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COMPARITIVE STUDY OF SOIL TEST KITS

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ABSTRACT

The feasibility of using soil test kits to analyze basic nutrient levels is examined. Of the two kits tested, the LaMotte kit may be acceptable for field testing of potassium levels. Reliance on the kits for other nutrient levels for fertilizer recommendations is extremely risky and may jeopardize our good standing among the Territory's farmers.

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At present, Land Grant's Soil Testing Laboratory does not test soils for lack of chemical reagents. Until reagents arrive it has been suggested that the 26 soil samples awaiting testing be analyzed using soil test kits. This report focuses on why reliance on kits is unacceptable

This study compares soil test kits against a procedure for available potassium approved by the Soil Science Society of America (SSSA). Also, results of soil nitrogen tests from two kits, and the phosphorous test of one kit, are given

II EQUIPMENT

The Soil Testing Laboratory at Land Grant has three soil test kits:

1 Hellige-Truog (1)
2 Sudbury (2)
3 LaMotte (3)

Each kit includes instruction booklets for performing the tests, color charts for matching test colors against standards, and tables for interpreting the results. All three kits can test for nitrogen, phosphorous, potassium and the lime requirement. The Hellige-Truog and LaMotte kits can test for other nutrients also But the Hellige-Truog kit was eliminated from this study because of missing materials.

In order to conduct a study comparing results from the two remaining soil test kits against a certified" method,

soil potassium K levels were tested This is the only test available in both soil test kits that the Laboratory has a SSSA-approved method for, (4, pp 229-231)

A separate study on soil nitrogen levels was performed using the Sudbury and the LaMotte soil test kits, and the phosphorous reagents of the LaMotte kit were tested using standard solutions of phosphorous.

III. SOILS

Six soils were tested for exchangeable K and three of these six were further tested for soil nitrogen. These soils are among the 26 dried and sieved soils awaiting testing They are

Soil #	Description
6*	Taputimu Agricultural Station: Voc-Rehab's Onion Plot
7*	Lupulele Elementary School's Proposed Garden Plot
11	Job Training Partnership Administration's Plot in Ofu, Sample #2
13	Firewood Crop Project: A'oloaufou Site Sample #2
24*	Firewood Crop Project: Dept. of Agriculture, Tafuna Site, Sample A
26	Peanut Variety Plot, Land Grant Station

* Used in nitrogen test also

These six soils represent a wide range of soil textures, colors and location sites in American Samoa

IV. PROCEDURES

A Potassium Tests

1 Sudbury

The Sudbury soil test kit has a Potash Test that consists of two solutions (Potash #6 & #7) mixed in equal amounts 1/4 test tube, or about 3 ml each) with 1/4 test tube of soil The contents of Potash #6 & #7 are not disclosed The soil is shaken in the mixed solutions for 30 sec, then allowed to settle before comparing the color of the supernatant against the potash color chart.

This chart consists of five bars ranging in color from yellow-green to salmon-pink Beside each color bar is a letter (A to E), a percentage (2 to 16), and two columns labeled PPM CONTENT and LBS/ACRE CONTENT which range from 20 to 2 and from 160 to 10, respectively. The letters are unexplained. The percent figures are the percentages of potassium that should be added to the soil The values in the two columns are added for those interested but are not required for testing." I assume that, because as percent increases while PPM CONTENT and LBS/ACRE CONTENT decrease and LBS/ACRE CONTENT = 8 * PPM CONTENT, these latter two values depict the potassium content of the soil

2 LaMotte

The LaMotte method differs from the Sudbury method in one important way the nutrients are first extracted from the soil and the potassium test is then conducted on this extract not on the soil itself

The soil is measured by volume about 4 ml) into a test tube containing 14 ml of Universal Extracting Solution (presumably SSSA-approved Morgan solution) and shaken for 60 sec The slurry is then filtered and the filtrate used for subsequent testing

A yellow-orange sodium cobaltinitrite tablet is dissolved in about 5 ml of the filtrate About 5 ml of ethanol is slowly added to facilitate precipitation of sodium potassium cobaltinitrite. This cloudly suspension is added to a specially calibrated tube that is placed over a white plate with a black line etched on it until the black line can no longer be seen against the white background. The potassium content is read directly off the tube as lbs/acre

3 Ammonium Acetate/Flame Emission

There are several approved" methods for testing available potassium in soils. They vary in their extraction solutions, ratio of soil to extraction solution time and method of shaking, method of separating soil

from supernatant, and instrument used for analysis. The preferred" method uses neutral 1N ammonium acetate as the extracting solution and a flame emission spectrophotometer for analysis

For this study, 5.0 g soil was stirred for 30 sec with 25 ml ammonium acetate solution, then allowed to stand for 4 hrs. The suspension was filtered and washed with more ammonium acetate until a volume of 50 ml was collected

The Perkin-Elmer Model 2280 Atomic Absorption Spectrophotometer was adjusted for flame emission spectroscopy. Three standard solutions of 20, 40 and 60 ppm K were prepared from a 1000 ppm K commercial standard solution These three standard solutions were used to make a curve correlating the flame emission readout values to ppm K. The filtrate from each soil sample was aspirated into the flame and the readout recorded From the standard curve the readout was converted to ppm K in the soil filtrates These values were then converted to ppm K in the soils.

B Nitrogen Tests

1 Sudbury

The nitrogen (N) test follows the same procedure as the potash test except the two solutions are Nitrogen #2

& #3 The nitrogen color chart also has five color bars with an associated letter, percentage, PPM CONTENT, LBS/ACRE CONTENT

2 LaMotte

As for the potassium test, the filtrate from the soil/Universal Extraction Solution slurry is used to test for nitrate nitrogen (The LaMotte kit also tests ammonium nitrogen and nitrite nitrogen Since most organic nitrogen in well drained soils is in the nitrate form, this was the form tested).

Using a pipette, 1 ml of the filtrate was transferred to a spot plate and 10 drops of a potassium acid sulfate solution were added Next, 0.5 g of a N-(1-naphthyl)ethylene diamine dihydrochloride, sulfanilamide, zinc dust and barium sulfate mixture was added, stirred, allowed to settle. After 5 min the color was compared to a color chart containing six bars ranging in color from light to dark pink with associated values of Pounds Acre Nitrate Nitrogen ranging from 10 to 150

C Phosphorous Test

The LaMotte kit uses the ammonium paramolybdate method to test for phosphorous (P) The reagents react with phosphate ion to form a blue complex; the intensity

of the blue color indicating the amount of P present. Instead of using the color chart included in the kit, the more sensitive and less subjective Bausch & Lomb Spectronic 20 was used to measure Percent Transmittance (%T) at 660 nm. And instead of soil extracts, standard solutions of P were prepared at concentrations from 0.1 to 1.0 ppm P at 0.1 ppm increments.

Appropriate amounts of a 50 ppm P commercial standard solution were added to 25 ml volumetric flasks and diluted with 10 ml distilled water. Six drops of Phosphorous Reagent 2 (ammonium paramolybdate) and one Phosphorous Reagent 3 Tablet (stannous chloride) were added to each flask. After the tablets dissolved, the flasks were diluted to volume and transferred to cuvettes for readings taken 5 to 10 min later. A water blank was used to set %T at 100.

V. RESULTS

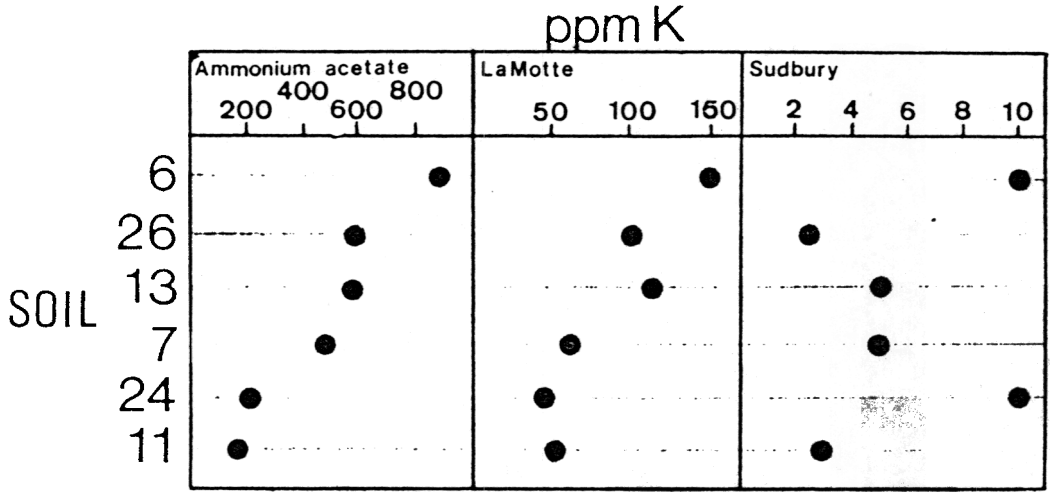
A. Potassium Tests

Available potassium values for the three methods are given below.

PPM K (SOIL)

Soil #	Ammonium acetate	LaMotte	Sudbury
6	890	150	10
7	490	60	5
11	190	50	3
13	580	115	5
24	210	45	10
26	590	100	2.5

These values are also plotted in order of increasing K concentration for the ammonium acetate method in order to compare trends



The three methods differ widely in their absolute K concentration, with Sudbury giving the lowest and the ammonium acetate method the highest values This is perhaps expected, given the different approaches to extraction solutions, extraction times and the sensitivity of the method or instrument used for the analysis

What is of more interest is the relative values of the K concentration within each method Using the ammonium acetate values as a guide, the LaMotte method shows a similar trend in ranking the soils from lowest to highest in potassium All three methods rank Soil #6 highest in K (This soil is rich in chicken manure and Soil #11 at or near the lowest in K But the Sudbury method gives an unusually high

value to Soil #24 and an unusually low value to Soil #26.

These differences in absolute K concentrations among the three test methods underscores two problems every soil testing laboratory must address: does the method really test for the amount of nutrient available to a plant, and what do the test values mean regarding fertilizer recommendations? These are problems of correlation and calibration, respectively

As a simple case consider the nutrient potassium as being present in the soil in four forms: dissolved in soil water, sticking to the outside of clay sheets, sandwiched between clay sheets and bound in the crystal structure of minerals In theory, plants can only absorb potassium that is present in the first two forms The other two forms release potassium to replace that used by the plants or lost to leaching But their release processes are usually too slow to benefit the plant during its growing season

Because the Sudbury method uses no extraction solution and the results are read within minutes of mixing the soil with the test reagents, the low K values probably reflect the potassium concentration of the soil water only

The LaMotte method however, uses an extraction solution, but the contact time with the soil is only a few minutes The higher potassium values probably reflect the K concentration of the soil water plus some of the K sticking

to the clay sheets.

The ammonium acetate extraction method, because of its longer extraction time and use of concentrated ammonium ion to replace the K sticking to clay sheets, removes almost all of the K sticking to--and perhaps even some K between--clay sheets

Different soils containing the same amount of potassium would give different values using each of these methods Such differences would even exist among the various SSSA-approved methods. This is because potassium is very much dependent on the kinds and amounts of clays present in soils An important job for our soil testing laboratory will be to determine which of several methods most accurately depicts the plant-available concentration of each nutrient for the soils of American Samoa

The second problem, calibration, will require years of testing Meanwhile, we must rely on calibration estimates used elsewhere This will become clearer in the following example

> The two soil test kits give fertilizer recommendations based upon the results of each test If we were to amend Soil #11 for potassium using Simplox fertilizer (12-6-18), the Sudbury results would have us add 1481 lbs Simplox/acre; for LaMotte 1000 lbs Simplox/acre; and according to the "Tentative

Fertilizer Recommendations for Crops in Hawaii" (5), Soil #11 has more than an adequate supply of potassium for growing, say, Chinese cabbage IF the guide is based upon a method that gives similar values for soil potassium levels as the ammonium acetate method.

B. Nitrogen Tests

The Sudbury kit does not specify which form of nitrogen is being tested. It is safe to assume that it, like the LaMotte test, is for nitrate nitrogen since this is the most common form of inorganic nitrogen in well drained soils. The results are:

ppm N

Soil #	Sudbury	LaMotte
6	20	*
7	20	60 - 100
24	50	*

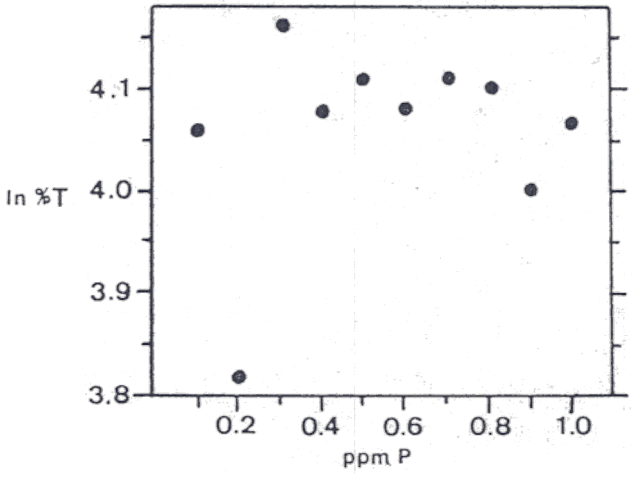
* Hue of sample did not match any bars on the color card.

The SSSA reference (4, pp 676-679) lists many colorimetric methods for determining nitrate, but few have been evaluated for applicability to soil extracts. The method used in the LaMotte kit is among those listed, but the procedure is considerably more involved than that given in the kit. Side reactions and the subjective method of comparing colors against a color chart make accurate readings difficult.

Soil testing laboratories generally conduct a total nitrogen test using either the Dumas or, more often, the Kjeldahl method Both are multi-step procedures involving long reaction times at high temperatures with special glassware and/or instruments

C Phosphorous Test

A plot of ln %T against ppm P is given below



The absence of a linear relationship between the two parameters indicates a problem with the procedure. The spectrophotometer was examined using known, increasing concentrations of copper sulfate and was found to be operating correctly In the SSSA-approved procedure testing for phosphorous using the ammonium paramolybdate method, it is recommended that the ammonium paramolybdate reagent be prepared fresh every two months (4, p 417 Since the age of

the LaMotte kit exceeds two months, the problem with this method may lie with outdated reagents

VI CONCLUSION

The three most important nutrients any soil testing laboratory should be able to analyze for are nitrogen, phosphorous and potassium. These are generally the limiting nutrients affecting crop yield

Because nitrogen occurs in several forms, each with its own chemical properties, no simple procedure currently exists for its complete analysis The only reliable methods employ long reaction times at high temperatures under carefully controlled conditions None of the soil test kits has an adequately reliable nitrogen test

The test for soil phosphorous is relatively straightforward and reliable--provided fresh reagents are used Preparing reagents as needed, though, would compromise the convenience of the soil test kits. Therefore, all prepared reagents for testing phosphorous in kits should be suspect; their reagents are probably outdated

The LaMotte procedure for testing soil potassium matches the ammonium acetate method remarkably well in trend. The LaMotte procedure is also given in the SSSA reference, (4, pp 231-232) except instead of being precipitated with ethanol the sodium potassium cobaltinitrite is either dried and

weighed or titrated with standard potassium permanganate solution The LaMotte kit may be useful in the field for quick testing when potassium levels are of interest, but the ammonium acetate/flame emission method is the method of choice in the laboratory.

Except for testing soil potassium levels using the LaMotte kit, soil test kits are not adequate alternatives for SSSA-approved methods Because they are inaccurate and/or difficult to read, recommendations based on kit results may irreconcilably erode farmers' confidence in our professional competence

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