Liming and Integrated Nutrient Management for Enhancing Maize Productivity on Acidic Soils of Northeast India

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ABSTRACT

Lime application and integrated nutrient management is often recommended to increase the crop productivity on acidic soils. To ascertain the individual and synergistic effects of lime, NPK and farm yard manure (FYM) application on maize productivity, a field experiment was undertaken on an acid Alfisol (pH 4.6) of Meghalaya, Northeast India. Application of recommended NPK dose (80, 60 and 40 kg/ha of N, P_2O_5 and K_2O) resulted in 53% yield improvement, while liming @ 300 kg/ha (furrow application) caused 32 % yield increase over control. Combined application of NPK + lime resulted in 147% yield increase while application of FYM @ 5 t/ha along with NPK + lime further boosted the yield improvement up to 291% over control. Results of this study suggest that liming along with integrated nutrient management practices, if adopted properly, can lead to more than three-fold increase in maize productivity on acidic soils of Meghalaya and other north-eastern states of India with similar soils.

Keywords: Crop productivity, Lime application, North-eastern India, Soil acidity

INTRODUCTION

Soil acidity affects nearly 50 percent of the world's potentially arable land, particularly in humid tropics (von Uexkull and Mutert 1995). 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, with nearly 65% of its area being under extreme forms of soil acidity (pH below 5.5) (Sharma and Singh 2002). Crop productivity on such soils is mostly constrained by aluminium (Al) and iron (Fe) toxicity, phosphorus (P) deficiency, low base saturation, impaired biological activity and other acidity-induced soil fertility and plant nutritional problems (Patiram 1991; Manoj-Kumar et al. 2012). The levels of soil acidity along with its associated impacts on soil fertility and crop productivity are expected to further intensify in a changing climate (Oh and Richter 2004; Manoj-Kumar 2011a&b). Soil acidity management and crop productivity improvement on such soils is therefore important for enhancing food security globally and regionally.

Meghalaya is an agriculturally important state in northeast India, with typically high levels of soil acidity and very high rainfall. Acidity–induced soil fertility problems coupled with traditionally minimal use of mineral fertilizers are often held responsible for low levels of crop productivity in the state. Lime application along with integrated nutrient management is often recommended to increase the phytoavailability of essential nutrients and ameliorate the other acidity-induced fertility constraints on such soils (Haynes 1984; Patiram 1991; Manoj-Kumar et al. 2012). It is therefore imperative to ascertain the yield benefits of individual as well as combined application of lime, chemical fertilisers and organic manure in a particular edapho-climatic condition. We evaluated the same in a field experiment (with maize as a test crop) on an acid Alfisol of Meghalaya, India. Additionally, we also evaluated the effectiveness of seed pelleting relative to furrow application of lime, either alone or in combination with other nutrient management practices.

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MATERIALS AND METHODS

A field experiment with maize (*Zea mays* L.) as test crop was undertaken on an acid Alfisol (pH 4.6) in research farm of Soil Science Division, ICAR Research Complex for NEH Region, Umiam, Meghalaya, India. Selected physico-chemical properties of the experimental soil and the weather parameters prevailing during the crop growing months are shown in Table 1 and Fig. 1, respectively. Maize (var. RCM-75) was grown with 12 treatment combinations, each replicated thrice, and arranged in the Randomized Complete Block Design (individual plot size: 3x4 m^2). The treatments were as follows: T1: control; T2: 100% of recommended NPK dose (80, 60 and 40 kg/ha of N, P_2O_5 and K_2O); T3: liming (furrow application @ 300 kg/ha); T4: 100% NPK + liming (furrow application @ 300 kg/ha); T5: 100% NPK + Liming (furrow application @ 300 kg/ha) + FYM @ 5 t/ha; T6: lime coated seed (rice starch as sticking agent); T7: lime coated seed (rice starch) + 100% NPK; T8: lime coated seed (rice starch) + 100% NPK+ FYM @ 5 t/ha; T9: lime coated seed (gum arabic as sticking agent); T10: lime coated seed (gum arabic) + 100% NPK; T11: lime coated seed (gum arabic) + 100% NPK+ FYM @ 5 t/ha. N, P and K were applied through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. Half of the N along with full doses of P and K was applied before sowing, while remaining half of the N was applied in two equal splits at 45 and 75 days after sowing. Lime was applied in furrows (Fig. 2) seven days before sowing and properly mixed with the soil. All recommended agronomic practices were followed during crop growth and the grain yield was recorded after harvesting the crop at maturity. Data were analyzed using the SPSS version 16.0 statistical package (SPSS Inc., Chicago, USA). Significance of the treatments' effect was considered at 0.05 probability level. The treatments' means were segregated using Duncan's Multiple Range Test.

Table 1: General physico-chemical properties of experimental soil

Soil properties	Values/description
Soil type	Typic Hapludalf
pH (1:2)	4.6
Sand (%)	52.7
Silt (%)	26.1
Clay (%)	21.2
Soil organic carbon (%)	1.02
Available N (kg/ha)	309
Available P (kg/ha)	23
Available K (kg/ha)	157

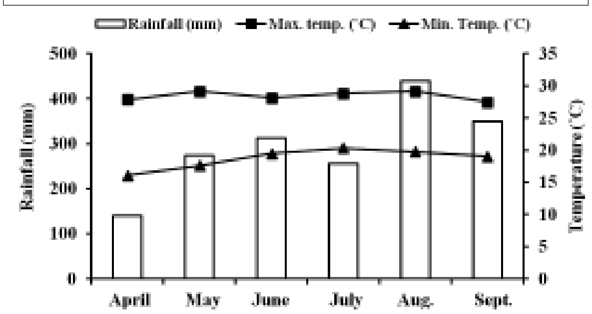

Fig. 1: Monthly distribution of rainfall and average temperature during crop growing season

Fig. 2: Furrow application of lime in the experimental plots

RESULTS AND DISCUSSION

Application of NPK, lime and FYM, either alone or in combination, had significant influences on the maize yield (Fig. 3). Application of recommended NPK dose resulted in 53.2% yield improvement and liming @ 300 kg/ha (furrow application) caused 32.4% yield increase over control. Combined application of NPK + lime resulted in 147% yield increase while application of FYM @ 5 t/ha along with NPK + lime further boosted the yield improvement up to 291% over control (Table 2). Our results are in conformity with the findings of Sharma et al. (2006) who, based on 141 experiments in farmers' field across the Assam and Meghalaya, reported 14-50% increase in yield of crops in response to lime application @ 2-4 q/ha, 22-100% yield increase by recommended dose of NPK application (i.e. 100% NPK), and 49-390% higher yield following combined use of NPK and lime compared to control (i.e. farmers' practice). Since

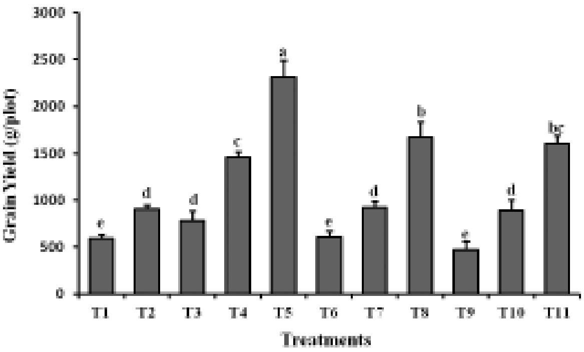

Fig. 3: Effect of liming and nutrient management practices on maize yield

Difference between values represented by bars having any common letter is statistically non-significant (P<0.05) and vice versa. (T1: control; T2: 100% of recommended NPK dose (80, 60 and 40 kg/ha of N, P_2O_5 and K_2O); T3: liming (furrow application @ 300 kg/ha); T4: 100% NPK + liming (furrow application @ 300 kg/ha); T5: 100% NPK + Liming (furrow application @ 300 kg/ha) + FYM @ 5 t/ha; T6: lime coated seed (rice starch as sticking agent); T7: lime coated seed (rice starch) + 100% NPK; T8: lime coated seed (rice starch) + 100% NPK+ FYM @ 5 t/ha; T9: lime coated seed (gum arabic as sticking agent); T10: lime coated seed (gum arabic) + 100% NPK; T11: lime coated seed (gum arabic) + 100% NPK+ FYM @ 5 t/ha).

the experimental soil was very strongly acidic in reaction (pH 4.6), the yield benefits from liming can be ascribed to the lime-induced increase in soil pH along with the associated improvement in nutrients' availability, reduced Al toxicity and many other attributes of soil fertility. Beneficial effects of NPK and FYM on maize yield can be understood given the fact that native NPK status of the experimental soil was in low to medium range. Seed coating with lime did not show any positive effect on crop yield. However, we suspect the low quality of liming material used for seed coating, which was obtained from the local market, might be the region behind this. Also, we might have failed to use the best possible concentration of sticking agent and coating techniques, leading to no improvement in maize yield by using the lime coated seeds. Thus we do not rule out the future possibility of this technique to be a potential technology in acidic soils; however, more research is required particularly for improving the seed coating techniques, which may lead to improved initial seedling establishment and subsequent crop yield.

Table 2: Comparative effects of liming and nutrient management practices on maize yield

Nutrient management practices	Percent increase in yield over control
Control	-
100% NPK (@ 80, 60 and 40 kg/ha of N, P_2O_5 and K_2O)	53.2
Liming (furrow application @ 300 kg/ha)	32.4
100% NPK + Liming	147
100% NPK + Liming + FYM (@ 5 t/ha)	291

To sum up, the results of this study suggest that liming along with integrated nutrient management practices, if adopted properly, can lead to more than three-fold increase in maize productivity on acidic soils of Meghalaya and other north-eastern states of India with similar soils.

ACKNOWLEDGEMENTS

Senior author is thankful to the Director, ICAR Research Complex for NEH Region, Umiam for providing necessary facilities to this work which constitute a part of the institute project "Evaluating the effectiveness of seed pelleting relative to furrow application of lime in *Zea mays* and *Phaseolus vulgaris*".

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