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Soil analysis for identifying the importance of soil quality and determining the soil Indicators

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ABSTRACT

Soil examination gives data which can be utilized to enhance soil ripeness through administration. The degree to which soil ripeness can be enhanced relies upon the inalienable properties of the site – soil texture1, mineralogy, incline also, atmosphere. Soil structure2 is likewise key to plant execution as it influences the capacity of plant roots to get to accessible supplements. In this Technical Leaflet we investigate a portion of the fundamental certainties drawn from inquire about and viable experience about soil investigation with a view to making the best utilize of accessible data. It merits recollecting that plant tissue examination can likewise be valuable, particularly for follow components.

Keywords : Soil, Testing , Soil density , Electrical Conductivity, PH , GIS

I. INTRODUCTION

The first and most critical step in soil testing is collecting a soil sample. A soil analysis can only be as good as the sample sent to the laboratory. It is important to recognize what a tiny portion of a field is actually analyzed in the laboratory. For example, a 1 lb soil sample collected from a 5 acre field represents just 1/10,000,000 of the field! Therefore, it is vital that the soil sample be representative of the entire field.

The most common and economical method for sampling an area is composite sampling, where sub-samples are collected from randomly selected locations in a field, and the sub-samples are composited for analysis. The analytical results from composite sampling provide average values for the sampled area. The actual number of sub-samples depends on field size and uniformity. Generally, a larger field or a less uniform field should be more intensively sampled than one that is small and uniform. No less than 5 sub-samples should be taken from a sampled area, and 15 to 25 are preferable.

Alternatively, areas can be grid-sampled in a regular pattern. Each sample is analyzed separately, so that variability in soil properties can be determined. With data provided by grid sampling, maps of soil test values can be constructed. This information can be entered into a geographical information system (GIS) and combined with additional geospatial data, such as soil texture, crop yields, leaf analyses, etc. and used in precision agriculture systems for variable application of fertilizers and other crop inputs. This is a much more expensive

method of soil analysis because of the large number of analyses required, although it provides valuable information about geospatial uniformity which can be used in precision agriculture.

Ideally, samples should be collected with a soil probe or auger (a small shovel or trowel can also be used), to the depth of tillage (usually 6 to 8 inches) or to the effective rooting depth of plants. Deeper samples may be collected for evaluation of subsoil properties, such as salt or nitrate accumulation. It is helpful to sample to the same depth each time a soil is sampled, so that year to year samples can be directly compared to monitor changes over time. Each sub-sample should be approximately equal in size. The sub-samples should be placed in a clean plastic bucket and mixed thoroughly. The desired sample amount is then removed from the bucket and the remainder discarded. Check with your testing laboratory to find out how large a sample they require.

The area or size of the field sampled is dependent upon management practices. Sample the smallest unit that will be managed separately. For example, if a field has two distinctly different sections, perhaps one half level and the other sloped, then sample the two areas separately, and fertilize each half separately to obtain optimum results. However, if each half of the area will not be fertilized or managed individually, there is no need for separate sampling. A single, representative sample will be less expensive and just as useful. Sample the smallest management unit. Soil samples should be air-dried or taken to a test laboratory as soon as possible. To dry a soil sample, spread the soil out in a clean, warm, dry area, and let it dry for two to three days. It is best not to heat or dry soil samples in an oven because soil chemical properties may be altered.

to a laboratory for analysis. Soil samples can be refrigerated for several days if they cannot be dried immediately.

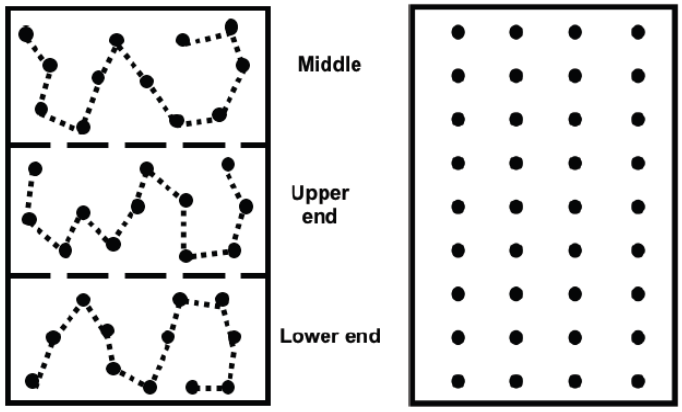

Figure 1. On the left: dividing and sampling scheme for a sloped field with distinct upper, middle, and lower areas. Circles represent sub-sample locations which are composited for each of the three areas. On the right: grid-sampling a field. Each sample is analyzed separately to evaluate field variability.

Fig.1 Soil Different Stage

II. METHODS

The present study deals with the analysis of soil samples from sugarcane field which were collected in a period 2009 - 2010 from Manjari, Hadapsar and Phursungi villages situated towards SE of Pune city and this region is affected by the solid waste disposal as well as industrial effluents. This study was primarily focused on testing

of soil quality from 12 representative sampling stations and the analytical results were expected to be representative for the entire field. The surface contaminated soil material were removed using spade or khurpi (Gupta, 2007) and for sampling V shaped holes were dug for collecting a uniform 2 cm thick slice of soil up to a depth of 22cm. which were collected in a plastic bucket. Samples collected were thoroughly mixed on a piece of clean cloth, air dried and the lumps were broken using wooden pestle and mortar (Tandon. 1993). Particles were disaggregated, crushed and sieved with 10 mesh diameter, stored in glass bottles and labelled.

pH values were determined using Equiptronics pH meter as described by Jackson (1967). For this 20 g soil sample was mixed with 40 ml distilled water in 1: 2 ratio. The suspension was stirred intermittently with glass rod for 30 minutes and left for one hour. The combine electrode was inserted into supernatant and pH was recorded.pH value as a measure of the hydrogen ion activity of the soil water system and expresses the acidity and alkalinity of the soil. It is a very important property of soil as it determines the availability of nutrients, microbial activity and physical condition of soil.

Electrical conductivity (EC) expresses ion contents of solution which determine the current carrying capacity thus giving a clear idea of the soluble salts present in the soil. The electrical conductivity of a soil samples was determined on an Equiptronics digital electrical conductivity bridge for which 20g soil was added in 40ml distilled water. The suspension was stirred intermittently for half an hour and kept it for 30 minutes without any disturbances for complete dissolution of soluble salts. The soil was allowed to settle down and then conductivity cell was inserted in solution to take the reading to record the EC values. Organic matter is useful in supplying nutrients and water to the plants and also provides good physical conditions to the plants. The quantity of organic carbon in the soil was estimated by using modified Walkey- black method (Walkey and black, 1934) as described by Jackson (1967). 1g finely ground dry soil sample was passed through 0.5mm sieve without loss and was taken into 500ml conical flask. To this 10ml of 1N potassium dichromate and 20ml con. H_2SO_4 were added and the contents were shaken for a minute and allowed to set aside for exactly for 30 minutes and then 200ml distilled water, 10ml phosphoric acid and 1ml diphenylamine indicator were added. The solution was titrated against standard ferrous ammonium sulphate till colour changes from blue violet to green. The blank titration was also carried without soil. In soils available phosphorus is found as orthophosphate in several forms and combinations but only a small fraction of it may be available to plants. Available phosphorus was estimated by Olsen's method (Olsen *et al*, 1954) modified by Watanbe (1965). The reagent for Olsen's P was 0.5 M $NaHCO_3$ (pH 8.5) prepared by dissolving 42g $NaHCO_3$ in distilled water and made up to 1 lit. The pH was adjusted at 8.5 with 20% NaOH solution. 2.5g of air dried soil was weighed into 150ml Erlenmeyer flask, 50ml of Olsen's reagent (0.5 M $NaHCO_3$ Solution, pH 8.5) and one teaspoonful of activate charcoal were added. The flasks were shaken for 30 minutes and contents were filtered immediately through Whatman filter paper (No. 41). 5ml of the filtrate was taken out by pipette into 25ml of volumetric flask and was neutralized with 1: 4 H_2SO_4 using p-nitrophenol as indicator and the volume was made up by adding distilled water. After addition

of few crystals of stannous oxalate blue colour developed and intensity of blue colour was read in photoelectric colorimeter within 10 minutes at a wavelength of 730nm.

A blank was run without soil. Potassium in soil water has been estimated by flame by preparing the standard solutions of potassium (ppm) and feeding the diluted extract in flame photometer for recording the reading for standard and sample with K filter. Micronutrients like Cu, Zn, Fe, Mn are estimated by using Atomic Absorption pectrophotometer employing standard methods (Trivedy and Goel, 1984). Micronutrients include iron, manganese, zinc, copper, boron, chlorine and molybdenum. The term refers to plant's needs, not to their abundance in soil. They are required in very small amounts but are essential to plant health in that most are required to speed up plant's metabolisms. They are generally available in the mineral component of the soil and the method commonly used for determination of available micronutrients in soil samples is by Lindsay and Norvell (1978) This method consists of use of DTPA (Diethylenetriaminepentaacetic acid) as an extracting which has been widely accepted for the simultaneous extraction of micronutrients like Zn, Cu, Fe Mn in neutral and alkaline soils. Most commonly used method for available boron is hot water extraction method as given by Berger and Truog (1939) which has been modified by (Gupta, 1967) in which boiling the soil with water is employed. The extracted boron in the filtered extract is determined by azomethine-H colorimetric method.

III. SOIL ANALYSES

After soil samples are received at a laboratory, a number of tests can be performed. A general understanding of soil testing will help you know how the results can be interpreted and to appreciate the accuracy of analytical results.

Soils supply most of the mineral nutrition for higher plants through the plant's root system. The root system extracts nutrients from the soil over a long period of time; two to three months for most annual crops, years for perennial crops. In contrast, a soil test determines the soil's nutrient supplying capacity by mixing soil for only a few minutes with a strong extracting solution (often an acid or a combination of acids). The soil reacts with the extracting solution, releasing some of the nutrients. The solution is filtered and assayed for the concentration of each nutrient. The nutrient concentration is then related to field calibration research that indicates the yield level reached with varying soil nutrient concentrations. This method works very well for some nutrients, but is less accurate for others, for example those nutrients supplied largely from organic matter (OM) decomposition such as nitrogen and sulfur. This is primarily due to the difficulty of estimating or predicting the rate at which OM will decompose and release these nutrients in plant-available forms.

Individual analyses included in a 'standard' or 'routine' soil test varies from laboratory to laboratory, but generally include soil pH, and available phosphorus (P) and potassium (K). They sometimes also include available calcium (Ca) and magnesium (Mg), salinity, and often include an analysis of OM content and soil texture. Most laboratories offer nitrogen (N), sulfur (S), and micronutrient analyses for additional cost.

The methods used to test soils vary depending on chemical properties of the soil. For example, tests used for measuring soil P are quite different in the acidic soils common in the southeastern U.S. than those used in the

alkaline soils of the southwest. Analysis of southwestern soils with methods tailored for acidic soils will provide erroneous results. Therefore, it is important to be aware of the methods used by test labs, and to select methods that are regionally appropriate. Local laboratories will generally use methods appropriate for your soils and your laboratory should provide you with test method information. A listing of local soil test laboratories may be found in the University of Arizona publication, "Laboratories Conducting Soil, Plant, Feed or Water Testing" (AZ1111) .

IV. COOPERATIVE EXTENSION

Nutrient levels are usually expressed on a mass (weight) basis using units of parts per million (ppm). These can be converted to a molar basis by dividing ppm by the molecular weight to get mmol/L (for liquids) or mmol/kg (for solids). Another useful unit for expressing nutrients is centimoles of charge per kilogram of soil (cmolc/kg). To calculate cmolc/kg, divide ppm by the molecular weight and then multiply this value times the charge on the nutrient ion. Older literature uses meq/100g, which is identical to cmolc/kg.

4.1 STANDARD SOIL TESTS

4.1.1PH

Soil pH is a measure of the acidity or alkalinity of a soil. The term pH applies to solutions, so the analysis must be conducted on a soil/water mixture. The soil sample is mixed with water, allowed to equilibrate for at least an hour, and then the pH measured. Several factors affect pH measurement. Primary among these is the salt concentration of a soil (a salt is any molecule that, when placed in water, separates into positively and negatively charged components or ions). The salt concentration of a soil may vary with the season or with fertilizer application, and is generally greater immediately following fertilizer application than before. The result may be an apparent pH drop up to one-half a pH unit.

When samples are collected frequently or at various times of the year it may be noted that pH values tend to increase and decrease, seemingly at random. This can lead to questions regarding the reliability of soil pH measurements, but the fluctuations may be due to changes in soil salt levels and do not usually present a serious problem in the use of the analysis. Some laboratories measure pH in a dilute salt solution to mask salt-induced variations. This method gives lower pH values for which the laboratory should provide interpretation guidelines.

Arizona soils are generally alkaline (high pH), and pH adjustment is not a common practice. In most other parts of the country, ground limestone is routinely added to soil to raise soil pH. In those parts of the country, "lime requirement" (amount of lime required to adjust the soil pH to a desired level) is determined. This test is not needed for alkaline Arizona soils.

4.1.2 Electrical Conductivity (EC)

Electrical conductivity (EC) of a soil extract is used to estimate the level of soluble salts. The standard method is to saturate the soil sample with water, vacuum filter to separate water from soil, and then measure EC of the

saturated paste extract. The result is referred to as ECe and is expressed in units of deciSiemens per meter (dS/m). Older literature will likely use units of millimhos per centimeter (mmho/cm), which are identical to dS/m. Some test laboratories use different soil:water ratios, and use a multiplication factor to convert results to an ECe equivalent.

EC is a very reliable test for soil salinity, and this is a routine test in the arid southwest. However, in wetter climates EC is not a standard test so, if soil samples are sent to a laboratory in another part of the country, EC may have to be specifically requested.

4.1.3 Nitrogen (N)

Nitrogen analyses are not difficult to conduct, but interpreting results can be problematic. This is because a major portion of soil N is contained in the soil OM. Plant availability of organic N is dependent on OM breakdown, which is difficult to estimate. Therefore analyses of "total N", a sum of all forms of soil N, including organic N, are not routinely conducted. Instead, N in the nitrate form (NO_3-N) is assayed. Nitrate is directly available to plants, so this test provides an indication of short term N availability. However, NO_3-N can be quickly lost from soil, either leached past the rooting zone, or lost to the atmosphere in gaseous forms.

Nitrate analyses can provide an accurate determination of the N available to plants at the time of soil sampling, although this may not provide reliable information concerning N availability later in the growing season. If soil N analysis is to be used for making fertilizer recommendations, soil samples should be collected either shortly before planting time or during the growing season.

The extractant used to remove NO_3-N from the soil is not particularly important because of its high solubility. Some laboratories extract NO_3-N from soil with a salt solution, such as potassium chloride (KCl). However, other laboratories in the southwestern U.S. measure NO_3-N in the same extract used to measure soil P (see below) to reduce analysis costs. Results from these two kinds of extractants are directly comparable.

4.1.4 Phosphorus (P)

Most soil P is tightly bound to soil particles or contained in relatively insoluble complexes. The P-containing complexes in alkaline soils are very different than those in neutral or acidic soils. The amount of P removed during soil extraction is very much dependent on the nature of P complexes and on the specific extractant used, so it is critical that P extractants be matched to soil properties.

The Olsen or bicarbonate extractant, a dilute sodium bicarbonate solution, is used to extract P from calcareous, alkaline, and neutral soils, and is appropriate for Arizona soils. In contrast, most other P extractants, such as the Mehlich extractants, are suited for acidic soils, and may not be suitable for arid-region soils. If an appropriate extractant is selected, P analysis is a reliable and useful soil test. On a soil test report, the analysis may be reported as PO_4-P.

4.1.5 Potassium (K), Calcium (Ca), Magnesium (Mg), and Sodium (Na)

The four major exchangeable cations in arid-region soils are K, Ca, Mg, and Na. All except Na are essential plant nutrients; however Na is included here because it plays an important role in soil physical properties. Soil Na level is needed for calculations of cation exchange capacity (CEC) and exchangeable sodium percentage (ESP), discussed later.

An ammonium acetate extractant is used to extract exchangeable K, Ca, Mg, and Na from arid-region soils, but it does not extract less plant-available forms. Some difficulty may be encountered in soils containing Ca or Mg carbonates (calcareous soils) because the ammonium acetate extraction may remove some Ca or Mg from these minerals along with the exchangeable forms. In these situations, the analytical results may indicate slightly elevated levels of these nutrients. Some laboratories adjust the pH of the ammonium acetate extractant to 8.5 to minimize this error. However, this is not usually a large problem and K, Ca and Mg tests generally provide excellent estimates of plant available levels of these nutrients.

V. CATION EXCHANGE CAPACITY (CEC)

Cation exchange capacity is often estimated by summing the major exchangeable cations (K, Ca, Mg, and Na) using units of cmolc/kg. Most laboratories do not routinely conduct a separate analysis for CEC, but use the ammonium acetate extractable levels of these elements (discussed above) for this calculation.

5.1 Exchangeable Sodium Percentage (ESP) and Sodium Adsorption Ratio (SAR)

ESP and SAR are measures of soil Na content relative to other soil cations. ESP is the concentration of Na divided by the CEC. As described above, the CEC is often estimated as the sum of the major exchangeable cations, so ESP = Na/(K+Ca+Mg +Na), in units of cmolc/kg. SAR is roughly comparable to ESP, but is a ratio of Na to Ca plus Mg. For this calculation, concentrations of Na, Ca, and Mg are measured in a saturated paste extract (see discussion of EC, above). The equation used for calculation of SAR is:

where concentrations are in units of mmol/kg or mmol/L. SAR and ESP are both very useful measures of the influence of Na on soil properties. The choice between the two is based largely on the type of extraction used for cation analyses. SAR can be used with either soil or water samples, whereas ESP is applicable only with soils.

5.2 Free Lime

Free lime is a measure of soil carbonates (salts of CO_3^{2-}). When combined with an acid, carbonates release gaseous CO_2. The test usually performed for soil carbonates is semi-quantitative. A weak acid solution is applied to the soil sample, and the degree of ‘fizzing’ or release of CO_2 gas is determined visually and categorized as ‘none’, ‘low’, ‘medium’, or ‘high’.

VI. OPTIONAL SOIL TESTS

6.1 Sulfur (S)

Sulfur, like N, may be contained primarily in the soil OM, but plants absorb only the inorganic sulfate (SO_4^{2-}) form. Measuring total soil S does not provide a good estimate of S plant availability because rates of release from OM cannot be accurately predicted. Instead, S in the sulfate form is a more common measure. Sulfate can be extracted from the soil with several extractants, including water or weak salt solutions. Analysis of SO4-S is relatively easy, but it usually provides a measure of immediately available S, and not the soil's long-term ability to provide S to a growing plant. Some desert soils contain large quantities of sulfates, in which case sulfate analysis gives a good indication of the soil's ability to supply S.

VII. CONCLUSION

Soil analyses can provide information that is important for maximizing nutrient use efficiency and agricultural productivity. A historical record of soil properties provided by long-term soil testing is useful for determining the effectiveness of fertilizer management strategies in maintaining soil fertility and sustainable agricultural productivity. Soil testing is also a useful tool for indentifying the causes of nutrient related plant growth problems.

Soil sampling is the critical first step in a soil testing program. The second is selection of a laboratory that will utilize analysis procedures appropriate for regional soils and conditions. However, an understanding of the accuracy and limitations of individual procedures and of the meaning of soil test results is essential. This publication provides information on these components of a soil testing program. The last steps, interpreting soil analysis values and developing a fertilizer management program, are crop specific and sometimes dependent on additional soil and climatic properties, and are beyond the scope of this document.

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