EFFECTS OF LIME ON THE GROWTH AND YIELD OF CORN IN MAASIN CLAY

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Portion of B.S. thesis conducted by the senior author in ViSCA.

Funded by the Philippine Coconut Producers Federation, Inc. (COCOFED).

ABSTRACT

Lime application did not affect the period from planting to seedling emergence, tasseling, and maturity; number of leaves at tasseling; plant height at maturity; and the number and weight of ears per plant and weight of 1000 grains. However, application of 3.3, 11.6 and 21.3 t dolomite/ha markedly increased stover yield, ear size, total grain yield and shelling percentage of corn. These levels of lime resulted in higher profitability over the control by as much as 209.57, 236.85 and 91.34 percent, respectively.

Application of 11.6 and 21.3 t dolomite/ha improved the chemical properties of the soil by increasing pH, organic matter and phosphorus. These lime rates also decreased the concentration of potassium and acidic ions like aluminum. In contrast, excessive lime application (31.3 t dolomite/ha) lowered the availability of P due to the formation of insoluble compounds. It also significantly reduced the different corn parameters.

Ann. Trop. Res. 9:34-42.

KEY WORDS: Lime. Dolomite. Corn (*Zea mays* L.). Growth. Yield. Maasin clay.

INTRODUCTION

Corn (*Zea mays* L.) ranks second to rice as the Philippines' most important staple food. It is also utilized in the manufacture of feeds, corn starch, corn oil and alcohol (PCARR, 1975). Due to the increasing human population and the progressing livestock industry in the country, it is necessary to increase corn production to meet the high demand for this commodity.

Reclamation of problem soils for corn production can alleviate corn shortage. A potential area for the cultivation of this crop is a large tract of land in Leyte (58,783.58 ha) which is dominated by Maasin clay of the Maasin soil series (Barrera et al., 1954). At present; it is not very productive due to its low pH (4 to 5.5), relatively high sesquioxide content, and deficiency in the basic essential nutrients. This area could be made more productive by liming which would adjust the soil pH to the desired level (5.6 to 7.5) for corn production.

This study was conducted to determine the appropriate amount of lime that would give optimum growth and yield of corn in Maasin clay; and to evaluate the effects of lime application on pH, organic matter, total nitrogen, available P and exchangeable K, Ca, Mg and Al of Maasin clay.

MATERIALS AND METHODS

Treatments and Experimental Design

The experiment was laid out in a 462 m^2 area with a soil pH of 4.8 using the randomized complete block design. Five rates of lime or dolomite, namely T_1 = 0 (control), T_2 = 3.3 t/ha, T_3 = 11.6 t/ha, T_4 = 21.3 t/ha and T_5 = 31.3 t/ha served as the treatments and each treatment was replicated 3 times. The said rates of dolomite were used to adjust the soil pH to 5.5, 6.5, 7.5 and 8.5, respectively. Each treatment plot measured 4.5 m wide and 5 m long. Alleyways of 1.5 and 0.75 m were provided between blocks and plots, respectively, to facilitate farm operations and cultural management.

Soil Sampling and Analysis

Before lime application; soil samples were collected at 15 cm depth, composited, air dried, sieved and then analyzed for pH, % organic matter (o.m.), total nitrogen (based on o.m. content using a factor of 1/20), phosphorus, potassium, aluminum, calcium and magnesium content. Another sampling was done at 2 months after planting for analysis of the same parameters. The soil samples were analyzed at the Bureau of Soils laboratory in Cebu City.

Lime and Fertilizer Application

The amount of lime required to adjust the soil pH to the desired level was determined using the Veitch method (Jackson, 1958). The required amounts of dolomite [$CaMg(CO_3)_2$, 75% pure] were uniformly broadcast and incorporated in the plow layer of the soil after land preparation but not later than one month before planting to allow the lime to react with the soil.

Inorganic fertilizer was applied following the recommended rate for corn (45-30-30 kg N, P_2O_5 and K_2O/ha) in all treatments. The whole amounts of P and K and half of N were applied at the time of planting and the remaining half of N was applied at one month after planting.

Planting and Cultural Management

One month after lime application, the area was plowed again and then harrowed before planting. Corn (Phil. DMR var. I) seeds were sown at a distance of 0.75 m between rows and 0.25 m between hills at the rate of 2 to 3 seeds/hill. The seedlings were thinned to one plant/hill at one week after emergence to get the desired plant population of 53,333 plants/ha.

Malathion and Benlate at the rate of 3 and 2 tbsp/5 gal of H_2O, respectively, were sprayed at 2-week interval to control insect pests and diseases. To control corn borer, Furadan granules were also applied to the whorl of each plant at the rate of 10 kg/ha prior to tassel emergence. Handweeding was done whenever necessary to keep the area weed-free throughout the growing period of the crop.

Determination of Growth and Yield Characters and Economic Analysis

Growth characters of corn such as the period from seeding to emergence and from emergence to tasseling and maturity were determined when about 85% of the plants had emerged, tasseled and matured, respectively. The number of leaves at tasseling and plant height at maturity were also recorded. Leaf area index (LAI) was observed when 85% of the plants had tasseled and stover yield, at harvest. Yield and yield components such as the number and weight of ears per plant, weight of 1000 grains, ear length and diameter, shelling percentage and total grain yield were noted after harvest. An economic analysis was made to identify the most profitable lime rate.

RESULTS AND DISCUSSION

Soil pH, Organic Matter, and Nutrient Content of the Soil

Table 1 shows the initial and final pH values, organic matter, N, P, K, Al, Ca and Mg content of the soil. The initial soil analysis indicated that the soil was very acidic (pH 4.8) with moderately low organic matter (2.5%) and available P (7 mg/kg), and high extractable K (106 mg/kg). The Al content was also relatively high (1.05 x 3.1 μMoles/kg soil) contributing to soil acidity. This level of Al is considered toxic to most cultivated crops (Gonzales-Erico et al., 1979).

Final soil analysis showed that lime application increased the soil pH, organic matter, total nitrogen (based on o.m. content) and avail-

Table 1. Initial and final pH values, organic matter, total N, available P, extractable K, and aluminum, calcium and magnesium contents of the soil as affected by rate of lime application.

Time of Analysis/ Lime Rate (t dolomite/ha)	pH	O.M. (%)	Total N (%)	Available Olsen's P (mg/kg)	Extractable K (mg/kg)	Extractable Al (mMoles/kg)	Extractable Ca (mMoles/kg)	Extractable Mg (mMoles/kg)
Initial[1]	4.8	2.5	0.125	7	106	3.26	3.2	0.7
Final[2]								
0 (control)	4.8	2.2	0.125	6	126	3.04	3.1	0.6
3.3	5.4	3.0	0.150	8	90	0.93	14.0	20.5
11.6	6.4	3.3	0.165	11	90	0.16	18.5	26.0
21.3	7.2	3.0	0.150	11	90	tr[3]	26.5	33.0
31.3	8.1	2.8	0.140	9	80	tr	27.5	35.5

[1] Determined before lime application

[2] Determined at harvest

[3] Trace amount

able P (Table 1). The increase in values could be due to the favorable influence of lime on microbial activity especially of those microorganisms which decompose soil organic matter and precipitate aluminum. This renders phosphorus available for plant use. The desired soil pH values for the different lime rates were not attained probably due to leaching of some liming materials. Application of 31.3 t dolomite/ha tended to decrease the aforementioned soil properties except pH. Brady (1974) claimed that excessive lime application induced P deficiency due to the formation of insoluble calcium or magnesium phosphate.

Application of lime in right amounts reduced the concentration of exchangeable aluminum ions and eliminated its toxic effect on the plant. Brady (1974) reported that increasing the rates of lime application correspondingly lowered the aluminum exchange capacity because of the conversion of aluminum into an insoluble gibbsite due to the presence of hydroxyl ions. Exchangeable potassium also decreased due to competition for cation adsorption sites. Upon lime application, most of the adsorbed K is replaced by calcium and magnesium which have higher replacing power and are greatly adsorbed by the soil. The concentrations of calcium and magnesium were greatly increased by high rates of lime application. This is expected because both are constituents of dolomite. The decrease in K could also be partly attributed to crop removal and leaching.

Agronomic Characters

The period from seeding to emergence and from emergence to tasseling and maturity, number of leaves at tasseling, and plant height at maturity were not significantly affected by lime application.

Leaf Area Index. Application of dolomite at 11.6 and 21.3 t/ha significantly increased the leaf area index of corn (Table 2). These levels of lime favored plant growth and development possibly due to greater solubility and availability of most macronutrients brought about by the increase in pH from 4.8 to 6.4 and 7.2, respectively. However, excessive amounts of lime (31.3 t dolomite/ha) tended to reduce LAI. This finding could be ascribed to the detrimental effects of overliming, e.g. deficiency of nutrients especially of phosphorus due to formation of complex and insoluble compounds. Brady (1974) reported that availability of P under this condition is greatly decreased due to the formation of insoluble calcium phosphate. In addition, the drastic change in pH (from 4.8 to 8.1) is in itself detrimental to plants.

Stover Yield. The stover yield of corn was significantly increased by the application of dolomite at 3.3, 11.6 and 21.3 t/ha (Table 2). This

Table 2. Leaf area index and stover yield of corn as affected by rate of lime application.[1]

Lime Rate (t dolomite/ha)	Leaf Area Index (LAI)	Stover Yield (t/ha)
0 (control)	1.50b	3.87c
3.3	1.70ab	5.13ab
11.6	1.90a	5.57a
21.3	1.74a	5.30a
31.3	1.56b	4.49bc
C.V. (%)	8.36	7.54

[1] Treatment means within a column followed by a common letter are not significantly different at 5% level, DMRT.

could be attributed to the beneficial effects of lime on crop growth as manifested by the production of bigger leaves. However, application of 31.3 t dolomite/ha remarkably decreased this parameter. This could be due to the drastic increase in soil pH from 4.8 to 8.1. Moreover, overliming also reduced nutrient availability due to fixation of P and some other micronutrients (Tisdale and Nelson, 1975).

Yield and Yield Components

The number and weight of ears per plant as well as the weight of 1000 grains were not significantly affected by lime application.

Ear Length. Application of 11.6 and 21.3 t dolomite/ha significantly increased the length of corn ears (Table 3). This could partly be ascribed to the increase in soil pH from 4.8 to 6.4 and 7.2, respectively, which led to the release of the essential macronutrients like nitrogen, phosphorus and potassium in the soil. However, application of 3.3 and 31.3 t dolomite/ha did not significantly affect this parameter. It seems that adjusting the soil pH from 4.8 to 5.4 is not sufficient to increase corn ear length. On the other hand, too much application of lime (31.3 t dolomite/ha) inhibited ear development.

Ear Diameter. The diameter of corn ears became considerably bigger with lime application regardless of rate. Ears with the biggest diameter (40 cm) were obtained

Table 3. Yield and yield components of corn as influenced by rate of lime application.[1]

Lime Rate (t dolomite/ha)	Ear Characteristic: Length (cm)	Ear Characteristic: Diameter (cm)	Shelling Percentage	Grain Yield (t/ha)
0 (control)	8.0c	3.5b	69.4c	1.4b
3.3	8.6bc	3.9a	74.5ab	2.6a
11.6	9.4a	4.0a	77.4a	3.0a
21.3	9.3ab	3.9a	75.1a	2.8a
31.3	8.3c	3.8ab	70.0bc	2.3ab
C.V. (%)	4.42	4.11	3.46	18.82

[1] Treatment means within a column followed by a common letter are not significantly different at 5% level, DMRT.

from plants treated with 11.6 t dolomite/ha while those with the smallest diameter (3.5 cm) were observed in the control plants (Table 3). Improved production and translocation of manufactured food as a result of increased leaf area probably led to the formation and development of bigger ears. However; higher amount of lime (31.3 t dolomite/ha) tended to reduce the ear diameter probably due to overliming of the soil. Overliming of soils which are high in oxide coating increases the absorptive capacity of the soil for elements like boron and phosphorus (Sanchez, 1976). This reduces the availability of other nutrients and must have consequently reduced corn ear diameter.

Shelling Percentage. Significant differences in shelling percentage of corn as affected by lime treatments were noted. The highest shelling percentage of 77.4% was obtained from plants treated with 11.6 t dolomite/ha while the lowest value (69.4%) was observed in the control. Application of higher amount of dolomite (31.3 t/ha) or none at all gave lower shelling percentages.

Lime application significantly influenced shelling percentage because of higher and better-regulated nutrient release from the soil especially the uptake of phosphorus. Brady (1974) pointed out that this characteristic is important during flowering and fruiting as well as during seed formation and development.

Total Grain Yield. Application of lime regardless of rate significantly increased the total grain yield (Table 3). However, application of 31.3 t dolomite/ha resulted in relatively lower yield probably because this level of lime precipitated some of the soil P and the low available P content could have affected the normal growth and development of the crop.

The highest grain yield (3.0 t/ha) was obtained in plants that received 11.6 t dolomite/ha while the lowest (1.4 t/ha) was observed in the control plants. The highest grain yield in the 11.6 t dolomite/ha treatment could be attributed to the production of more photosynthates due to increased leaf area. Furthermore, the improvement of the chemical properties of the soil due to the increase in soil organic matter and pH as well as the availability of most essential nutrients (Table 1) could have favored grain production.

Economic Analysis

Generally, lime application was profitable (Table 4). Application of 11.6 t dolomite/ha gave the highest net return of ₱2769.58/ha, followed by application of 3.3 t dolomite/ha (₱2545.26/ha), and 21.3 t dolomite/ha (₱1573.16/ha). These levels of lime increased profitability over the control by as much as 236.85, 209.57 and 91.34%, respectively. The least net return of ₱822.20/ha was noted in the control while a negative net return was obtained with application of 31.3 t dolomite/ha.

Application of lime increased corn yield and profitability. How-

Table 4. Economic analysis of corn production using different rates of lime application.

Lime Rate (t dolomite/ha)	Grain Yield (kg/ha)	Gross Return[1] (₱)	Cost of Production (₱)	Net Return (₱)
0 (control)	1430	2860	2037.80	822.20
3.3	2580	5160	2614.74	2545.26
11.6	3050	6100	3330.42	2769.58
21.3	2850	5700	4126.84	1573.16
31.3	2270	4540	4946.34	-406.34

[1] Computed based on sale price of ₱2.00/kg of corn.

ever, the addition of greater amounts of lime (beyond 21.3 t dolomite/ha) seems not economical due to higher cost of the fertilizer material and the added labor cost. Moreover, the detrimental effects of overliming on soil properties such as reduced nutrient availability, results in poor crop productivity.

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