Effect of liming on soil chemical properties under tista meander floodplain soil in Bangladesh

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Abstract: A study was conducted to evaluate the effects of liming on soil chemical properties at Gabtali Upazila in Bogra district during the period from October 2013 to February 2014. There were five lime treatments namely T_1: control (no lime), T_2: 0.5 ton lime ha^{-1} T_3: 1.0 ton lime ha^{-1}, T_4: 1.5 ton lime ha^{-1} and T_5: 2.0 ton lime ha^{-1}. The design of the experiment was Randomized Complete Block Design (RCBD) with four replications. Dolochun was used as the liming material. The application of different levels of lime in soil progressively increased soil pH, P, Ca, Mg, S and OM; and decreased the micronutrients (Zn and B). Nitrogen and Potassium availability were independent of liming. The treatment T_4 produced highest positive impact on soil properties and statistically different from others those found in T_1, T_2, T_3 and T5 treatments. Therefore, the application of 1.5 ton ha^{-1} lime appeared to be optimum for the desired soil pH (pH 6-7) which ultimately increased availability of nutrients in the study area.
Key words: Liming, soil, chemical properties and Tista meander.

Introduction

Bangladesh is an agriculture economy based country. More than 70% of her population directly and the rest 30% of her population indirectly depend on agriculture. Farming systems are basically subsistence in nature but still important from the national economic point of view. Agriculture contributes 16.33% of the total GDP (BBS, 2014). Crop sector alone contributes about 12% of the GDP. Bangladesh is a highly populated country and its population density is increasing day by day. Scarcity of food has become a chronic problem of this country. To mitigate the food shortage, measures should be taken to increase the total food production. Soil is an important natural resource for crop production. In order to produce high yield and quality crops, soil reaction (pH) and nutrients must be present in sufficient amounts, and in balance. But, acid soils are an important challenge for Bangladesh because of their adverse effect on soil fertility, crop productivity and food security. At present very strongly acid (pH<4.5) and strongly acid (pH 4.6-5.5) soils comprise 27% of the country and are gradually increasing in area and intensity over time. It is estimated that soils of 0.25 million ha lands are very strongly acidic (pH <4.5), 3.70 million ha lands are strongly acidic (pH 4.6-5.5) and 2.74 million ha lands are slightly acidic (pH 5.6-6.5) in Bangladesh (BARC, 2012). The potential of acid soil for crop production is limited due to less availability of phosphorus and toxicity of aluminum. Generally, availability of macronutrients and Mo increases as soil pH increases and reverse is true for micronutrients except Mo. In most cases, pH 6-7 is optimum for adequate availability of nutrients in soils (BARC, 2012).

Soils in the Tista Meander Floodplain are naturally acidic. Periodic applications of agricultural lime help to keep the soil's pH level within an acceptable range. Liming should be practiced in soils having pH below 5.5 (BARC, 2012). Liming raises soil pH, P, Ca and Mg contents and reduces aluminum concentration (Fageria and Stone, 2004). To solve this acidity problem of soil for quality crop production and increasing the yield of crop, liming is very essential. But in Bangladesh, a little research work has been done in this aspect. Keeping this in view, a study was undertaken in a strongly acidic soil of Tista Meander Floodplain to evaluate the effect of liming on soil chemical properties.

Materials and Methods

The study was conducted at Mouza-Deonai, Village-Deonai under Gabtali upazila in Bogra district during winter season of 2013-2014. The experimental field is located at $24^0 46'$ & $25^0 01'$N latitude and $89^0 24'$ & $89^0 31'$ E longitude at an elevation of 25.0 meters. The soil belongs to the Jamun soil series of Non-calcareous Grey Floodplain Soil (Brammer, 1971 and Shaheed, 1984) under Tista Meander Floodplain. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. There were altogether 20 unit plots, each plot measuring 5 m x 4 m. Five different levels of lime were as treatment viz. T_1: Control (no lime), T_2: 0.5 t lime ha^{-1}, T_3: 1.0 t lime ha^{-1}, T_4: 1.5 t lime ha^{-1}, T_5: 2.0 t lime ha^{-1}. Dolochun (20% Ca and 10% Mg) used as liming materials in this experiment. The liming material was applied to the soil on 26 October 2013 and incorporated in soil by spading. Soil sample was collected at 30, 60, 90and 120 days after liming (DAL) from each treatment then chemical analyzed for soil pH, organic matter, total N, available P, K, S, Zn, B, Ca and Mg. The initial composite soil sample was also chemically analyzed to know the soil characteristics. All soil samples was collected from 0-15 cm and analyzed as per standard methods. Soil pH was measured with the help of glass electrode pH meter using soil water suspension of 1:2.5 (Jackson, 1962). Organic carbon in soil was determined by wet oxidation method (Walkley and Black, 1934). Total nitrogen of soil was estimated by micro kjeldhal method (Bremner and Mulvaney, 1982). Available soil phosphorus was measured by Bray & Kurtz method and available sulphur was determined by turbidimetric method. Exchangeable K, Ca and Mg of soils were determined by flame photometer on the neutral ammonium acetate extract (Barker and Surh, 1982). Available soil Zn was determined by DTPA extraction method and boron was determined by Calcium chloride extraction method using atomic absorption spectrophotometer (Petersen, 1999). Finally the data were analyzed statistically by using MSTAT-C package program. The mean comparisons of the treatments were evaluated by Least Significant Different (LSD) Test.

Results and Discussion

Effects of liming on soil pH: The pH of initial soil was 4.9 (Table 1). Lime application at different rates increased soil pH from 5.3 to 6.7 (Table 2). The highest pH changes were recorded in treatment T_5 (6.7) with lime rate 2.0 ton ha^{-1} which was statistically similar in the treatment T_4 with lime rate 1.5 ton ha^{-1}. The lowest pH changes were recorded in treatment T_1 (control). In general soil pH should be maintained 6.0 to 7.0 to maximize plant available phosphorus (Clif *et al.,* 1999). So, the better pH range was observed within treatment T_4 and T_5. Here also found that the pH status was increased up to 90 days after liming (DAL) with the increased levels of lime application, but at 120th day it was decreased. Similar observations were also reported by Kamaruzzaman (2014) that pH of soil steeply increased during the first 30 day s after liming, then slightly increased and finally slightly decreased with time until the end of 120 days of experimentation.

Table 1. Chemical characteristics of initial soil of the experiment field

Characteristics	Content	Interpretation
pH (soil : water = l : 2.5)	4.9	Strongly acidic
Organic matter (%)	1.55	Low
Total N (%)	0.08	Very Low
Available P (ppm)	15.42	Medium
Available K (meq 100g^{-1} soil)	0.12	Low
Available Ca (meq 100g^{-1} soil)	1.63	Low
Available Mg (meq 100g^{-1} soil)	0.61	Low
Available S (ppm)	18.1	Medium
Available Zn (ppm)	0.70	Low
Available B (ppm)	0.18	Low

Table 2. Soil pH status before liming and at different days after liming

Treatment	Before Liming	30 DAL	60 DAL	90 DAL	120 DAL
T_1	4.90	4.90 b	4.90 b	4.90 c	4.80 c
T_2	4.90	5.30 b	5.50 ab	5.70 b	5.60 a
T_3	4.90	5.40 b	5.70 ab	5.90 b	5.80 ab
T_4	4.90	6.00 a	6.20 a	6.50 a	6.30 a
T_5	4.90	6.10 a	6.30 a	6.70 a	6.40 a
CV (%)	-	5.69	8.90	6.02	6.92
LSD	-	0.489	0.784	0.551	0.616

DAL=Days after liming

Effects of liming on soil Organic Matter (OM): After adding lime to experiment field, the status of OM was found to change significantly and increased up to 60 days where the highest value of OM was 2.29% in T_4 Treatment but at 90 DAL it was decreasing trend up to 120 DAL (Table 3). This was due to the liming effect which increased pH of the initial acidic soil, as a result the microbial activities of the soil increased. Finally due to increased microbial activities, soil organic matter was mineralized and decreased. These finding was also in agreement with the observation of Curtin *et al.* (1998) that it was expected that liming will bring an increase in microbial activity and a decreased in OM content in the soil.

Table 3. Soil OM (%)status before liming and at different days after liming

Treatment	Before Liming	30 DAL	60 DAL	90 DAL	120 DAL
T_1	1.55	1.93 b	1.99 c	1.86 e	1.71 d
T_2	1.55	1.97 b	2.07 b	2.01 c	1.88 c
T_3	1.55	2.04 ab	2.11 b	2.06 b	1.99 a
T_4	1.55	2.20 a	2.29 a	2.10 a	1.95 b
T_5	1.55	2.05 a	2.09 b	1.88 d	1.70 d
CV (%)	-	5.48	7.57	8.97	5.06
LSD	-	1.75	0.048	0.02	0.02

Effects of liming on soil Total Nitrogen: From the study we found, the total nitrogen content of initial soil was very low. After liming total nitrogen content in soil was not remarkably increased or reduced (Table 4) i.e. the variation among the treatments were non-significant. Similar observations were also reported by Well *et al.* (1990).

Table 4. Soil N (%) status before liming and at different days after liming.

Treatment	Before Liming	30 DAL	60 DAL	90 DAL	120 DAL
T_1	1.55	1.93 b	1.99 c	1.86 e	1.71 d
T_2	1.55	1.97 b	2.07 b	2.01 c	1.88 c
T_3	1.55	2.04 ab	2.11 b	2.06 b	1.99 a
T_4	1.55	2.20 a	2.29 a	2.10 a	1.95 b
T_5	1.55	2.05 a	2.09 b	1.88 d	1.70 d
CV (%)	-	5.48	7.57	8.97	5.06
LSD	-	1.75	0.048	0.02	0.02

Effects of liming on soil available Phosphorus: At the beginning of the experiment, the value of available phosphorus was 15.42 ppm (Table 5). The low available P could be explained by the low pH levels/acidity of the soils that leads to P fixation into unavailable forms (Nurlaeny *et al.,* 1996). Soil available P decreased in the control treatments, while application of dolochun increased soil available P at all sampling periods (Table 5). However at 30, 60, 90 and 120 DAL, the effects of lime on available phosphorus were significantly different. Lime application increased the soil pH which helped the release of fixed P from the oxides and hydroxides of Fe and Al thus increased the P availability in soils. Fageria *et al.* (1989) reported an increase of soil phosphorus as pH increased from 5.0 to 6.5, due to release of P ions from Al and Fe oxides, which are responsible of P fixation.

Table 5. Soil P (ppm) status before liming and at different days after liming

Treatment	Before Liming	30 DAL	60 DAL	90 DAL	120 DAL
T_1	15.42	26.50 c	26.22 c	25.62 d	25.50 e
T_2	15.42	29.40 c	32.25 b	33.57 c	35.15 d
T_3	15.42	33.85 b	35.78 ab	37.12 b	38.42 c
T_4	15.42	36.37 ab	39.59 a	40.13 a	41.55 b
T_5	15.42	38.43 a	41.15 a	42.19 a	43.15 a
CV (%)	-	7.09	10.34	6.47	5.83
LSD	-	3.587	5.574	1.912	1.603

Effects of liming on soil exchangeable Potassium: Despite a slight increase in K saturation, the effect of limes was not significantly different, but in all DALs, K was higher in T_4 treatment (Table 6). Bodruzzaman *et al.* (2014) observed that soil extractable potassium (1M ammonium acetate) levels were unaffected by dolochun at 1 t ha^{-1} and 2 t ha^{-1} rates.

Table 6. Soil K (meq 100g^{-1} soil) status before liming and at different days after liming.

Treatment	Before Liming	30 DAL	60 DAL	90 DAL	120 DAL
T_1	0.120	0.170	0.150	0.140	0.120
T_2	0.120	0.176	0.155	0.145	0.127
T_3	0.120	0.169	0.156	0.135	0.128
T_4	0.120	0.178	0.157	0.138	0.129
T_5	0.120	0.175	0.154	0.160	0.127

CV (%)	-	8.35	8.43	8.84	7.27
LSD	-	NS	NS	NS	NS

Effects of liming on soil available Sulphur: After adding lime to experiment field the status of Sulphur was found to change significantly and increased up to 60 days, but it was decreased from 90 DAL to 120 DAL (Table 7**).** It is expected that liming will bring an increase in microbial activity (Curtain *et al*., 1998). Clif *et al*. (1999) reported that S availability is greatly influenced by the activities of micro-organisms. After the availability of sulphur, it has great potential to leach along with many of the bases (Ca^{++}, Mg^{++} and K^{+}), which leach out as sulphates (Curtain *et al*., 1998). At the experiment, highest available S was found in T_4 treatment for every sampling period.

Table 7. Soil S (ppm) status before liming and at different days after liming.

Treatment	Before Liming	30 DAL	60 DAL	90 DAL	120 DAL
T_1	21.91	20.46 b	23.15 b	21.20 b	20.30 a
T_2	21.91	24.26 ab	30.17 ab	26.66 ab	22.23 a
T_3	21.91	26.32 ab	32.44 ab	29.21 a	27.97 b
T_4	21.91	29.12 a	35.11 a	32.45 a	28.56 a
T_5	21.91	27.29 ab	33.78 ab	30.67a	29.21 a
CV (%)	-	19.10	20.88	15.58	17.53
LSD	-	7.499	9.950	6.731	7.307

Effects of liming on soil available Calcium: The status of available calcium was increased sharply with the increased levels of lime application and the better concentration of Ca was observed (3.01) in respect of treatment T5 which was statistically identical with T4 (Table 8). Because of that the liming material used as Dolochun [Dolomite, CaMg(CO3)2], which on dissolution released a large amount of Ca and thus the available Ca increased in soil after liming. This result also agreed to report of Bodruzzaman et al. (2014) where observed that exchangeable Ca increased 118%, 233%, 362% and 514% with 1, 2, 4 and 6 t ha-1 dolochun applications. On the other hand, the increasing trend of available calcium was found from just after liming to 90 DAL, and then it decreased upto 120 DAL.

Table 8. Soil Ca (meq $100g^{-1}$ soil) status before liming and at different days after liming.

Treatment	Before Liming	30 DAL	60 DAL	90 DAL	120 DAL
T_1	1.63	1.63 d	1.64 c	1.67 c	1.62 d
T_2	1.63	2.08 c	2.22 b	2.43 b	2.15 c
T_3	1.63	2.28 bc	2.40 ab	2.55 ab	2.37 b
T_4	1.63	2.40 ab	2.56 a	2.80 ab	2.45 ab
T_5	1.63	2.55 a	2.68 a	3.01 a	2.56 a
CV (%)	-	6.63	8.65	12.27	4.93
LSD	-	0.22	0.308	0.472	0.168

Effects of liming on available Magnesium: The status of Mg changed significantly with different treatments and different days after liming (Table 9).

Table 9. Soil Mg (meq 100g-1 soil) status before liming and at different days after liming.

Treatment	Before Liming	30 DAL	60 DAL	90 DAL	120 DAL
T_1	0.61	0.61 d	0.62 c	0.63 c	0.61 d
T_2	0.61	1.09 c	1.20 b	1.31 b	1.16 c
T_3	0.61	1.21 b	1.35 b	1.39 b	1.30 bc
T_4	0.61	1.33 a	1.56 a	1.63 ab	1.49 ab
T_5	0.61	1.41 a	1.63 a	1.75 a	1.55 a
CV (%)	-	4.98	10.11	16.40	10.56
LSD	-	0.084	0.200	0.337	0.200

The recorded highest value was found 1.75 meq l00g $soil^{-1}$ in respect of treatment T_5 which was statistically similar with T4 treatment (1.63 meq l00g soil-1). The reason behind the result was that the liming material used as Dolochun [Dolomite, CaMg(CO3)2], which on dissolution released a large amount of Mg and thus the available Mg increased in soil after liming. This result agreed to report of Bodruzzaman et al. (2014). He found that exchangeable Mg increased 105%, 179%, 258% and 340% with 1, 2, 4 and 6 t ha-1 dolochun applications. Here also observed, the availability of Mg in soil was increased gradually just after liming to 90 DAL, but it decreased upto 120 DAL with different rates of lime application.

Effects of liming on soil available Zinc: Soil available zinc was significantly affected by different levels of lime but it was slightly decreasing trend (Table 10). The highest value of zinc was recorded 0.70 ppm in respect of treatment T_1 (control) and the lowest was o.57 ppm in respect of treatment T_5 treatment. The trend of decreased availability of zinc was possibility due to increased pH after liming. Similar observation was also reported by Mikkelsen *et al.* (1994) that after liming in acid soil, the availability of zinc decreased greatly by increased soil pH.

Table 10. Soil Zn (ppm) status before liming and at different days after liming.

Treatment	Before Liming	30 DAL	60 DAL	90 DAL	120 DAL
T_1	0.70	0.71 a	0.72 a	0.72 a	0.69 a
T_2	0.70	0.66 ab	0.63 b	0.61 b	0.60 b
T_3	0.70	0.61 b	0.60 b	0.59 b	0.57 b
T_4	0.70	0.60 b	0.59 b	0.59 b	0.58 b
T_5	0.70	0.59 b	0.57b	0.58 b	0.57 b
CV (%)	-	7.95	9.18	7.21	6.03
LSD	-	0.084	0.084	0.068	0.048

Effects of liming on soil available Boron: Soil available boron was significantly affected by different treatments. Available boron in the initial soil was 0.16 which decreased slighty with increased levels of lime application. The highest value of boron was recorded 0.16 ppm in respect of treatment T_1 (control) and the lowest was o.11 ppm in respect of treatment T_5 (Table11). The trend of decreased availability of boron was possibility due to increased pH after liming. Bodruzzaman *et al*. (2014) reported that just like zinc, available boron levels decreased by addition of dolochun in his experiment.

Table 11. Soil B (ppm) status before liming and at different days after liming.

Treatment	Before Liming	30 DAL	60 DAL	90 DAL	120 DAL
T_1	0.16	0.16 a	0.16 a	0.15	0.15 a
T_2	0.16	0.16 a	0.14 ab	0.13	0.13 ab
T_3	0.16	0.14 ab	0.13 b	0.12	0.12 b
T_4	0.16	0.13 b	0.12 b	0.13	0.12 b
T_5	0.16	0.12 b	0.11 c	0.12	0.11 b
CV (%)	-	9.27	11.23	13.17	11.74
LSD	-	0.02	0.02	NS	0.02

Liming with dolochun considerably influenced soil chemical properties and raised soil pH from initially strongly acidic to neutral reaction. Improvement of soil acidity increased availability of P, Ca, Mg, S and organic matter in soils which had positive impact on soil fertility that will help to increase crop yield. Treatment T_4 i.e. application of 1.5 ton lime ha^{-1} appeared to be optimum for proper soil chemical properties of the study area. In future, soil monitoring regarding soil chemical properties of the stationary experiment is recommended, as liming have the residual effect.

References

BARC (Bangladesh Agricultural Research Council). 2012. Fertilizer Recommendation Guide. Dr. A. A. Hasan et al. (eds.), Farmgate, Dhaka. 274 p.

Barker, D.E. and Surh, N.H. 1982. Atomic absorption and flame emission spectroscopy. In: methods of soil analysis, Part2. Chemical and microbiological properties, (eds.) A.I., Page, R.H. Miller and D.R. Keeney, American Society of Agronomy Inc., Madison, WI, USA, 13-26 pp

BBS (Bangladesh Bureau of Statistics). 2014. Statistical Yearbook of Bangladesh. Bangladesh Bur. Stat. Ministry of Planning. Govt. of the People's Republic of Bangladesh, Dhaka.

Bodruzzaman, M., Rahman, G.K.M., Islam, M.S., Roy, M.C., Duxbury, J.M. and Lauren, J.G. 2014. Lime Technology for the Acid Soils Regions of Bangladesh. United States Department of Agriculture. Published by: Food for Progress Program in Bangladesh on August 2014.

Brammar, H. 1971. The Geography of the Soils of Bangladesh. University Press Ltd., Dhaka. 287p.S

Bremner, J.M. and Mulvaney, C.S. 1982. Total Nitrogen, In Methods of Soil Analysis. Miller. R. H. and Xeeny, D. R. 1982. Amer. Soc. Agreon. Inc. Madi. Wis. USA. pp. 595-622.

Clif, L. and McCutcheon, J. 1999. Fertility Management of Meadows, Agriculture and Natural Resources, Ohio State University Extension Fact Sheet, 2120 Fyffe Road, Columbus, Ohio :43210-1084

Curtin, D., Campell, C.A. and Jalil, A. 1998. Effects of acidity on mineralization: pH-dependence of organic matter mineralization in weakly acidic soils. Soil Biology & Biochemistry, v.30, p.57-64.

Fageria, N.K. 1989b. Effect of phosphorus on growth, yield and nutrient accumulation in the common bean. Trop. Agric, 249-255.

Fageria, N.K. and Stone L.F. 2004. Yield of common bean in no-tillage system with application of lime and zinc. Pesq. Agropec. Braas, 73-78.

Jackson, M.I. 1962. Soil chemistry analysis. Prentice Hall Inc. Englewood Cliffe, N. J.

Kamaruzzaman, M., Islam, M.N., Siddique, M.N.A., Sarker, B.C., Islam, M.J. and Rasel, S.M.M. 2014. Liming effect on changes of soil properties of wheat field: a case of bariend area in Bangladesh. Online Journal of Bioscience and Informatics, ISSN 2320-2912.

Mikkelsen and Camberato. 1994. Use of Potassium, Sulfur, Lime and Micronutrients. Nutrient Management, Institute of Food and Agricultural Science, University of Florida.

Nurlaeny, N., Marschner, H. and George, E. 1996. Effects of liming and mycorrhizal colonization on soil phosphate depletion and phosphate uptake by maize (*Zea mays* L.) and soybean (*Glycine max* L.) grown in two tropical acid soils. Plant Soil, 275-285.

Petersen, L. 1999. Soil Analytical Methods. Soil Testing, Management and Development of SRDI Project. Soil Resource Development Institute, Danida Kampsax, Dhaka.

Shaheed, S. M. 1984. Country Report Bangladesh, Expert Consultation of the Asian Network on Problem soils, FAO held in 23-27 October 1995 Manila, Philippines.

Walkley and Black, C.A. 1934. An examination of Degtjareff method for determining soil organic matter and proposed modification for the chromic acid titration method. Soil Sci., 37:29-38

Well, R.R. and Tumer, W.R.S. 1990. Nitrrate contamination of ground water under irrigated coastal plain soils. Journal of Environmental Quality. 19 (3): 44-448.