International Journal of Research in Agricultural Sciences
Volume 2, Issue 2, ISSN (Online): 2348 – 3997)

# Soil Nutrient Management for Hybrid Corn Grown in Acid Upland Soil of Eastern Samar Based on NuMASS Prediction

**Lito D. Lacaba**
Ph.D. Eastern Samar State University Salcedo Campus Salcedo, Eastern Samar Philippines
email: essu_salcedo@yahoo.com

***Abstract:*** **A field experiment was conducted at the Research Center of the Eastern Samar State University-Salcedo campus, Salcedo, Eastern Samar. This experiment was conducted to identify soil nutrient management practices in acid upland that favorably improves the growth and yield of hybrid corn; determine the optimum rate of nitrogen and phosphorus favorable for hybrid corn; determine the growth and yield of hybrid corn due to liming; evaluate the liming effect of organic matter; and, validate the diagnosis and prediction of NuMASS for hybrid corn in Eastern Samar.**

**Grid samples were analyzed before and after the experiment. These samples served as basis for NuMASS prediction. Plot samples analysis was made before and after the experiment to determine changes in its chemical properties. Randomized Complete Block Design (RCBD) was used in the experiment involving three replications and 16 treatments.**

**Results showed that exchangeable bases ($Ca^{++}$, $Mg^{++}$, $K^{+}$) were increased due to liming thereby reducing the level of exchangeable $H^{+}$ and $Al^{3+}$. Moreover, the effective cation exchange capacity (ECEC) was increased; Al saturation was lower below the critical level thereby increasing pH and available P.**

**Corn plants applied with the predicted level of nitrogen (180 kg/ha), phosphorus (60 kg/ha) and lime (4 t/ha) showed the highest yield (5,685.48 kg/ha) among the treatments indicating high reliability of diagnostic and predictive capability of NuMASS for N, P and lime. Applying one-half of the NuMASS recommended rate yielded only 1,557.81 kg/ha with a difference of 4,127.67 kg/ha from the recommended level. Two tons of lime applied failed to increase the exchangeable bases to lower the critical Al saturation of corn plants (<30%).**

**Soil analysis showed that plots applied with 90 kg N/ha and 30 kg P/ha have low level of nitrogen and phosphorus after harvest. P buffer coefficient was established at 0.218. Doubling the rate of N (360 kg/ha) and P (120 kg/ha) along with the recommended rate of lime showed a slight reduction in yield (5,580.09 kg/ha) with a difference of 105.39 kg/ha from plots applied with NuMASS predicted rate. The complete check had 100 percent barren plants.**

**Liming the soil with dolomite at the rate of 4 t/ha significantly improved all agronomic parameters of the corn plant. The effect of this liming material was better than using 50% dolomite and 50% gypsum. Results of plant tissue analysis showed higher concentrations of $Mg^{++}$ of the ear leaf (at silking) vegetative parts (at maturity) and grains.**

**Application of organic materials like ipil-ipil leaves or rice hull ash at the rate of 5 tons/ha improved the growth and yield of corn plants than the unlimted plots. Results of soil analysis showed reductions in the concentrations of micronutrients particularly iron and manganese as a result of organic materials application. Also, organic materials lower Al concentration below the critical level. In general, ipil-ipil leaves were more effective than rice hull in increasing the yield of corn.**

***Key words:*** **NuMASS, Lime, Nitrogen, Phosphorus**

## I. INTRODUCTION

Soil acidity is one of the problem soils that persist in most underdeveloped countries. These soils are low in nutrients and often are far from sources of lime and fertilizers making it difficult to increase their fertility (Brady, 1996). The consequences of poor yields include food insecurity, economic hardship, further deforestation and increased soil exposure, erosion and downstream pollution. Upon overcoming soil acidity and nutrient constraints new cropping strategies are possible, products and services are diversified, vegetative soil protection increases and off-site nutrient is minimized (Osmond *et al.*, 1999).

Corn is grown on approximately eight million hectares of acidic (pH <5.6) soils where P deficiency is an important limitation to its productivity (Pandy *et al.*, 1994 as cited by Fageria *et al.*, 1997). These soil problems are the most localized and often the most obscure of the environmental constraints on development because it reveal themselves to casual observation and may change significantly within a traverse of a few meters.

Relevant to this, various agricultural programs are geared towards this effort of finding a solution to soil acidity. In fact, the Soil Management Collaborative Research Support Program (SM-CRSP) through PhilRice as one of its networks has developed and introduced software to assist researchers for effective soil nutrient management decisions. This program is known as NuMaSS, which stands for Nutrient Management Support System. It has three components namely: acidity decision support system (ADSS), nitrogen decision support system (NDSS) and phosphorus decision support system (PDSS). This computer-based system allows users to diagnose individual nutrient problems and evaluate different solutions. With user replying to questions about soils, crops, available nutrient-supplying materials, the programs recommend best management strategies (Osmond *et al.*, 1999). Thus, given with best alternatives to ameliorate soil acidity along with levels of fertilizers that a researcher/farmer must apply, it would be feasible that production and income will be boosted.

## II. Objectives of the Study

The general objective of the research was to gather information needed to alleviate soil acidity problem by liming and organic matter addition in growing hybrid corn.

Specifically, the study was designed to:

1. Identify soil management practices in acid upland that would favorably improve the growth and yield of hybrid corn;
2. Determine the growth and yield of hybrid corn due to liming;
3. Determine the optimum rate of nitrogen and phosphorus fertilization favorable for hybrid corn production;
4. Evaluate the liming effect of organic matter; and,
5. Validate the diagnosis and protection of NuMaSS for hybrid corn in Eastern Samar.

## III. Methodology

### *Experimental Design*

The experiment was laid out in Randomized Complete Block Design (RCBD) and replicated three times. The experimental treatments were based mainly on NuMaSS prediction. Specific responses for N, P, lime and organic amendment were also determined. These various groupings were provided with control or check.

### *Soil Sampling and Analysis*

During the first sampling, soil samples were collected from 8m x 9m grid of the whole experimental area consisting of 21 grids with 10 points in each grid. Soil samples were collected at a depth of 0-15 cm using small shovel before plowing the area. Air-dried samples (500 g) were also analyzed at PhilRice to determine some important physical and chemical properties. These included pH 1:1 soil: water, % organic carbon, total N, Mehlich 1-P, P buffer coefficient, exchangeable bases (Ca, Mg, K) and micronutrients (Mn, Fe, Cu, Zn). Moreover, two important physical properties were also analyzed. These were percentage clay and bulk density. Average data obtained from this analysis was used to predict the amount of N, P, and lime to be used in the experiment.

After the field was laid out, soil sample at 0-15 cm depth was again collected from each plot (composite sample from 5 cores/plot). Moreover, subsoil samples from plots with gypsum application were taken at a depth of 15-30 cm to determine changes in pH.

The third sampling was done after the harvest of the corn crop at a depth of 0-15 cm near the base of the plant from 5 cores. Result of the soil analysis of samples before planting and after harvest of the corn crop was compared to determine if there were significant changes in nutrient levels.

## IV. Results and Discussion

### *Soil Analysis*

*Soil pH.* Established pH before conducting the experiment ranges from 4.43 to 4.56. The pH levels were true throughout the experimental area. After the experiment, Results showed that plots receiving the recommended rate for lime were increased to high as 6.65. Similar result was obtained with the veitch method simulated in the laboratory to see the trend in pH level with the incremental addition of lime. In fact, it reached almost neutral as the lime added was increased to 6.0 tons/ha. This result is coupled with a significant reduction in the exchangeable $H^+$ and $Al^{3+}$ in the soil reaching zero (0) value as the pH approaches to 7.0.

*Organic Carbon.* Level of organic carbon was slightly increased especially in plots treated with organic matter. This can be attributed to decomposition of the organic material added to the soil.

*Nitrogen.* Total nitrogen was not significantly increased in the soil after the experiment except in plots treated with 360 kg N and applied with 180 kg N + organic matter.

*Phosphorus.* With respect to P level, significant changes were observed in plots treated with lime and at the same time receiving the predicted level of phosphorus. This can be explained by the fact that as the $Al^{3+}$ and $H^+$ concentrations and to some extent $Fe^{3+}$ and $Mn^{2+}$ are neutralized in the soil, a relatively high amount of P becomes available in the solutions. This implies that fixation of added P fertilizer is minimized and at the same time, soil P is released which were precipitated by $Al^{3+}$ of fixed in the clay micelles. Liming had a very significant influence on P availability since it was found out that soil used in the experiment has a high P buffer coefficient of 0.218. This means that more P fertilizer is required to saturate the P fixation capacity of the soil without lime.

*Exchangeable $Al^{3+}$ and $H^+$.* Significant reduction in the exchangeable aluminum and acidity was recorded as more lime was added. This was expected because the bases, e.g. $Ca^{2+}$ and $Mg^{2+}$ contained in the liming materials have replaced hydrogen ion and aluminum on the colloidal complex. The reduction therefore of exchangeable $Al^{3+}$ and $H^+$ with the subsequent adsorption of calcium and magnesium ions raised the percentage base saturation, depressed Al saturation but increased the pH of the soil solution.

*Exchangeable bases.* Addition of lime increased the level of exchangeable bases. Calcium, magnesium and potassium were significantly increased to a level enough to increase the effective cation exchange capacity and reduce the percentage of aluminum saturation of the soil favorable for corn plant (<30%).

*Aluminum Saturation.* Prior to the experiment, the aluminum saturation concentration ranges from 51.92% to 57.89% which is beyond the critical level for corn plant. However, with the application of the recommended rate of lime, it was significantly reduced to as low as 3.61%

*Micronutrients.* With the subsequent increase in the pH level due to the addition of lime, micronutrients particularly Fe, Mn and Zn were considerably reduced except Cu concentration with increasing value.

## V. Growth Parameters

Table 1 shows that among the 15 treatments evaluated, corn plants applied with 360N-60P-4L and 180N-120P-4L were considered the best having attained plant height ranging from 213.97 cm to 217.20 cm. The least of the treatments is the complete check that achieved only 53.30 cm. Severe nutrient deficiency was observed in this treatment characterized by internodes that were very short.

With regards to the stem diameter, the obtained value ranged from 0.44 cm in the complete check to 3.58 in plots receiving the NuMaSS Prediction. This implies that liming had sufficiently neutralized acidity and lowered Al concentration thus enabling the plant to effectively utilize both soil and applied P in addition to sufficient nitrogen applied into the soil.

Percent barren plants were also affected by the levels of nitrogen, phosphorus and lime. As the amount of lime increased, percentage barrenness was reduced from 31.10 to 0. This is because calcium supplied is essential in the production of seeds and in the movement of sugar and starch within the plant. Moreover, fixed P was released into the soils. Available nitrogen also enhances amino acid production, protein synthesis and cell division.

Table 1. Growth of Corn Applied with Varying Levels of Nitrogen, Phosphorus and Lime

| **Treatment (N*-P*-L**)** | **Plant Height (cm)** | **Stem Diameter (cm)** | **Percent Barren Plants (%)** |
|---|---|---|---|
| 0-0-0 (complete check) | 53.30$^{j}$ | 0.44$^{d}$ | 100.00$^{a}$ |
| 90-30-2 | 165.00$^{f}$ | 1.75$^{c}$ | 26.92$^{c}$ |
| 180-60-4 | 206.90$^{b}$ | 3.58$^{a}$ | 0.00$^{h}$ |
| 360-120-4 | 197.63$^{c}$ | 3.58$^{a}$ | 0.00$^{h}$ |
| 0-60-4 | 117.03$^{i}$ | 1.85$^{c}$ | 24.92$^{d}$ |
| 90-60-4 | 145.83$^{h}$ | 2.34$^{c}$ | 18.18$^{e}$ |
| 360-60-4 | 217.20$^{a}$ | 3.54$^{a}$ | 0.00$^{h}$ |
| 180-0-4 | 152.13$^{g}$ | 0.75$^{c}$ | 24.35$^{d}$ |
| 180-30-4 | 163.80$^{f}$ | 0.93$^{b}$ | 16.57$^{f}$ |
| 180-120-4 | 213.97$^{a}$ | 1.18$^{a}$ | 0.00$^{h}$ |
| 180-60-0 | 145.80$^{h}$ | 0.62$^{c}$ | 31.10$^{b}$ |
| 180-60-2 | 164.97$^{f}$ | 1.02$^{b}$ | 8.54$^{g}$ |
| 180-60-(2+2) | 207.33$^{b}$ | 3.39$^{b}$ | 4.27$^{g}$ |
| 180-60-(0+ipil-ipil) | 176.83$^{e}$ | 2.37$^{c}$ | 9.40$^{f}$ |
| 180-60-2 +ipil-ipil | 183.73$^{d}$ | 3.40$^{b}$ | 2.99$^{g}$ |
| 180-60-(0+rha) | 165.07$^{f}$ | 2.26$^{c}$ | 16.23$^{e}$ |

*kg/ha **t/ha
Treatment means followed by common letters are not significantly different using DMRT=.05

## VI. Yield Parameters

Table 2 indicates that the recommended rate of nitrogen, phosphorus and lime produced the highest yield among the treatments evaluated in this study. This has something to do with the availability of nitrogen, and phosphorus which are essential in protein synthesis and cell division. The presence of $Mg^{2+}$ which are essential in chlorophyll formation, which enhances the photosynthetic process of the plants.

Table 2. Yield and Yield Components of Corn Plants Applied with Varying Levels of Nitrogen, Phosphorus and Lime.

| **Treatment (N*-P*-L**)** | **Number of kernel row/ear** | **Number of kernels/ kernel row** | **Number of kernels/ ear** | **Length of effective ear** | **Ear diameter** | **Shelling recovery** | **Yield (kg/ha)** |
|---|---|---|---|---|---|---|---|
| 0-0-0 (complete check) | 0.00$^{g}$ | 0.00$^{f}$ | 0.00$^{k}$ | 0.00$^{j}$ | 0.00$^{j}$ | 0.00$^{g}$ | 0.00$^{k}$ |
| 90-30-2 | 13.13$^{f}$ | 31.53$^{e}$ | 295.27$^{g}$ | 14.13$^{f}$ | 3.22$^{f}$ | 63.87$^{cd}$ | 1157.81$^{gh}$ |
| 180-60-4 | 18.07$^{a}$ | 41.80$^{a}$ | 632.70$^{a}$ | 21.43$^{c}$ | 5.32$^{a}$ | 83.52$^{a}$ | 5685.48$^{a}$ |
| 360-120-4 | 17.33$^{abc}$ | 42.27$^{a}$ | 631.17$^{a}$ | 22.00$^{b}$ | 5.32$^{a}$ | 82.43$^{a}$ | 5580.09$^{a}$ |
| 0-60-4 | 13.13$^{f}$ | 21.47$^{g}$ | 183.87$^{i}$ | 10.83$^{h}$ | 2.70$^{h}$ | 58.63$^{e}$ | 527.77$^{i}$ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 90-60-4 | $14.60^{edf}$ | $37.00^{d}$ | $421.77^{e}$ | $17.67^{e}$ | $4.16^{e}$ | $76.76^{b}$ | $2662.94^{d}$ |
| 360-60-4 | $17.40^{ab}$ | $42.40^{a}$ | $627.03^{a}$ | $22.57^{a}$ | $5.34^{a}$ | $83.68^{a}$ | $4975.53^{ab}$ |
| 180-0-4 | $13.47^{ef}$ | $22.23^{g}$ | $178.67^{i}$ | $11.45^{gh}$ | $2.61^{h}$ | $65.96^{c}$ | $699.31^{h}$ |
| 180-30-4 | $15.20^{bcde}$ | $37.20^{d}$ | $401.50^{f}$ | $17.63^{de}$ | $4.35^{d}$ | $73.60^{b}$ | $2433.41^{de}$ |
| 180-120-4 | $16.00^{abcd}$ | $42.33^{a}$ | $630.90^{a}$ | $22.60^{a}$ | $5.30^{a}$ | $84.44^{a}$ | $5219.76^{a}$ |
| 180-60-0 | $13.53^{ef}$ | $18.70^{h}$ | $116.03^{j}$ | $8.30^{i}$ | $2.69^{h}$ | $53.03^{f}$ | $492.32^{j}$ |
| 180-60-2 | $15.20^{cdef}$ | $38.77^{c}$ | $469.57^{d}$ | $18.32^{d}$ | $4.53^{c}$ | $76.32^{b}$ | $2227.82^{def}$ |
| 180-60-(2+2) | $16.20^{abcd}$ | $41.00^{b}$ | $591.70^{b}$ | $21.68^{b}$ | $5.10^{b}$ | $83.06^{a}$ | $4247.98^{bc}$ |
| 180-60-(0+ipil-ipil) | $12.60^{f}$ | $26.77^{f}$ | $221.90^{h}$ | $14.57^{f}$ | $3.12^{g}$ | $65.08^{cd}$ | $1685.07^{efg}$ |
| 180-60-2 +ipil-ipil | $15.13^{cdef}$ | $40.60^{b}$ | $503.00^{c}$ | $21.37^{bc}$ | $5.24^{a}$ | $83.64^{a}$ | $4056.58^{c}$ |
| 180-60-(0+rha) | $12.73^{f}$ | $22.03^{g}$ | $181.63^{f}$ | $11.23^{g}$ | $2.46^{i}$ | $61.84^{de}$ | $1357.14^{g}$ |

*kg/ha **t/ha

Treatment means followed by common letters are not significantly different using DMRT=.05

## VII. Conclusions

Based from the findings enumerated, the following conclusions were drawn.

1. Growth and yield of hybrid corn can be improved and maximize in acid upland soil if appropriate soil management practices are followed by the farmers. Application of the right amount of N, P and Lime improve the nutrient conditions of soil and reduced Al saturation, decreasing Fe and Mn, and increasing pH and available P.
2. Application of the right amount and kind of lime in acid soil coupled with the application of recommended level of nitrogen and phosphorus maximized production. Oversupply of nitrogen and phosphorus beyond the recommended rate however, had no significant effect particularly in the yield of corn.
3. NuMaSS had predicted the N, P, and Lime requirement of the corn in this acid upland soil.

## VIII. Recommendations

From the data gathered, the researcher attempts to recommend the following:

1. Lime coupled with the addition of the recommended levels of N and P must be used by farmers in acid upland soil to improve the growth and yield of hybrid corn. Prior to liming and fertilizer application, soil samples must first be analyzed to get a valid recommendation. Since acid soil is also depleted or deficient with magnesium as much as possible farmers must select dolomitic lime whenever available.
2. Agricultural institutions must showcase the technology for farmers to actually see the importance of using this technology as a means of improving productivity of acid upland.
3. To establish validity and reliability of NuMaSS in predicting the N, P and Lime requirements, on-farm trials in farmers' field involving more sites be conducted in Eastern Samar.

## References

[1] BRADY, N.C. and R.R. WEIL, 1996. The Nature and of Properties of Soil, 11th ed. Prentice Hall, Inc. 271-305.
[2] FAGERIA, and V.C. BAGERIA 1997. Soil Acidity Affects Availability of NPK. Better Crop International, Journal of Plant Nutrition 20 (10):
[3] OSMOND, D.L., T.J. SMYTH, W.S. REID, R.S. YOST, W. BRANCH and X. WANG. 1999. Nutrient Management Support System (NuMaSS, version 1.0. Soil Management Collaborative Research Support System. Raleigh, N.C. North Carolina State University.

## Author's Profile

**Dr. Lito D. Lacaba** is a graduate of Doctor of Philosophy in Crop Science minor in Soil Science. Presently, he is connected to the EASTERN SAMAR STATE UNIVERSITY-Salcedo Campus as Associate Professor V and designated as Dean of the College of Agriculture and Allied Sciences and in concurrent capacity as Head of the Research Services of the campus.

He had conducted a number of researches, presented research findings in national and international conferences and serve as research adviser for undergraduate and graduate students.

email: essu_salcedo@yahoo.com