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REMINERALISATION OF TROPICAL FERALLITIC SOILS USING VOLCANIC ROCK (TEPHRA) POWDER IN THE FERTILISATION OF BAMBILI SOILS, EXPERIMENTED ON *ZEA MAYS*, CAMEROON

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ABSTRACT

Totap is situated at the North-East of Mount Bambouto, explosive volcanism emplaced strombolian cones with tephra. Tephra is often used as a constituent of cement and for road surfacing. This product is abundant in Cameroon which is not exploited by the agricultural sector as a natural fertiliser. The goal of this experiment was to evaluate the fertilisation potentials of different proportions of tephra (15, 20 and 25%) on the growth of *Zea mays*. The experiment was carried out in pots and evaluation was done through some soil physico-chemical parameters like pH, cationic exchange capacity (CEC), exchangeable bases and plant growth parameters (number of leaves, height and diameter of girth). It was observed that, .after eight weeks of growth there was a general decrease in plant growth on soil without fertilizer (T0), a slight increase in those with NPK fertiliser (T1) and a progressive increase with increase in the proportion of tephra. The use of NPK and Tephra had a general increase in number of leaves, height of plant and diameter of girth over the control. The general increase of growth parameters was due to a progressive release of elements in the tephra, treatments with 20% tephra presented the best results compared to the others. Tephra powder can be use as a natural fertiliser to ameliorate crop productivity and foster economic growth within Cameroon.

INTRODUCTION

The rate of famine in Africa has been on the increase especially in Sub-Saharan Africa (30%) due to a demographic explosion and also due to the low use of chemical fertilizers which are expensive. These chemical fertilizers have a lot of inconveniences in that when used, they are rapidly leached deep down into the soil within a few weeks and the plants are not usually well nourished with the nutrients for a long time, since their roots are not very deep (Joanna, 1991). They can also affect the environment negatively when mobilized by percolating ground water for example pollution of the water table and acidification of the soil (Schaetzl and Anderson, 2005).

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In humid tropical regions like Cameroon, the weathering of rocks and leaching of the elements is high, producing ferallitic (soils which are rich in Fe and Al oxides) soils which are usually poor in soil nutrients. Consequently most of the elements are leached to deeper layers where plants roots can't attain. The use of rock powder as natural fertilizers is of great advantage over chemical fertilizers. Rock powder is rich in elements necessary for plant growth and they are progressively released from the rocks over a long period of time. This also ameliorates the cationic exchange capacity of the soils (Joanna, 1992). The release of nutrients is neither too fast nor slow but relatively moderate due to its fine granulometry. When the release is slow, plants like herbs and shrubs cannot absorb sufficient nutrients following their vegetative cycle (Anderson and Ingram, 1993). In Cameroon tephra is used mainly as a constituent of cement and for road surfacing. In the field or agriculture, however, it had been used as a natural fertilizer in the growth of maize in the Noun river basin (Njofang, 2005) and Tombel graben (Nkouathio *et al*., 2008). Volcanic rocks are abundant along the Cameroon Volcanic Line which can be use as rock fertilizers. Maize plant was chosen because it is the major cash and food crop consumed by Cameroonians. Recently the brewery industry has been engaged in the use of corn rather than malt in brewing alcohol. This requires huge amount of corn to be grown to meet it demand. The aim of this study was to evaluate the fertilizing potential of Totap tephra on Bambili ferallitic soils using *Zea Mays* as the test plant.

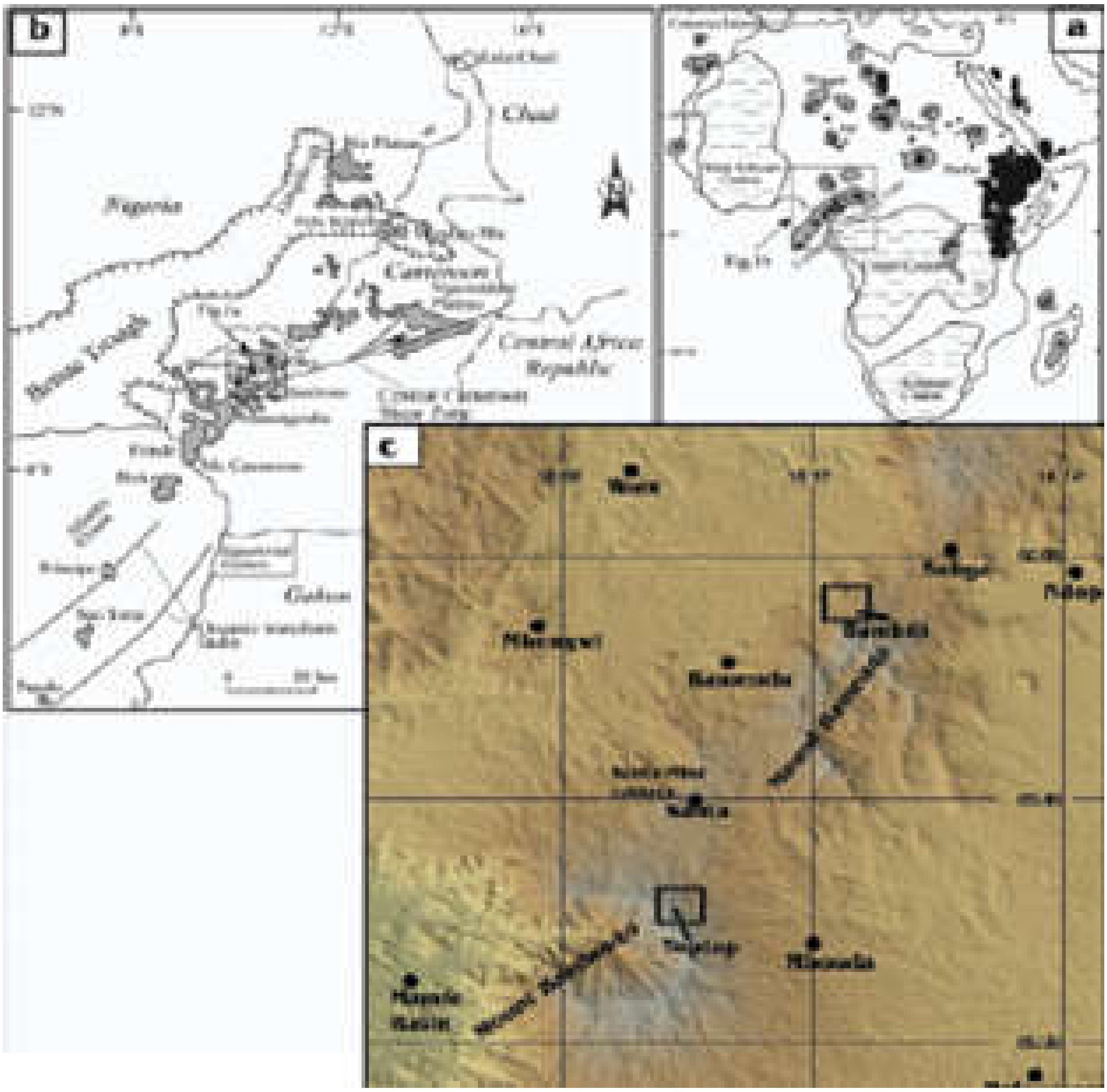

Figure 1. a) Location map of the Cameroon Volcanic Line (CVL); the main geologic features of Africa are indicated. b) The main volcanic centers of the Cameroon Volcanic Line. c) Digital Elevation Model (DEM) of Mounts Bambouto and Bamenda indicating Totap and Bambili

Location and characteristics of Totap tephra

Totap is situated at the NE flank of Mount Bambouto which is a major volcano along the Cameroon Volcanic Line (Figure 1). The Bambouto mountain is a strombolian cone (2100 x 1700 m) covering a surface area of 2.7 Km^2, and a crater (750 x350 m) and 100 m deep (Kagou Dongmo *et al*., 2010). The Totap tephra are fragments of vacuolar lava of diameter between 2-7 cm, low density and irregular porous surface. Chemical analysis reveal that they have an ultra basic character (SiO_2 <43%) and alkali (K_2O + NaO = 3.30%, attaining 3.39%) (Table1) (Kagou Dongmo *et al*., 2010). This is marked by their mineralogical composition analyzed under the electronic microscope (Casting electronic microwave) and their chemical composition determined by atomic emission spectrometer (ICP-AES) and by mass spectrometer (ICP-MS) (Kagou Dongmo *et al*., 2010).

Mineralogically, this tephra is made up of olivine, clinopyroxene (augite and diopside), plagioclase (labradorite), oxides (spinelle and titanomagnetite), felspathoids (Nepheline and leucite). The majority of them consist of opaque and basic silicate minerals rich in Na, Mg, Ca and Fe.

Table 1. Chemical analysis of some tephra from Totap volcano, Mount Bambouto. Analyses by ICP-AES for major elements. LOI, loss on ignition (Kagou Dongmo *et al*., 2010)

Element	KTP-16 tephra basanite	KTP-17 tephra basanite
SiO_2	41.95	42.23
TiO_2	2.83	2.95
Al_2O_3	11.77	12.09
Fe_2O_3	13.46	13.95
MnO	0.19	0.20
MgO	12.40	12.74
CaO	11.40	10.85
Na_2O	2.09	2.75
K_2O	0.94	1.20
$T3O_5$	0.78	0.81
LOI	2.09	0.04
Total	99.87	99.72

MATERIALS AND METHODS

Materials

The experiment was carried out in Bambili in the month of March to April 2011 using maize plants in pots containing ferallitic soils from Bambili mixed with NPK (20-10-10) or tephra at different proportions (15, 20 and 25%; wt/wt). *Zea mays* (maize) is the main cash crop in Cameroon (IFDC/USAID, 1986). It is an exigent plant, very sensitive to soil fertility. The specie of *Zea mays* used in this experiment is a variety of CHC 201, selected by IRAD (Institute of Agricultural Research for Development) Bambui. Its particularity is that it adapts well in the Western Highlands and is tolerant to altitude and diseases (IRAD, 2009).

Methods

Fifty perforated bags were filled with ferallitic soils from Bambili and divided into five groups of 10 each per treatment. The first treatment was without any input and denoted as the control (T0). The second group was supplemented with NPK (20-10-10) fertilizer (T1). The third group was with 15% wt of tephra (T2), the fourth group with 20% wt of tephra (T3) and last group with 25% wt of tephra (T4). These bags were disposed in 5 columns and 10 rows and all subjected under the same environmental conditions. Soil was collected i.e. initial soils prior to applying the supplements in the different treatments. Eight weeks after, soils of each treatment were also collected. Collected soils were dried in an oven at 40°C for 48 hours, grind into powder and sieved using a 2 mm mesh sieve.

Physico-chemical analyses were carried out in the Faculty of Agriculture and Agronomic Sciences (FASA) Laboratory University of Dschang, Cameroon. The pH_{water} and pH_{KCl} were measured using a pH meter after standardizing at pH 7 and then at pH 4. Exchangeable bases were determined by spectrometry for K and Na and complexiometry for Ca and Mg (Pauwels *et al*., 1992). The cationic exchange capacity (CEC) was determined by saturating a 5 g absorbant complex using NH_4^+. Phosphorus was determined by atomic absorption spectrometry. Dosage of exchangeable acidity was determined by titration of phenolpthalene with 0.02 M NaOH. Al^{3+} was determined by complexiometry with Fluorine.

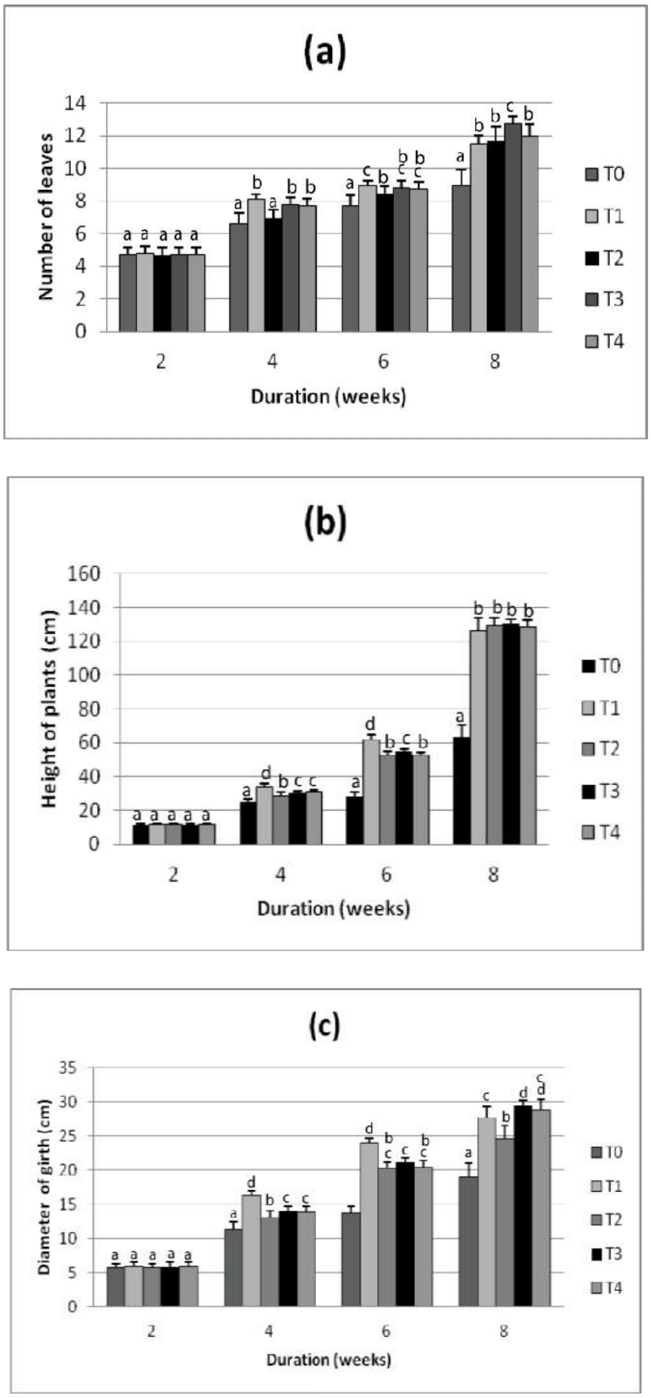

Figure 2. Variation of some growth parameters of the maize plant under different treatments within the experimental time. (a) number of leaves (b) height of plant (c) diameter of girth

The maize (*Zea mays*) seedlings were planted after one week; this was to synchronize the liberation of elements that the plant needs. The duration of the experiment was for 8 weeks. The growth parameters (height of plants, number of leaves and diameter of the girth) were measured every 2 weeks from planting up to 8 weeks. The data collected were presented in forms of means ± Standard Deviations. Comparison of means for different treatments at the same time interval was done by analysis of variance (ANOVA), using Duncan test at the level of significance 0.05. The SPSS 17.0 for windows was use for these analyses.

Table 2. Analysis of physico-chemical parameters soils and tephra after the experiment, S: initial soil

Chemical parameters	s	Final composition of soil				
		T_0	T1	T2	T3	T4
pH $_{water}$	5.30	5.14	5.41	5.62	5.83	6.17
pH $_{KCl}$	4.77	4.71	4.98	5.12	5.43	5.72
Exchangeable acidity	0.41	0.52	0.28	0.25	0.15	0.11
Exchangeable Al	0.23	0.23	0.12	0.00	0.00	0.00
Assimilable Phosphurus	1.79	1.26	1.46	1.77	1.84	2.36
Exchangeable Mg^{2+}	1.11	0.51	1.83	2.48	2.98	4.12
Exchangeable Ca^{2+}	1.88	1.57	2.12	2.79	3.16	4.06
Exchangeable K^{+}	0.25	0.17	0.26	0.29	0.33	0.41
Exchangeable Na^{+}	0.03	0.00	0.00	0.02	0.07	0.13
CEC	22.31	20.11	24.13	26.91	28.19	31.14
Sum of exchangeable bases	3.27	2.25	4.21	5.58	6.54	8.72
Saturation in bases (Sb/CEC)	14.66	11.19	17.45	20.74	23.20	28.00

RESULTS AND DISCUSSION

There was a significant increase in the evolution of the pH during the experiment. The initial soil (S) moderately acidic became more acidic in the control (T0) while in the other treatments it became less acidic. Treatment T4 presented the highest value of pH (Table 2). This evolution trend is similar to that obtained by Nkouathio *et al*. (2008) who fertilized soils using basaltic pyroclasites from Tombel on the growth of maize. An increase in the proportion of tephra was accompanied by a progressive decrease in acidity due to the release of Ca^{2+} and Mg^{2+} from the tephra. The soil without fertilizer (T0) became more acidic due to inadequate bases in the soil. The amount in the quantity of exchangeable bases (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and the cationic exchange capacity (CEC) showed an increase which is proportional to the concentration of tephra supplemented within the soil as well as soil treated with NPK fertilizer (T1) (Table 2) he highest concentrations were those of Mg^{2+}, followed by Ca^{2+} and lastly those of K^{+} and Na^{+}.

This implied an important release of Mg^{2+} and Ca^{2+} contained in the tephra. The low amounts of K^{+} and Na^{+} can be explained by their low concentrations in the tephra (Kagou *et al*., 2010). The drop in the quantity of the exchangeable bases and CEC in the soil without fertilizer (T0) can be explained by the exhaustion of these elements in the initial soil without any potential replenishing source to equilibrate or increase their concentrations in the soil. The Totap Tephra is rich in agronomic bases, mainly MgO, CaO, and K_2O. This tephra is rich in soil nutrients and in order to make up as natural fertilizers, they must be mineralized by grinding the rocks to increase the surface area for reaction, facilitating the release of elements. Concerning the comparison between the different soils treated with tephra, we noticed that the chemical properties were ameliorated with an increase in proportion of pyroclastic materials. The evaluation of growth parameters showed a gradual increase with time for the number of leaves, height of plant and diameter of girth (Figure 2). After four week of growth, there was no significant difference in term of number of leaves in plants of treatment T2 and control. After six and eight weeks of growth, there was a significant difference noticed between control plants and plants of other treatment in term of number of leaves, plant with treatment T3 recorded the highest value (8.8±0.42) (Figure 2a).

As regards the height of plant and diameter of girth, after first six weeks of growth, there was a significant difference in the plants in the other treatments compared to the control plant. This difference was more perceptible after eight weeks of growth, plant with treatment T3 had the highest values (130.5±2.36cm and 29.4±0.84cm respectively) (Figure 2a and b). The morphological parameters of the plants of treatments with tephra showed higher values due to the gradual and progressive release of soil nutrients contained in the tephra. The low number of leaves, height and diameter of girth of the control plant was due to the depletion of soils nutrients in the soil during growth (Mbouobda *et al*., 2013). The tephra had an advantage over NPK fertilser in that; it liberates nutritive elements in a slow and progressive way, harmless to the environment and takes a long period of time to be exhausted.

Conclusion

This study has proven that Totap tephra can enrich poor soils through the progressive liberation of nutritive elements they contain. Tephra is easy to exploit and when remineralized, it contributes to a better yield of plants and reduce the demand for chemical fertilizers by farmers.

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