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Evaluation of Three Soil Test Kits for the Determination of Soil pH of Cacao Plantations in Nigeria

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Abstract:
pH of soils planted to cocoa in Nigeria ranged between slight acidity to near neutral. Soil fertility management of such plantations should ensure no further decrease in the pH of the soil, hence the need to monitor the soil pH. Conventional analytical laboratory methods of soil analysis are presently being used for soil analysis on limited scale in Nigeria. These methods employ mostly imported sophisticated, electricity dependent and expensive equipment which makes soil testing quite expensive. Most of the cocoa farmers in Nigeria are resource limited small holders who cannot afford the cost of conventional soil analytical methods hence there is an urgent need to explore the use of affordable quick soil test kits for soil testing. Three soil test kits (LaMotte, Rapitest, Hanna soil test kits) and conventional analytical methods were evaluated at the Department of Soil and Water Science Laboratory, Tropical Research and Education Center, University of Florida for the determination of soil pH of soils collected from different cocoa plantations in Nigeria. The results from the kits were compared with those obtained by means of conventional analytical method. The t- test values of 0.091 and 0.483 obtained when comparing conventional analytical methods with each of LaMotte and Hanna test kits at p=0.05 indicated that there was no significant difference between each of these two test kits and the conventional method for pH determination. Rapitest kit could not detect pH values below 5. It was an indication that Rapitest might not be good for determination of soil pH of acidic soils with pH values below 5.

Keywords: *Aocoa, Acidity, Soil fertility, pH, test kits*

1. Introduction

Soil fertility is the basis for food production both plant and animal, and is therefore pivotal to all aspects of human endeavors particularly crop production (Brandenberger *et al*., 2016). Crop cultivation affects nutrients status of soil (Asowata *et al*., 2017). The fertility of soils is constantly changing as crops extract essential nutrients from the soil for their growth and nutrients are replenished through the addition of plant or animal residues and fertilizers. The process of extracting nutrients then returning them back to the soil is termed nutrient cycling (Magdoff and Van Es, 2009). The availability of some plant nutrients is greatly affected by soil pH (Thomas L., 2010). Soil pH is one of the most important chemical properties used as an index in soil management for crop production. It is a measure of activity of H+ ions in the soil solution, which measures the degree of acidity or alkalinity of a soil. A soil with a pH of 3 is 10 times more acidicthan one with a pH of 4 and 100 times more acid than one with pH 5. Soil acidification refers to a complex set of processes that result in the formation of an acid soil with pH less than 7.0 (Roberge and Johnson, 1992). Acidity is a major degrading factor of soils and affects extensive areas both in the tropics and in temperate zones. Acid soils are reported to occupy about 3 billion hectares, of which over 89% are Oxisols and Utisols situated in the tropics (Eswaran et al., 1993). Soil acidity may result from parent materials that were acid and naturally low in basic cations(Ca2+, Mg2+. K+ and Na+). It could also be as a result of leaching of the basic cations by heavy rains (Fageria et al., 1990). Acidity may also be produced by the decomposition of plant residues or organic wastes into organic acids. This process is of particular important in many forest soils. The important yield-limiting factors in acid soils are: toxicities of H+, Al, and Mn; deficiencies of N, P, K, Ca, Mg, Zn; and reduced activity of beneficial microorganisms (Fageria1990). Soil acidity constraints in crop production are very complex. Soil pH of soils planted to cocoa in Nigeria ranged between slight acidity to near neutral (Ogunlde *etal*., 2010).Soil fertility management of such plantations should ensure no further decrease in the pH of the soil. Therefore, it is very important to monitor the soil pH with a view to manage it for better soil productivity. Conventional analytical laboratory methods of soil analysis are presently being used for soil analysis on limited scale in Nigeria. These methods

employ mostly imported sophisticated, electricity dependent and expensive equipment which makes soil testing quite expensive. Most of the cocoa farmers in Nigeria are resource limited small holders who cannot afford the cost of conventional soil analytical methods (Ogunlade *et al.,*2015), hence the need to explore the use of affordable quick soil test kits for soil pH determination. Therefore, the objectives of this study are to i. explore the adaptability of affordable and quick soil test kits for soil pH determination, ii. determine soil pH using conventional analytical method and iiicompare and correlate the analytical results obtained from above methods

2. Materials and Methods

The soil samples used for this study were collected from cocoa plantations across important cocoa producing communities covering 12 states among cocoa growing states of Nigeria. The cocoa plantations are old with age of cocoa trees ranging from ages 25 – 50 years. No history of fertilizer application exists in any of the plantations since establishment. The annual total rainfall ranges from 1300mm in the south western Nigeria to between 1500 and 2500mm in the south eastern part. The temperature ranges between a maximum of 30 – 32^{o}C and a minimum of 18 – 21^{o}C. Most of the soils collected from south western Nigeria were derived from basement complex rocks mainly of the igneous origin containing fine grained biotites, gneisses and schists and they belong to the order Alfisols (Smyth and Montgomery, 1962) while those of the south eastern part were formed from sandstone/shale, coastal plain sand, beach ridge sand, alluvial deposits and are predominantly Ultisols (FAO/UNESCO, 1974). In all the cocoa farms, soil samples were collected from 0-30cm depth using soil auger. At each site, ten core samples were taken randomly. The core samples in each farm were bulked in to a composite sample, bagged and labelled. Thirty-eight composite samples collected from various cocoa farms were air dried and processed for laboratory analysis. The pH of the soils was determined in 1:2 soil – water ratio using accumet AR60 dual channel pH/electrical conductivity meter. Figure 1 showing the component of a soil test kit.

Figure 1: Example of a Soil Test Kit Components

2.1. Soil test kits for Determining Soil pH

The underlying principle of soil testing using soil test kits involves colorimetric chemical reactions. Soil pH was determined using the three test kits following the procedures in the manufacturers' manual.

The three soil test kits used were:

- La Motte soil test kit model 5679-01: The colours that developed after the addition of the pH color reagent to the measured soil samples were matched with the color charts provided in the kit to determine the pH of the soil.
- Rapitest soil test kit (Model 1601) and (iii) Hanna soil test kit (Model HI 3895). The soil samples were extracted with distilled deionized water after which the powder (color reagent) was added to the soil extract and the colors that developed were matched with the color charts provided in the kit. The results were compared using t-test and regression analysis

3. Results and Discussion

3.1. Soil pH

The soil pH values obtained using conventional analytical method and the three test kits indicated a high degree of association between the conventional and two of the test kits- La Motte and Hanna soil test kits (Fig.1a-c). The coefficient of determination for linear regression (r^2=0.87) obtained for both conventional versus LaMotte and Conventional versus Hanna showed significant linear relationship between the conventional and each of the two test kits. This was similar to the findings of Maggini et.al. 2010. There was low degree of association between conventional and Rapitest (r^2=0.57)

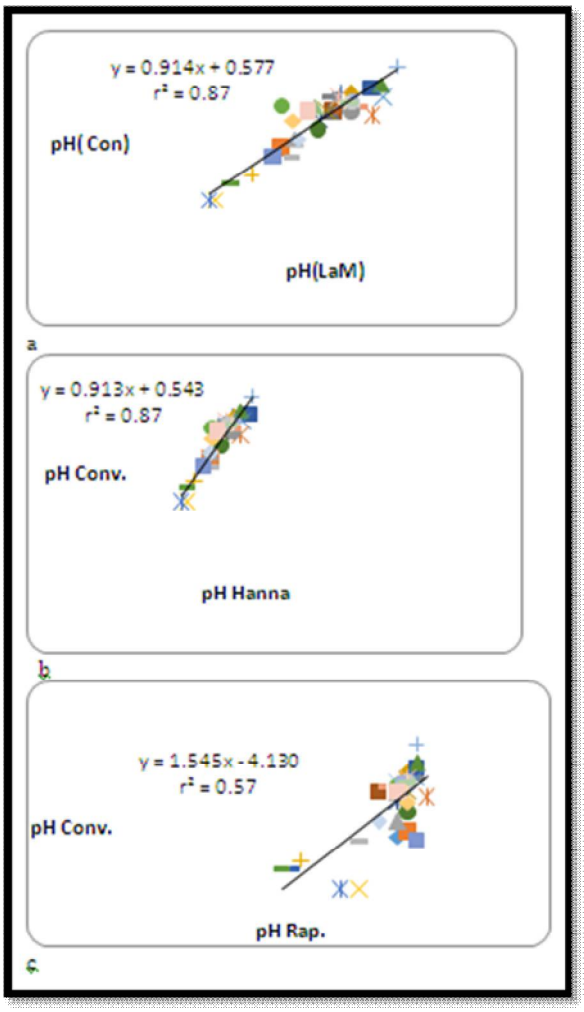

Figure 2: a-c: Correlation of Soil Ph Values Obtained from Conventional and La Motte, Hanna and Rapitest Soil Test Kit Analytical Methods

The t-test values of 0.0908 and 0.483 for conventional versus LaMotte and conventional versus Hanna kit respectively at 5% probability level also indicated that there is no significance difference between conventional analytical method and each of the two test kits for pH determination. However, the t-test value ($5.69E^{-08}$) obtained while comparing conventional method with Rapitest kit for soil pH determination indicated that Rapitest will not be good for pH determination of the soils of the study area (Table 1)

Parameter	Methods Compared	T-Values	Correlation Coefficients(R)
pH	Conv. Versus LaMotte	0.0908	0.93
pH	Conv. Versus Rapitest	$5.69E^{-08}$	0.76
pH	Conv. Versus Hanna	0.483	0.93

Table 1: T-test Values for Conventional and Soil Test Kit Analytical Methods for Ph at P=0.05

Table 2 reveals the defects of using Rapitest kit for pH determination for the soils of the study areas. While conventional, LaMotte and Hanna test kit analytical methods measured pH values of less than 5 for 13.2% of the soil samples examined, Rapitest kit could not detect pH values below 5. It was an indication that Rapitest might not be good for the determination of pH of soils having pH values below 5.

pH range	Conv. Method	LaMotte kit	Rapitest kit	Hanna kit
4-4.99	5(13.2%)	5(13.2%)	0(0%)	5(13.2%)
5-5.49	4(10.5%)	5(13.2%)	1(2.6%)	2(5.3%)
5.5-6.5	24(63.2%)	22(57.9%)	9(22.7%)	26(68.4%)
6.51-7.5	5(13.2%)	6(15.8%)	28(73.7%)	5(13.2%)

Table 2: Distribution of Soil Ph Determined by Conventional and Quick Soil Test Kits Analytical Methods

4. Conclusion

La Motte soil test kit results correlated significantly with those from conventional analytical methods for pH. The kit is suitable for the soils of the study areas because it proved to be accurate over a wide pH range. Results obtained using Hanna test kit for pH matched those from the conventional method. Rapitest kit could not detect pH values below 5. It was an indication that Rapitest might not be good for determination of soil pH of acidic soils with pH values below 5. Therefore, La Motte and Hanna soil test kit could be used for the determination of soil pH of the soils of the study areas.

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