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Soil pH and lime requirement for high potential communal areas of Zimbabwe

J. Nyamangara[1] and S. E. Mpofu[2]

[1]Crop Nutrition Section, Chemistry and Soil Research Institute, P. O. Box CY 550, Causeway, Harare, Zimbabwe

[2]Institute of Agricultural Engineering, P. O. Box BW 330, Borrowdale, Harare, Zimbabwe

Abstract

A steady increase in the use of acidifying nitrogenous fertilisers by Zimbabwe's communal area farmers since 1980 has not been matched by liming the soils to correct soil pH. A study was conducted in 1995 to assess the pH status of soils based on soil samples submitted to the Chemistry and Soil Research Institute of the Department of Research and Specialist Services by the communal area farmers in 1982-84 and 1992-94 so as to assess the lime requirement of the soils. Results showed that there was a gradual acidification of the soils. During the 10-year period the proportion of soils with pH of 5,0 or less increased from 42% to 77%. The soil pH results implied potential problems of crop production which included low fertiliser effectiveness in 77% of the soils with pH of 5,0 or less, Al toxicity and P deficiency in 43% of the soils with pH of 4,5 or less, and micronutrient deficiency (e.g. Mo).

Key words: Soil, lime, communal, pH

Introduction

Soil pH gives an indication of relative availability of plant nutrients. At low pH values, Fe, Zn, Cu and Co become more available but Mo becomes less available. P is never readily available, but availability is generally highest around pH 6,5. At pH values below 5,5 Al, Mn and Fe may become toxic to plants. Using regular dressings of lime is a basic principle of good farming, especially on soils that have a low buffering capacity (Cooke, 1975). Liming eliminates acid toxicity, improves Ca supply, increases P and Mo availability and ensures optimal bacterial nitrogen fixation (Finck, 1982). Maintenance of soil pH through liming assures optimal conditions for organisms responsible for the decomposition of organic matter and transformation of N, P and S to available forms. However, over-liming may induce trace-element deficiency problems especially on acid sandy soils.

Since 1980, there has been a steady increase in Communal Area (CA) crop production, especially in high rainfall communal areas. Average maize yield in communal areas rose from 402 kg/ha in 1969/70 to 1154 kg/ha in 1988/89 (Anderson *et al.*, 1993). Shumba and Waddington (1993) reported that maize yield in communal areas increased from 342 kg/ha in 1951-55 to 1 056 kg/ha in 1986-90. Shumba (1986) reported an average yield of 2 670 to 3 700 kg/ha in Mangwende CA. Table 1 shows some high maize yields attained by some CA farmers in high rainfall areas during the 1992-93 and 1993-94 seasons. Humphreys (1991) noted that the increase was due to better access by the communal farmers to credit facilities to acquire the necessary inputs. The same author reported that the amount of fertiliser used by communal and small-scale commercial farmers increased from 27 113 tonnes in 1979/80 to 110 953 tonnes in 1989/90. The contribution of maize delivered to the Grain Marketing Board (GMB) by communal farmers rose from 8% in 1976-80 to 48% in 1984-88. A large proportion (80%) of this maize delivered came from high

Table 1: Maize yields from selected high rainfall communal areas in Zimbabwe (Agritex-Contill Project)

Communal Area	Season	Average Yield (t/ha)	Yield Range (t/ha)	n
Musana	1992/93	7,65	3,70 - 10,65	15
Chinamhora	1992/93	6,67	3,15 - 11,42	21
Chiweshe	1992/93	5,27	2,62 - 7,72	23
Musana	1993/94	6,61	3,72 - 8,90	21
Chinamhora	1993/94	7,37	3,72 - 10,10	15
Chiweshe	1993/94	5,18	1,62 - 8,34	22

rainfall (greater than 750 mm/annum) areas (Shumba and Waddington, 1993).

However, the apparent increase in the use of fertilisers has not been matched by an increased use of lime to correct soil acidity in communal areas. Although maize, the staple crop, is generally tolerant to acidity (Grant, 1971) most crop rotations in Zimbabwe's communal areas are based on maize and millets in a limited rotation with groundnuts (Mashiringwani, 1983). A groundnut yield response has been reported in soils with pH values less than 5,0 ($CaCl_2$) (Shumba, 1983). Therefore, if the full benefits of the inclusion of groundnuts or other legumes in a rotation are to be realised, the soils have to be limed to pH values of about 5,0 ($CaCl_2$).

Earlier research work (Grant, 1981) reported that the need for lime in communal areas was minimal because only small amounts of acidifying nitrogenous fertilisers were used. The other reason was the use of manure, the traditional form of fertiliser, which reduces soil acidity. In recent years it has been found that this is no longer the case. Avila (1987) reported that the majority of communal area farmers do not own enough cattle to produce adequate manure to fertilise their fields. Extension workers in the Chinamhora communal lands noted that soil acidity was a major yield limiting factor in the area where some farmers applied fertiliser rates of 300 kg Compound D (8% N, 14% P_2O_5, 7% K_2O, 6.5% S) and 300 kg Ammonium Nitrate (34.5% N) per hectare to their maize fields (Nyamangara, personal comm., 1994). The aim of this study was to assess the pH status of communal area soils based on soil

Table 2: Distribution of soil samples submitted by communal area farmers to the Chemistry and Soil Research Institute in 1982-84 and 1992-94 according to texture

Texture	1982-84		1992-94	
Sa	35	(51)	161	(64)
LSa	8	(11)	27	(11)
SaL	13	(19)	22	(9)
SaCL	9	(13)	30	(12)
SaC, C	4	(4)	12	(5)
Total	69	(100)	252	(100)

Key: (1) Sa= sand; LSa = Loamy sand; SaL = Sandy loam; SaCL = Sandy Clay Loam; SaC = Sandy Clay; C = Clay
(2) Soil samples in each textural class-number and percentage (brackets)

samples submitted to the Chemistry and Soil Research Institute (CSRI) by communal area farmers, and thereby assess the lime requirement for the soils.

Methods and materials

Soil pH and texture results of soil samples submitted by and on behalf of CA farmers to the CSRI in 1992-94 were compiled. A total of 252 soil samples were submitted by CA farmers during this period. The soils were classified according to Natural Regions and Farming Areas of origin (Surveyor General, 1984). 64% of the samples originated from Natural Region (NR) II, 34% from NR III and 4% from NR IV. Soil pH and texture results of soil samples (69) submitted by CA farmers to CSRI in 1982-84 were also compiled for comparative purposes. Of the 69 samples, 54% originated from NR II, 20% from NR III, and 26% from NR IV and V. Table 2 shows the distribution of the soil samples used in the study according to texture.

Soil pH determination was based on air-dried soil passed through a 2 mm sieve. A 15g sub-sample was weighed into a honey jar to which 75 ml of 0,01M $CaCl_2$ was added. The mixture was shaken for 1 hour before pH was read from the suspension. Soil texture was determined by hand texturing. The soils were classified into pH categories using the criteria shown in Table 3.

Table 3: Criteria used to classify soils into different pH categories at the Chemistry and Soil Research Institute

pH value ($CaCl_2$)	pH status
Below 4,0	Extremely acid
4,0 - 4,5	Very strongly acid
4,5 - 5,0	Strongly acid
5,0 - 5,5	Medium acid
5,5 - 6,0	Slightly acid
6,0 - 6,5	Neutral
6,5 - 7,0	Mildly alkaline
7,0 - 7,5	Alkaline
Above 7,5	Strongly alkaline

Results

The number of soil samples submitted for analysis by CA farmers in 1982-84 were relatively small (69) compared to 1992-94 (252). However, the majority of the samples, 62% in 1982-84 and 75% in 1992-94, were either sands or loamy sands. This was expected since the majority of communal areas are located on sandy soils which cover two-thirds of Zimbabwe (Grant, 1981).

The results showed that 43,25% of the soils in 1992-94 had pH values ($CaCl_2$) in the very strongly acid range (4,0 to 4,5) compared to 18,84% in 1982-84 (Table 4). In 1992-94, 33,73% of the samples were in the strongly acid range (4.6 to 5.0) compared to 21,74% in 1982-84. The remainder of the soils, 23,02% in 1992-94 and 57,97% in 1982-82, had pH values above 5,0 ($CaCl_2$).

Table 4: Soil sample pH ($CaCl_2$) categories for soil samples submitted to Chemistry and Soil Research Institute by CA farmers in 1982-84 and 1992-94

pH Range	1982-84		1992-94	
Below 4,0	1	(1,45)	0	(0)
4,0 to 4,5	13	(18,84)	109	(43,25)
4,6 to 5,0	15	(21,74)	85	(33,73)
5,1 to 5,5	21	(30,43)	32	(12,70)
Above 5,5	19	(27,54)	26	(10,32)
Total	69	(100,00)	252	(100,00)

Notes: Soil samples in each pH category-number and percentage (brackets)

The data in Table 4 showed that about 24% of arable soils in communal areas had become very strongly acid over a 10-year period. During the same period about 12% of the soils had become strongly acid. Soils with pH values above 5,0, which is the favourable range for most arable crops, had decreased by about 35%.

Discussion

The pH range between 6,0 and 7,0 (about 5,0-6,0 on the $CaCl_2$ scale) is the most favourable for the availability and effectiveness of most nutrients (Jacob and Uexkull, 1958). The results implied potential problems of crop production which include low fertiliser effectiveness in 77% of the soils with pH of 5,0 or less, and Al toxicity and P deficiency in 43% of the soils with pH of 4,5 or less. The evident soil pH decline over a 10-year period may become a major soil fertility constraint to crop production in communal areas in the future.

Table 5: The criteria used at the Chemistry and Soil Research Institute to determine the amount of lime required to increase soil pH by 0,3 units for most Zimbabwean soils

Soil Texture	Lime Required (kg/ha)
Sand	600
Loamy Sand	800
Sandy Loam	1000
Sandy Clay Loam	1500
Clay	2000

Table 5 shows the criteria used at CSRI to determine the amount of lime required to increase soil pH ($CaCl_2$) by 0,3 units for most Zimbabwean soils. According to Grant (1971), for maize production, granitic sandveld soils must be limed to a pH value of 4.7 ($CaCl_2$). Based on that criterion, 56% of the soils analysed in 1992-94 needed to be limed compared to 26% in 1982-84. Since most of the soils evaluated are sands which have a low buffering capacity, the pH should be raised to favourable thresholds gradually to avoid possible micronutrient deficiencies, e.g. Zn (Marschner, 1986). Although "ploughing in" is a less effective method of lime application compared to "discing in" (Grant, 1970), it is the best alternative that will auger well with most communal area farming systems.

A survey conducted in Chinamhora CA revealed that farmers were aware of the need to lime their soils, but were limited by the unavailability of lime in local shops, the large threshold tonnage required when purchasing from the manufacturer and information on lime requirement. Most farmers rotated maize with vegetables. Vegetables have a lucrative market in Harare and are heavily fertilised with nitrogenous fertilisers and thus contribute considerably to the acidification of the soils.

Conclusion

The majority of CA farmers, especially in high potential areas, are now applying high rates of acidifying nitrogen fertilisers. This is evidenced by the relatively high maize yields realised by some CA farmers. There is a gradual acidification of CA arable soils which might become a major soil fertility constraint to crop production in future. The soil pH results implied increasing potential problems of crop production on the soils which include low fertiliser effectiveness, P and micronutrient deficiency and Al toxicity. Although it has been reported that many tropical crops do not respond to liming if pH exceeds 5.2 (Russel, 1973), the significance of high acidity in reducing fertiliser use efficiency in Zimbabwe's communal areas has not been assessed. Therefore, the majority of the soils, especially in high rainfall areas, must be limed to a pH value of about 5,0 ($CaCl_2$), which is the favourable threshold for many crops rotated or intercropped with maize in the communal areas.

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