

A comparative study on the use of Calcium Acetate Lactate, Calcium chloride and Acidic Ammonium Acetate- Ethylene Diaminetetra acetic acid (AAAc-EDTA) for the quantification of extractable, P, K and Mg from acidic soils.

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ABSTRACT

The Calcium Acetate lactate (CAL) for the extraction of available soil K and P and the CaCl₂ method for the extraction of available Mg were compared with the Acidic ammonium acetate- ethylene diamine tetraacetic acid (AAAc-EDTA) method for the determination of these elements in soil were compared in order to choose the best method to be adopted for testing of acidic soils. A survey was carried out to collect top soil samples under Hevea plantations in the South west and Littoral regions of Cameroon. A total of 130 samples were collected and analysed for the K, P and Mg contents using the above-mentioned extractants. According to the results, CAL and AAAc-EDTA methods were similar in their extracting power for soil extractable P. In the case of soil K, the CAL method extracted only about half of K extracted using the AAAc-EDTA method. It was the same situation for Mg where CaCl₂ extracted just about half of what was extracted using the AAAc-EDTA method. These methods were consequently poorly correlated to each other except the methods for soil P. This shows that soil P data obtained by the two methods can be interpreted in the same way. On the other hand, soil Mg and K obtained by the two methods may not be similarly interpreted. Most of the nutrients extracted by the AAAc-EDTA extractant were not significantly correlation to soil pH and organic carbon. Concerning the choice of the extraction method, the AAAc-EDTA is favoured because it can extract more nutrients at a go thus minimizing time and reagent.

Keywords: Calcium Acetate lactate, Calcium Chloride, Acidic Ammonium acetate-ethylenediaminetetraacetic acid, potassium, magnesium and phosphorus.

1. INTRODUCTION

Soil testing using chemical methods is among the most common methods used to diagnose the nutrient status of soils and consequent fertilization (Matula, 2009). The main advantage of soil tests is that plant nutrient disorder resulting from the soil nutrient deficiency can be detected before they are visible in the plant. However, the biggest challenge is to select

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from a multitude of soil extraction methods those methods that will allow for the simultaneous extraction of several nutrients so that the possibility of making full usage of multi element analysers like ICP can be maximized (Jones, 1998). Most soil test methods used till now were developed during the green revolution when more intensive use of commercial fertilizers began. At that time, the sensitivity of most analytical methods was low. However, this draw back was compensated for by using extractants with high strength and this is considered till date (Matula, 2009).

A number of methods have been used for the extraction of available P, K and Mg in soils. Some commonly used methods for the extraction of plant available K and P are the Bray 2 method for available P and neutral ammonium acetate method for available K (Ehabe et al., 2010; Ngane et al., 2011). The Bray 2 extract consists of ammonium fluoride and hydrochloric acid. Studies found that the Bray 2 extractable P in some soils diverge considerably depending on the extraction time and soil fineness (Hylander et al., 1999). 0.5M NaHCO₃ was used for the determination of P, 1N ammonium acetate for K and ammonium bicarbonate diethylene triamine pentaacetic acid (AB-DTPA) (Khan et al., 2007). Some studies have compared the use of Mehlich 3, ammonium acetate and water as multi nutrient extractants for the determination of the bioavailability of K, Mg, P, Mn and B (Matula, 2009). Several methods have been used for the extraction of soil Mg notably; the A-L (Egner-Riehm-Domingo), calcium chloride (Schachtschabel, 0.0125 M CaCl₂ 1:20), potassium chloride (1 M KCl 1:10), ammonium acetate (1 M NH₄OAc 1:10), Mehlich 3 methods and water soluble magnesium (1:5) (Staugaitis and Rutkauskiene, 2010). Studying soils in Ethiopia it was found that the magnitude of soil available P extraction was in the order Truog > CAL > Olsen > Bray II > Warren and Cooke (Mamo et al., 2002). Another study on soils in Endo state Nigeria using five extractants; distilled water, 0.5 N NaHCO₃ (pH 8.5), 0.01 M CaCl₂, 0.1 N HNO₃ and 1 N NH₄OAc (pH 7) for available K showed that the amount of extractable K by 1 N NH₄OAc (pH 7) and 0.1 N HNO₃ showed the highest significant linear correlation with K uptake and dry matter yield in maize when compared with distilled water, 0.5 N NaHCO₃ (pH 8.5) and 0.01 M CaCl₂ (Osemwota, 2007). AAAC-EDTA was used in the analysis of cotton soils in Egypt and it has the advantage of being a multinutrient extractant (Klages, 2011).

There are a multitude of extractants in use but as summarized by Mutula in 2009, modern soil test should have the following qualities; simultaneous extraction of all important nutrients from the soil, efficient in all soil types, accurate and reproducible, simple, not expensive, good for expeditious detection and relate soil available nutrients to plant nutrients. It is true that no soil test method can fulfill all these roles; the suitability of a method can be based on how close the method fulfills these conditions. Research evidence has shown that soil nutrients depend on soil pH, and humus content or organic carbon content Staugaitis and Rutkauskiene, 2010).

Calcium and potassium chloride extracts are usually used only for magnesium determination, and available phosphorus and potassium are measured by other methods. The draw back is that it is time-consuming and requires higher reagent and labour input; therefore time and money will be saved by using one extract for the determination of all these nutrients (Matejovic and Durackova, 1994).

The objective of this work was to determine the content of P, K and Mg in acidic soils extracted using two methods of extraction, compare and correlate the methods to each other as well as correlate extracted nutrients to soil pH and organic carbon.

2. MATERIAL AND METHODS

2.1 Soil sampling and analysis

One hundred and thirty (130) composite soil samples were collected from rubber estates belonging to the rubber estates of the Cameroon Development Corporation of Cameroon which lies between latitude 4°05' - 4°42' N and longitude 9°22' - 9°40' E and the Société Forestière Agricole du Cameroon (SAFACAM) rubber estate which lies between latitude 3°46' - 3°51' N and longitude 9°7' - 9°9' E. Samples were collected after augering to a depth of 0-15 cm. Each sample consisted of at least 10 sub-samples from the entire sampled area. The collected soil samples were stored in properly labeled polythene bags and taken to the laboratory for analyses. On arrival at the laboratory, samples were air-dried separately on shelves in the soil drying room in order to avoid contamination. The dried samples were passed through 2-mm sieves in preparation for laboratory analyses.

The determination of total carbon and total nitrogen was done by dry oxidation at high temperature (i. e. 1,200 °C with Elemental analyzer vario MAX CNS). Conversion of total carbon to organic carbon was done by using the factor 1.724, which represents the mean C concentration in soil organic matter.

Soil pH was measured using a pH-meter with a glass electrode in a suspension of 1:2.5 soil and 0.01M CaCl₂ (DINISO 2005). The macro nutrients (P, K and Mg) were determined using two methods each:

- the Inductively coupled plasma - Optical Emission Spectrometry (ICP - OES) after extraction with Acidic Ammonium Acetate – Ethylenediaminetetra - acetic acid (AAAc-EDTA), [0.5M ammonium acetate + 0.5M acetic acid + 0.02M Na₂EDTA (pH 4.65)] solution (Lakanen and Ervio 1971) was used for all the tree elements.
- The second method used for P and K was the spectral photometer determination after extraction with a solution of Calcium Acetate Lactate (CAL) at a ratio of 1:20 and buffered at pH of 4.1 (Schüller, 1969).
- The method that was used for the analysis of Magnesium was the Schachtschabel, 1954 method. In this method Mg was extract by 0.125M CaCl₂ and read using the Inductively coupled plasma - Optical Emission Spectrometry (ICP - OES).

2.2 Statistical analysis

An analysis of variance was carried out to investigate the statistical difference between the methods of analysis for each element using the JMP statistical software (SAS 2002). Simple linear correlations were carried out to study the relationship between the methods of analysis for each nutrient element and the method with soil pH and organic carbon

3. RESULTS AND DISCUSSION

3.1 Soil nutrient concentrations

The soils in the studied site were all acidic with pH < 6 (Table 1). Average K, P and Mg extracted by the various methods varied. This is because the nutrient extracted from soils depends on soil and extractants characteristics (Hosseinpour and Zarenia, 2012). Soil organic carbon varied between 1 and 14%. This could be attributed to the varying nature of the cover crops found in the fields sampled.

Table 1 Mean, Minimum, and Maximum values of soil pH, Organic carbon and P, K and Mg concentrations

Parameter	pH	%organic C	K (mg/kg)		P (mg/kg)		Mg (mg/kg)	
	CaCl ₂		AAAc- EDTA	CAL	AAAc- EDTA	CAL	AAAc- EDTA	CaCl ₂
Mean	4.3	3	219.7	120.5	8.8	8.6	38.5	76.0
Max	5.7	14.1	1753.3	941.3	68.5	84.2	615.5	566.6
Min	3.7	1	93.0	43.7	2.0	1.0	7.4	4.5
STDEV	0.5	1.6	163.6	96.4	11.2	14.3	64.8	91.1

3.2 A Comparison of the extraction methods

There was a significant difference between the amount of K extracted from the soil using the CAL method and the AAAC-EDTA method (Fig. 1) as well as the amount of Mg extracted by the CaCl₂ and the AAAC-EDTA method. The AAAC-EDTA method extracted about twice the amount of K extracted by CAL and about twice the amount of Mg extracted by CaCl₂. This could be attributed to the high extracting power of AAAC-EDTA (Haneklaus et al., 1999) compared to CAL and CaCl₂. Considering the mechanism involve in the extraction of K and Mg ions by the extractants we found that it involves the displacement of cations by cations of different sizes. The displacing cation in CAL and CaCl₂ extractants is Ca²⁺ (ionic radius = 0.099nm) which is smaller than K⁺ ion (ionic radius = 0.133nm) but larger than the Mg²⁺ ion (0.065nm). In the case of AAAC-EDTA, it contains NH⁴⁺, whose ionic radius is similar to K⁺ (Hosseinpur and Zarenia, 2012). From this analogy it shows that Ca²⁺ can easily displace and replace K⁺ and not Mg²⁺ ion. However, the fact that AAAC-EDTA extracted more K and Mg is because the concentration of the NH⁴⁺ ions in solution was higher.

On the other hand, there was no significant difference between the amount of soil P extracted by CAL and AAAC-EDTA methods. The mechanism of P removal can be by dissolution of sorbing components or by desorption depending on the pH of the extractant (Popović et al., 2010). This suggests the two extractants use a similar mechanism for P removal and can both be used for the determination of extractable P in these soils with similar interpretations.

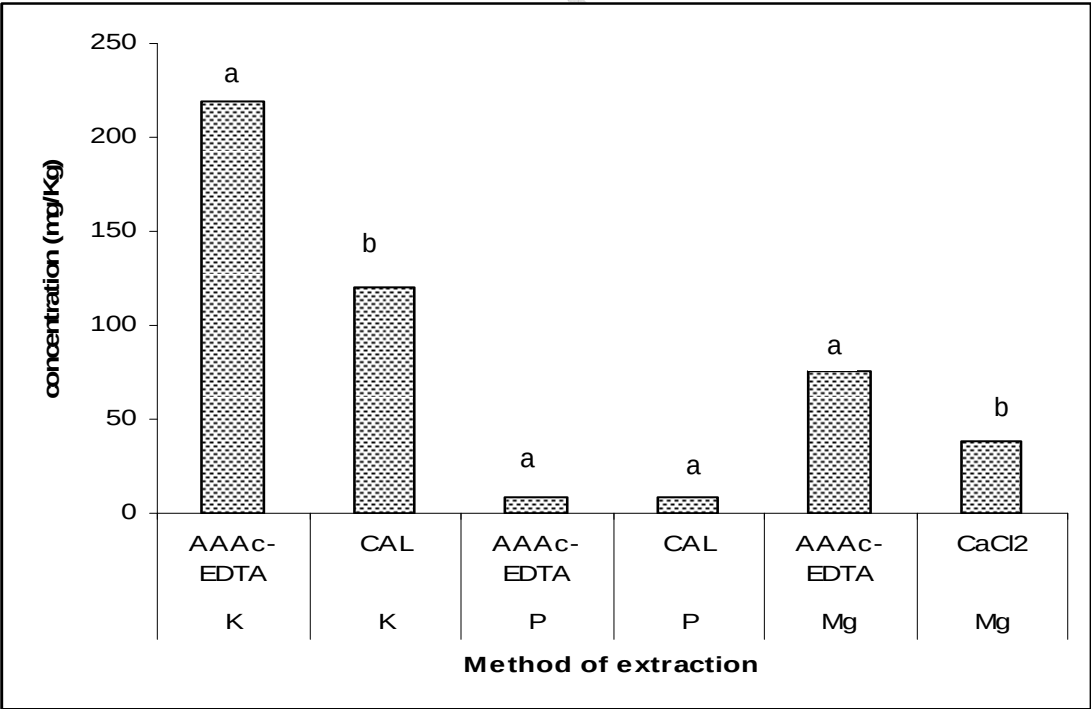


Figure 1. An analysis if variance showing the difference between P, K and Mg values analysed by different methods.

Levels not connected by same letter are significantly different

3.3 Correlation Studies
3.3.1 Correlations between methods of nutrient extraction

In order to know how well the extraction methods correlate with each other, each nutrient element was considered in turn. There was a highly significant correlation between the AAac-EDTA and CAL methods for the extraction of soil P with a correlation coefficient of 0.72 (Fig. 2). This confirms the fact that the obtained values were not different using the both methods. Concerning K and Mg, non significant correlations were obtained between both methods of extraction. This shows that the methods of nutrient extraction were independent of each other.

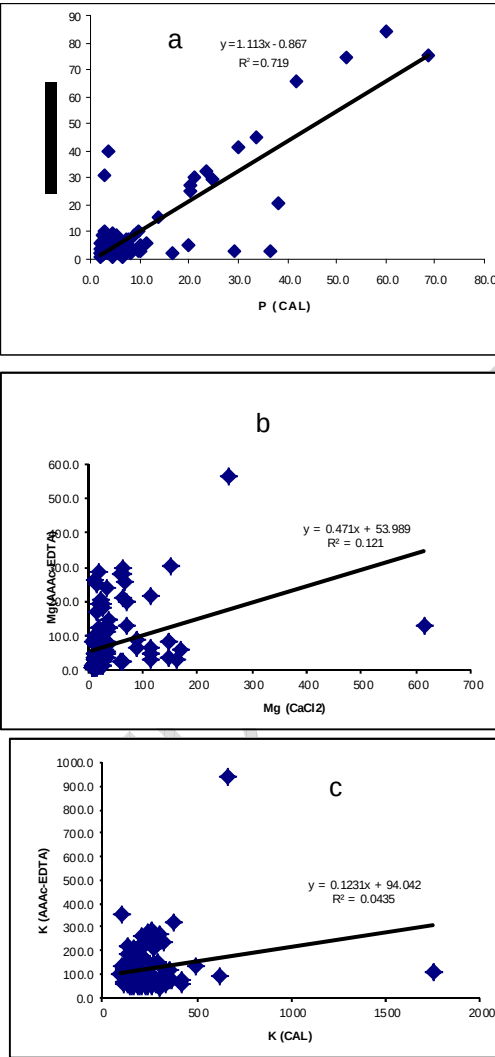


Fig. 2. Correlations between the methods of analysis (a) P, (b) Mg and (c) K

3.2.2 Correlation between nutrients with soil pH and Organic carbon

The correlations between soil nutrients and pH varied with the method of extraction as well as the nutrient element involved (Table 2). This was similar to the correlation between soil nutrients and organic carbon. Significant correlations

between two parameters show that a change in one parameter affects another with positive correlation meaning increasing one parameter increase another and negative correlation meaning increasing one parameter decreases another.

Significant positive correlations were obtained between both soil pH and organic carbon and K extracted by the CAL method as well as Mg extracted by the CaCl_2 extraction method. There was however a significant correlation between pH and Mg extracted by AAAC-EDTA. The level of significance was lower than that obtained with CaCl_2 extraction method. These significant correlations show that the amount of nutrients extracted will vary with change in soil pH or organic carbon. This means the method may not be good in many soil types. The Nutrients extracted by the AAAC-EDTA method were not significantly related to soil pH and organic carbon. This shows that this extraction method is independent of the soil parameters and thus can be used over many soil series. Similar results for the effect of soil pH on Mg content extracted by CaCl_2 and other methods Staugaitis and Rutkauskiene (2010). Osemwota in 2007 found that pH was positively and significantly correlated with available K but concluded that the relationship with pH were strictly empirical as the pH of any soil is influenced by many factors (Russell and Russell, 1973). In this study this association should be treated with caution because the range of pH observed for the soil was small (4.3 to 5.7). It has been suggested that this relationship of extractable soil K with soil pH might be due to the fact that the pH of a soil is often related to its base saturation and this relationship was also observed by Osemwota (2007) in his study.

Table 2 Correlation coefficient between soil nutrients obtained by different extraction methods with pH and organic carbon

Parameter	K (mg/kg)		P (mg/kg)		Mg (mg/kg)	
	AAAC- EDTA	CAL	AAAC- EDTA	CAL	AAAC- EDTA	CaCl_2
pH	0.22	0.28*	0.13	-0.22	0.25*	0.72*
% organic C	0.1	0.54*	0.1	-0.1	0.17	0.57*

*significant at 1% alpha level

4. CONCLUSION

The soils studied were all acidic. There was a significant difference between the values of K and Mg obtained following the two methods of extraction. On the other hand no difference was obtained for P following the two methods of extraction. Consequently, a significant correlation was found between the two methods of P extraction. Most of the nutrients extracted by the AAAC-EDTA method were not significant correlated to soil pH and organic carbon. This implies that the AAAC-EDTA is the best choice for the extraction of available P, K and Mg from the soil. It is a multnutrient extractant and thus saves time ns energy.

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AUTHORS' CONTRIBUTIONS

All the authors participated in preparing the protocol for sample collection. The samples were collected by Njukeng J N who equally drafted the manuscript which was corrected by Ehabe EE and Nkeng GE. Ewald Schnug managed the analysis of soil samples in the laboratory.

Authors may use the following wordings for this section: " 'Author A' designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. 'Author B' and 'Author C' managed the analyses of the study. 'Author C' managed the literature searches..... All authors read and approved the final manuscript."

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