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Original Research Article

Productivity Enhancement of Maize (*Zea mays*) through Liming under Rain Fed Condition of Northeast India

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A B S T R A C T

Agriculture is the major economic activity of North eastern part of India but the productivity of agricultural crop is very less only because of improper management of agricultural activities. Soil acidity is also a factor of low productivity of some of the major crops. A Front Line Demonstration (FLD) was conducted at the farmers' field during the year 2016-2017, 2017-2018 and 2018-2019 to test the feasibility of a technology in the RiBhoi District of Meghalaya. The aim of the demonstration was to management of acidic soils by application of lime for increased the productivity of Maize (*Zea mays*) for maintaining the soil health and reducing the rate of chemical fertilizers. The demonstration was consists of 2 treatments with 10 numbers of trials in ten different farmers' field of RiBhoi District of Meghalaya. The total area of the demonstration was 4 ha. The results of the FLD revealed that the application of Lime @ 500kg/ ha in furrows + 50 % recommended dose of fertilizers (80, 60 and 40 kg/ha of N, P_2O_5 and K_2O) + 1 ton/ ha vermicompost gave significantly higher yield followed by Farmers practice. The average yield was significantly increase in all the years (41.77 q/ha)as compared to Farmers practice (23.17 q/ha) with increased BC ratio of 2.10 as compared to Farmers practice (BC ratio 1.4).Moreover improved and significantly higher soil nutrient status was recorded for all the years as compared to Farmers practice. So, the integrated use of Lime in Furrows along with NPK fertilizers and vermicompost can be effectively used for increased the productivity of Maize crop and can reduce the rate of Lime application for sustaining the soil nutrient and maintain the soil acidity in Northeast India.

Keywords

FLD, Maize, Soil health, RCM 1/3, Northeast India

Introduction

The economy of Northeast India is based on Agriculture. But due to the occurrence of heavy rainfall in this area, the high soil acidity is experiencing in this region which affects the crop productivity. Moreover the people of this area are very less aware about the modernization of Agriculture and not fond of chemical fertilizers and pesticides. All those factors lead to low productivity of crops in Northeast India in General and particularly in Meghalaya.

Approximately, 84 per cent of the soils in the North Eastern Hill (NEH) region of India are acidic in reaction, having low available phosphorus (P) and zinc whereas toxicity of iron and aluminium (Lyngdoh and Sanjay-Swami, 2020). 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 alumina-silicate minerals (Lyngdoh and Sanjay-Swami,2018; Sanjay-Swami and Lyngdoh, 2019). In acid soils, P adsorption is generally attributed to hydrous oxides of iron and aluminium. There is great possibility that some natural phosphates of aluminium or iron (such as variscite and strengite) may formed in these soils making P the most limiting nutrient for crop production (Sanjay-Swami and Maurya, 2018; Sanjay-Swami *et al.*,2019, Singh and Sanjay-Swami,2020a; Sanjay-Swami and Singh, 2020). In Meghalaya, the acid soils are found under different acidic ranges like moderately acidic soils (1.19 million ha), and slightly acidic soils (1.05 million ha) (Maji *et al.*, 2012).Quantifying optimum soil acidity indices is an important strategy for achieving maximum economic yield of crops on acid soils (Yadav, and Sanjay-Swami,2019). Moreover, emphasis on available P status in acid soils with time intervals to synchronize the crop P demands is essential (Singh and Sanjay-Swami,2020b).

Application of Lime ($CaCO_3$) to the surface soil increased the soil pH resulting increased in root growth, leading to greater uptake of water and nutrients which results the crop grain yield (Caires *et al.*, 2006;Holland *et al.*, 2018). Some other studies also reveals that application of lime increases soil pH which results in decrease the anion absorption and increase in cation adsorption and cation exchange capacity of the soil as a result P and Mo concentration was increases and decreases the Zn and Mn concentration of soil (Dickson *et al.*,1998;Tang, 2003). So, due to the application of lime the phosphorus uptake of the plants incenses (Scanlan, 2017).

Lime along with INM is useful for increasing the availability of essential nutrients (Haynes, 1984). Liming in acid soil creates a favourable environment to improve the microbial activity which results the decomposition of soil organic matter. The decomposition could result in increased mineral N and P and loses of soil organic carbon through CO_2 emission in the soil (Paradelo *et al.*, 2015; Grover *et al.*, 2017). The lime application increases P availability by decreasing Al^{3+} and Fe^{3+} ions and fixation on aluminium and iron oxides while over-liming to pH values up to 8.5 could result in precipitation of calcium phosphate (Takahashi and Dahlgren, 2016).

Based on these facts, a Front Line Demonstration was conducted in the Farmers Field of RiBhoi District of Meghalaya to demonstrate the integrated nutrient management with lime application for improvement of productivity of Maize.

Materials and Methods

A Front Line Demonstration (FLD) was conducted at the farmers' field during the year 2016-2017, 2017-2018 and 2018-2019 to test the feasibility of a technology in the RiBhoi District of Meghalaya.

The aim of the demonstration was to management of acidic soils by application of lime for increased the productivity of Maize (*Zea mays*) for maintaining the soil health and reducing the rate of chemical fertilizers.

The total area of the demonstration was 4 ha in three different villages of Meghalaya namely Kyrdem, Umeit and Thadnongiaw. The villages are falls between the altitudes of 842 to 885 amsl.

The RiBhoi District is lies between the North Latitudes 25.15$^{/}$ and 26.15$^{/}$ and East Longitudes 91.45$^{/}$ and 92.15$^{/}$. The total area of RiBhoi District is 2378 sq. km with a total population of 2, 58,840 (Anonymous, 2011).

The area falls under humid subtropical with an average rainfall of 1000mm to 2500 mm. The area under each OFT was 0.4 ha. The Maize variety used for the experiment was RCM 1-3. The demonstration was consists of 2 treatments, where Treatment 1 comprises of Lime @ 500kg/ ha in Furrows along with 50% recommended dose of chemical fertilizers(80, 60 and 40 kg/ha of N, $P_2O_5$and K_2O) + 1 t/ha vermicompost and Treatment 2 was Farmers Practice which includes imbalance fertilizer application (35:22:18 NPK kg/ha). All the participating farmers were trained on all aspects of Maize production and soil fertility management before implementing the FLDs at their field. To study the impact of FLD, data from each experimental plot were collected and analyzed.

The soil fertility statuses were estimated by soil analysis of composite soil sample from each plot before transplanting and after harvesting of crop. The soil of the experimental site was sandy loam and acidic in reaction. The data related to yield parameters and soil fertility status were collected from all the plots before and after the implementation of the programme.

The economics of the experiment was also analyzed for proper conclusion of the experiment.

The extension gap, technology gap and technology index along with benefit cost ratio were calculated using the formula as suggested by Samui *et al.*,(2000) as follows:

Technology Gap = Potential yield – Demonstration Yield (q/ha)

Extension Gap = Demonstration Yield – Farmers Yield (q/ha)

Technology Index = Potential Yield – Demonstration Yield/ Potential Yield x 100

Results and Discussion

Crop yield

From the Table 1 it is revealed that the application of Lime @ 400kg/ ha in Furrows + 50 % RDF + 1 t/ha vermicompost gave significantly higher yield (at 5% level of significance) of Maize followed by Farmers practice. The average yield was significantly higher in Treatment 1 i.e. Lime @ 400kg/ ha in Furrows + 50 % RDF + 1 t/ha vermicompost (41.77 q/ha) followed by Treatment 2 i.e. Farmers practice (23.17 q/ha) for all the years.

The percent increase in average yield over local is180.28 %.The highest stover yield was recorded with the application of 1.5 t ha^{-1} of lime.

This may be due to improvement in soil pH and other physico-chemical properties of soil that increases plant availability of soil nutrients. This is also similarly reported by Sanjay-Swami and Singh (2020).

Economics analysis

The input and output cost of products exist during the period of demonstrations were taken for calculating the cost of cultivation, net return and benefit cost ration show in Table 1. The highest B.C ratio was recorded in the T1 i.e. Lime @ 400kg/ ha in Furrows + 50 % RDF + 1 t/ha vermicompost for all the years i.e. average B: C ratio for three years is 2.10, followed by Treatment 2 i.e. Farmers practice (average B:C ratio of three years is 1.47).

The recorded results were achieved may be due to higher yield obtained under the experimental plot compare to Farmers practice. The suitable BC ratio reveals the economic viability of the FLD and convinced the farmers to adopt the Technology.

Table.1 Effect of lime on maize yield and economics under rain fed condition

Treatments	**Avg. yield (q/ha**	**% increase/ change in avg. yield over local**	**Gross Cost (Rs/ha)/ (Rs./ unit)**	**Gross Return (Rs/ha) / (Rs./ unit)**	**Net Return (Rs/ha)/ (Rs./ Unit)**	**BCR**	**Technology gap (q/ha)**	**Extension gap (q/ha)**	**Technology Index**
T1	41.77	180.28	28052	58879	30827	2.10	8.23	18.6	16.46
T2	23.17		16833	18850	7850	1.47			
P<0.05	1.06								

Table.2 Effect of lime on soil fertility status under rain fed condition

Treatments	**pH**		**Organic C (%)**			**Available N (kg/ha)**			**Available P (kg/ha)**			**Available K (kg/ha)**		
	Before	**After**	**Before**	**After**	**% increase**	**Before**	**After**	**% increase**	**Before**	**After**	**% increase**	**Before**	**After**	**% increase**
T 1	4.45	5.12	1.09	1.42	130.28	308.21	392.42	127.32	29.32	45.56	155.39	148.53	164.31	110.62
T 2	4.48	4.62	1.11	1.16	104.50	306.34	318.66	104.02	30.45	34.22	112.38	147.22	152.34	103.48

Fig.1 Furrow application of Lime in maize crop cultivation at Farmers field for three continuous demonstration years

Gap Analysis

From the Table 1 it is seems that the Extension Gap for the demonstrated Technology is 18.6 q/ha emphasized the need to educate the farmers through various mean for adoption of improved agricultural production to reverse the trend of wide extension gap. The technology gap is found 8.23 q/ha reflected the farmers' cooperation in carrying out such demonstration with encouraging results in all the years. The technology index of 16.46 per cent showed the feasibility of the evolved technology at the farmer's field. The reduction in technology index exhibited the feasibility of the demonstrated technology in this region.

Soil Fertility Status

Soil sample were collected and analyzed before the implementation of the FLD and after the harvesting of the Maize crop. The soil fertility status was significantly increased with the application of Lime along with organic and inorganic combination of fertilizer from initial to final stage of the crop during both the years of experimentation. From Table 2it is reveals that the soil is acidic in nature with high organic carbon content. A suitable pH is achieved in Treated plot i.e. pH 5.12 compare to Farmers practice i.e. pH 4.62. The Organic Carbon content is increased up to 130.28 % after the implementation of T1 i.e. Lime @ 400kg/ ha in Furrows + 50 % RDF + 1 t/ha vermicompost compare to Farmers practice. The available nitrogen, available phosphorus and available potassium status of soil after harvest of the crop was significantly increased (at 5% level of significance) due to application of the Treatment for all the year. There is a increase of 127.32 % of available nitrogen, 155.39% increase of available phosphorus and 110.62 % increase of available potassium is achieved in the Treated plot compare to the soil nutrient status before the implementation of the programme. It indicates that applications of organic sources with inorganic sources along with Lime were found more effective in building up soil fertility status as compared to farmers practice. So, the application of integrated use of recommended fertilizer dose along with Lime can successfully use for maintain and improve the soil fertility.

Maize is a very important crop among the farmers of RiBhoi District of Meghalaya. Soil acidity decreases the availability of most of the plant nutrients and so affects adversely on the productivity of crop. From the study, it can be concluded that application of Lime @ 400kg/ ha in Furrows + 50 % RDF + 1 t/ha vermicompost found effective for getting the highest yield of Maize as well as for improving the soil nutrient status. The suitable BC ratio reveals the economic viability of the demonstration and convinced the farmers to adopt the Technology. So, this soil test based Technology of application of reduced rate of lime as well as chemical fertilizers and vermicompost if adopt properly can lead to increase the Maize productivity in acidic soil and defiantly play an important role for motivating the farmers for adoption of new technology by popularizing the FLD among the Farmers of Meghalaya. Further researches are required for more reduction of Lime for increase the productivity of Maize crop in acidic soil of Northeast Region.

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