REPUBLIC OF KENYA

KALRO
Kenya Agricultural & Livestock Research Organization

NAVCDP
National Agricultural Value Chain Development Project
Transitioning from Subsistence to Commercial Farming

INTERPRETATING SOIL TEST RESULTS

1. **Background**	Soil analysis report provide information necessary for setting nutrient application targets, used to calculate quantities of manure and fertilizer application rates and allows monitoring and detection of changes in soil parameters. When a soil analysis test results shows **low levels** of a particular nutrient application of that nutrient is expected to **increase** crop yield. Generally, nutrient analysis is arbitrarily classified as **very low, low, adequate, high, and excessive.** At **very low** nutrient levels, yields are expected to be **<70%** of the expected yield and a larger application of fertilizer for soil-building purposes is required. After the application of the required amounts of nutrient, plant growth is expected to be dramatic and profitable. At the **low** fertility level, yields are expected to be **70–90%** of the expected yield. Under these conditions, annual application of the recommended dosage of fertilizer is necessary to produce **maximum** response and increase soil fertility. The increase in **yields** should justify the **cost of fertilization.**

2. **Nutrient analysis**	Is the determination of the measure of nutrients contained in the soil sample using an extraction solution and forms the basis for fertilizer recommendation. This is usually reported in parts per million (ppm) or mg/kg
3. **Determining Soil Nutrient levels**	***Example*** A soil analysis report indicates that there is 10 ppm N in 0-15 cm depth. How much is that N in kg/ha? ***Solution*** Nutrient (kg/ha) = [Nutrient (ppm)x2xsample depth (cm)] divided by sample depth Therefore: nutrient – 10 ppm; sample depth – 15 cm [10 ppmx2x15] divided by 15= **20 kg N/ha**

4. **KALRO recommendations**

Table 1: Mineral elements and their recommendation

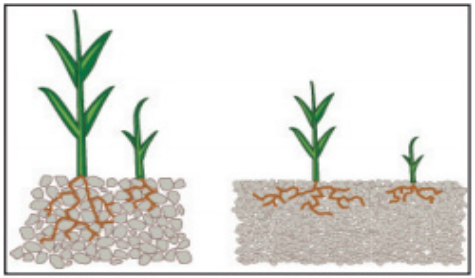
Mineral element	Recommendation
Soil N	100 mg/kg (Total N >0.15%)
P	2000 to 5000 mg/kg
K	1 to 100 mg/kg
Ca	2 to 400 mg/kg
Na	20 to 250 mg

(Adopted from Akenga et al., 2014)

5. **Salinity**

This is a condition where the soil contains excess soluble salts thus causing the reduction in growth of most crops. These soluble salts consist of cations of the elements; sodium (Na^{+}), potassium (K^{+}), calcium (Ca^{2+}) and magnesium (Mg^{2+}) along with anions chloride (Cl^{-}), sulfate (SO_4^{2-}), nitrate (NO^{3-}), bicarbonate (HCO^{3-}) and carbonate (CO_3^{2-}).

Salinity is caused by several factors, among them, land use activities such as irrigation with water containing high concentration of salt. Such soils are characterized by poor soil structure and surface crusting.

6. **Effects of salinity**	Salinity causes physiological water stress to plants as it reduces availability of water to plants. The soil may contain sufficient moisture but is unavailable to plants because the moisture is held more strongly to the soil. This is critical is during establishment and early plant growth. Plants may exhibit poor root growth, browning/ tip burns on foliage, inhibited flowering, poor plant growth and eventual low yields.
7. **Sodicity**	This is a condition where the soils have high levels of sodium (i.e. concentration greater than 15% of CEC). Such soils have poor soil structure hence low water infiltration capacity resulting in stunted plant growth  Soil with good structure (non-sodic soil) Soil with poor and dense structure (sodic soil). *Source: Sonon, Saha and Kissel, 2015* **Difference between sodic and non-sodic soils**

How to determine sodicity

Table 2: Characteristics of soils suspected to be saline, sodic or saline-sodic

Soil status	Characteristic
Saline	White crust on soil surface. Water-stressed plants. Leaf tip burn
Sodic	Poor drainage. Black powdery residue on soil surface
Saline-sodic	Grey-coloured soil. Plants showing water stress.

Source: *Waskom et al., 2010. Diagnosing saline and sodic soil problems. Colorado State University Extension Fact Sheet # 0.521*

Salinity and sodicity in soils are determined using electrical conductivity (EC), total soluble salts (TSS), sodium adsorption ratio (SAR) and exchangeable sodium percentage

Electrical conductivity

Measure of the ability of the soil solution to conduct electricity and is expressed in decisiemens per meter (dS/m, which is equivalent to mmhos/cm). Saline soils have an EC of >4 dS/m; an equivalent of approximately 40 mmol salts per litre.

Crops vary in their tolerance to salinity and some may be adversely affected at ECs <4 dS/m. For example, peach is sensitive, whereas cotton is more salt tolerant (Maas, 1990). Beets and asparagus are very tolerant of salinity.

Table 3: Guidelines in interpreting EC data from soil extracts (1:2 soil-to-water ratio)

Electrical Conductivity (mmhos/cm)	Rating	Interpretation
0 - 0.15	Very low	Plants may be starved of nutrients.
0.15 - 0.50	Low	If soil lacks organic matter. Satisfactory if soil is high in organic matter.
0.51 - 1.25	Medium	Okay range for established plants.
1.26 - 1.75	High	Okay for most established plants. Too high for seedlings or cuttings.
1.76 - 2.00	Very high	Plants usually stunted or chlorotic.
>2.00	Excessively high	Plants severely dwarfed; seedlings and rooted cuttings frequently killed.

Total soluble salts (TSS)/Total dissolved salts (TDS)	Refers to the total amount of soluble salts in a soil-saturated paste extract expressed in parts per million or milligrams per litre (ppm or mg/L). A linear relationship exists between TSS and EC within a certain range that can be useful to closely estimate soluble salts in a soil solution or extract. The ratio of TSS to EC of various salt solutions ranges from 550 to 700 ppm per dS/m. Sodium chloride, the most common salt, has a TSS of 640 ppm per dS/m. So if EC is known, TSS can be estimated using the formula below: *TSS (mg/L or ppm)*= EC (mmhos/cm or dS/m) x 640

Sodium Adsorption Ration (SAR)	Describes the proportion of sodium ions to calcium and magnesium ions in soil solution. The formula to calculate SAR is given below, with concentrations expressed in milliequivalents per liter (meq/L) analyzed from a saturated paste soil extract (Sonon, Saha & Kissel, 2015). $$SAR = \frac{[Na^+]}{\sqrt{1/2\,([Ca^{2+}] + [Mg^{2+}])}}$$ (*source: Sonon, Saha&Kissel, 2015*) Normal soils: SAR <13 Sodic soils: SAR >13 Excess sodium in soils causes soil particles to repel each other, preventing the formation of soil aggregates, resulting in tight soil structure with very poor water infiltration, poor aeration, and surface crusting. Such soils are difficult to cultivate and contribute to low emergence and root growth. SAR is used to determine sodium concentration in soil, soil solution and irrigated water. Exchangeable sodium percentage (ESP) – a ratio describing sodicity of the soil, particularly proportion of sodium cations attached on soil particles in relation to other cations. It is expressed as a percentage in relation to the CEC. ESP is used only in soils but not in irrigated water. Normal soils have ESP <15% ESP =[(Na+)/CEC]x 100

Cation exchange capacity (CEC)

Expression of the sum of the major exchangeable cations, including hydrogen. It is expressed as meq/100g. CEC is influenced by soil texture and presence of organic matter. CEC is highest clay, followed by Silt, followed by sand

Table 5: Classification of salt-affected soils using the saturated paste extraction:

Class	EC (mmhos/cm)	SAR	ESP
Normal	Below 4.0	Below 13	Below 15
Saline	Above 4.0	Below 13	Below 15
Sodic	Below 4.0	Above 13	Above 15
Saline-Sodic	Above 4.0	Above 13	Above 15

Source: (*Sonon, Saha and Kissel, 2015*)

What to do to correct such soils

1.Leaching – check quality of irrigation water before application

Table 6: Leaching and its effect on salty soils

Estimated leaching requirements to remove salts	
Volume of salt-free water	Reduction of salt content in soil
6 inches	50%
12 inches	80%
24 inches	90%

Source: (*Sonon, Saha and Kissel, 2015*)

2.Chemical treatment – apply gypsum (calcium sulfate, $CaSO4 \cdot 2H2O$). Incorporate in the soil followed by high quality irrigation water.

Mandate Centre for Potato Research:	KALRO Tigoni
Reference Links – book, journal paper, magazine, brochure, bulletin, fact sheet, web etc. KALRO E-mimi web-site	**(http://www.kalro.org/navcdp)**
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