Himalaya. Ind J Agril Sci 82(10): 841-844