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# Understanding your FERTREC soil analysis report

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Achieving and maintaining appropriate levels of soil fertility is essential for sustained agricultural production. The standard soil fertility analysis offered by the KZNDARD Soil Fertility Laboratory at Cedara provides a number of important measures of soil fertility, including nutrient availability for plant uptake, acid saturation and soil pH. This information is presented to the client in the form of a FERTREC report. Interpretation and use of the information provided in the report is an important next step in managing the nutrient supply and other soil characteristics that influence soil fertility for any crop.

There is an option on the FERTREC submission form for the client to request fertiliser recommendations for up to three crop species. The given recommendations are based on crop requirements as determined by many field research trials and are designed to keep nutrients and acidity from being limiting factors for crop production. However, it is valuable for the land manager to have an understanding of what the numbers on the report mean beyond the resulting fertiliser or lime recommendations.

## Different methods of analysis give different results

It is important to note that results from one laboratory are often different to those obtained from another. Due to variations in soil properties between different geographic locations, soil laboratories may use different methods to extract plant-available nutrients from the soil sample (see Manson, Bainbridge & Thibaud, 2020, for analytical methods used by the KZNDARD Laboratory). Values for specific nutrients are likely to differ with testing method. It is therefore important to use the interpretative data for the specific method to avoid incorrect interpretation of the results. The Cedara Analytical Laboratories participate in the AgriLASA inter-laboratory proficiency test scheme, which serves as a form of quality control, informing laboratory managers of the reliability of the results generated in the laboratory.

## Sample density (g.mL$^{-1}$)

Soil density is the relationship between the mass and the volume of a dry, crushed soil sample. Typical values for most soils vary within the range of 0.9 to 1.5 g.mL$^{-1}$. Sandy soils usually have higher density values than clay soils because they have less pore space between particles. Soils with high levels of soil organic matter generally have low sample densities.

## Phosphorus and Potassium

Phosphorus (P) and potassium (K) are two important macronutrients that often need to be supplied as fertilizers for optimum crop growth. They are required in larger amounts compared to the micronutrients (e.g. zinc, iron, boron). The Cedara Soil Laboratory measures plant-available P and K using the Ambic-2 extraction method.

Total P comprises about 0.01 - 0.1% of most topsoils, but only a fraction of that is available for plant uptake. Between 25% and 90% of total soil P is bound up in organic matter, and most of the rest is bound to or in soil minerals. There is no correlation between total soil P and crop response, and therefore soil analyses estimate the amount of plant-available P in the soil. Phosphorus fertiliser recommendations are based on the analysis of extractable P and the soil sample density. The inclusion of sample density in the determination of the P fertiliser recommendation takes into account the increased P-fixation ability of clay soils (low sample density) compared with sandy soils. Most soils in KwaZulu-Natal are very deficient in P and will require P fertilisation for acceptable yields. Yield response to P fertilization is unlikely when the soil P test is greater than 36 $mg.L^{-1}$ for row and forage crops, above 25 $mg.L^{-1}$ for fruit crops and above 75 $mg.L^{-1}$ for vegetable production. A minimum "starter" dressing of 20 kg $P.ha^{-1}$ is recommended for all pastures at establishment and most row crops, unless the soil P test is greater than or equal to 120 $mg.L^{-1}$ (Manson, et al., 2017).

Potassium levels in KwaZulu-Natal vary from high to very low, but in cropped soils K is rapidly depleted and fertiliser K is usually needed to sustain production.

**Table 1. Target soil K test values for selected crops, giving an optimum range based on potential yield**

| Crop | Target soil K ($mg.L^{-1}$) |
|---|---|
| Kikuyu | 100-140 |
| *Eragrostis curvula / tef* | 120-180 |
| Tall fescue | 100-140 |
| Annual ryegrass | 100-140 |
| Temperate fodder cereals | 80-120 |
| Maize (Bio 3, 4 & 6) | 120 |
| Potato | 160-260 |
| Vegetables (general) | 100-200 |
| Soyabean | 80 |
| Citrus | 300 |

Applied K is generally efficiently used by crops as it is rarely leached from soils with a clay content greater than 15%. The target K test value varies depending on the crop, as different species vary both in the amount of K they require for optimum growth, as well as in their ability to utilise the exchangeable K present in the soil. Potassium fertiliser recommendations also take into consideration yield potential, which depends on the climate, soil suitability and level of crop management (Table 1).

## Calcium and Magnesium

Although both calcium (Ca) and magnesium (Mg) are essential nutrients for plant growth, very little information is available on the soil test values required to ensure adequate Ca and Mg levels in the soil. Deficiency in nature is not common, usually occurring only in strongly acidic soils, or where soil K is exceptionally high due to over-fertilisation. If the soil pH is in the recommended range for the crop grown, Ca deficiency is very unlikely. Magnesium levels are considered to need correcting when the soil test indicates Mg levels are below 60 $mg.L^{-1}$.

Concentrations of exchangeable Ca and Mg are determined in the Cedara Soil Laboratory after extraction with a KCl solution. Due to the low levels of Ca and Mg required by plants, no specific recommendation is made to correct low soil test levels: deficiencies are usually corrected when the recommended lime is applied to increase soil pH. Either dolomitic lime or calcitic lime can be used in many KZN soils, but dolomitic lime is recommended if soil Mg is low; calcitic lime is recommended if the Ca:Mg ratio is low.

## Exchangeable acidity, Total cations and Acid saturation %

The effective cation exchange capacity (ECEC) is a measure of the soil's ability to hold cations (positively-charged elements). Soils with a low ECEC (<4 $cmol_c.L^{-1}$) are more susceptible to nutrient loss by leaching and are more likely to be deficient in cations. The cations are composed of both basic elements, *viz*., potassium, calcium, magnesium and sodium, and acid elements, *viz.,* aluminium and hydrogen. On the FERTREC report, the value for total cations is used as an estimate of the ECEC of the soil, and is calculated as the sum of the extractable Ca, Mg, K and acidity.

Exchangeable acidity refers to the titratable acidity determined after extraction with KCl. This is an estimate of the quantity of acid cations (hydrogen and aluminium) occupying the ECEC. Acid saturation is the exchangeable acidity expressed as a percentage of the total cations, i.e., the percentage of the ECEC occupied by acid cations. This is an important index in soil fertility and crop production as it is an indication of the likely aluminium (Al) toxicity in a soil. High concentrations of $Al^{3+}$ ions inhibit root growth; this reduces the uptake of water and nutrients by most crop species (Figure 1). Poor uptake of N, P, Ca and Mg is often observed.

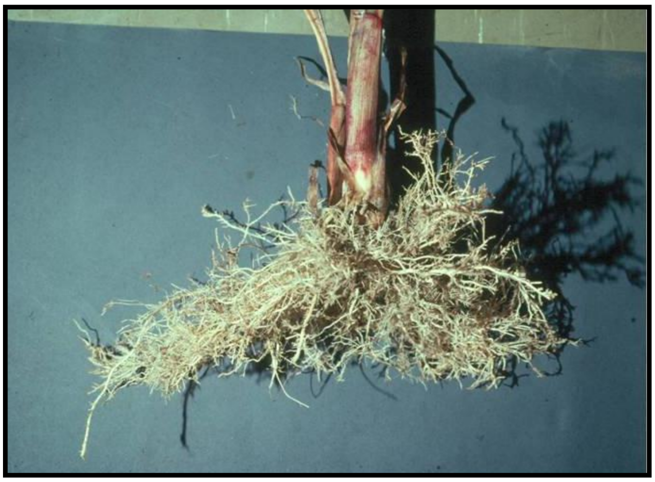

**FIGURE 1:** Aluminium toxicity severely limits the root growth of many species, as in this maize plant; high acid saturation indicates a high risk of Al toxicity. Photo by Mart Farina

The FERTREC report compares the calculated acid saturation value with the Permissible Acid Saturation (PAS) percentage for the crop in question. The PAS is the maximum acid saturation that allows optimum crop growth, and is used in the calculation of the lime requirement (see examples in Table 2).

**Table 2. Permissible acid saturation values for selected crops. Application of agricultural limestone is recommended when acid saturation is greater than PAS.**

| Crop | PAS (%) |
|---|---|
| Kikuyu | 40 |
| Perennial ryegrass | 1 |
| Eragrostis curvula / tef | 50 |
| Annual ryegrass | 10 |
| Tall fescue | 25 |
| Lucerne | 1 |
| Maize (Bio 3, 4 & 6) | 20 |
| Soyabean | 20 |
| Sweet potato | 10 |
| Cabbage | 1 |
| Fruit & nuts | 1 |
| Kikuyu | 40 |

## pH

There are two pools of acidity in soils: exchangeable acidity, reflected by acid saturation, and active acidity, which is a measure of the free hydrogen ions in solution. Soil pH is an indicator of active acidity, and is measured by the Cedara Soil Laboratory using a KCl solution. Soil pH measured using a KCl (salt) solution is generally lower than if distilled water is used. The difference between KCl pH and water pH is usually 0.5 to 1.0 pH units.

While pH is a useful measure of soil acidity for a wide range of soils, exchangeable acidity and acid saturation are more useful for determining the lime requirement in highly acidic soils. This is because these soils require large quantities of lime to change the pH by one unit. For soils with high exchangeable acidity, lime recommendations based on acid saturation are generally much lower (more affordable) than those based on pH.

## Zinc, Manganese and Copper

Zinc, manganese and copper are micronutrients that are essential for plant growth, but are required at far lower concentrations than N, P or K. They are analysed as part of the Cedara Soil Laboratory's routine soil fertility analysis, using Ambic-2 extraction. Zinc (Zn) is often deficient in KwaZulu-Natal soils, particularly in soils that have received little fertilizer in the past. Lime application can dramatically reduce zinc availability. A zinc-containing fertilizer is recommended for soils with a Zn concentration of less than 1.5 $mg.L^{-1}$.

Manganese (Mn) concentrations are adequate in most KZN soils, and the acid nature of most of the Province's soils ensures that soil Mn is sufficiently plant-available for optimum Mn nutrition. Manganese toxicity is a far more likely problem in KZN, particularly in broad-leafed crops, grown on acid soils. In KwaZulu-Natal, Mn toxicity has been observed in soyabean, dry bean, cabbage and lettuce. For these crops, if soil Mn is greater than 40 $mg.L^{-1}$, lime should be applied, even if the sample acid saturation is less than the crop PAS. Manganese toxicity is rare in cereals and grasses grown in KZN, and it is highly unlikely to cause yield loss in these crops if soils have been limed to the recommended PAS.

Copper (Cu) deficiency is also rare in KZN. Copper applications are recommended if the soil Cu test is less than 1 $mg.L^{-1}$. Care should be taken to not apply too much Cu; over-application of Cu can damage plant roots and leaves, and kill some soil microorganisms, such as the rhizobia that fix nitrogen in legumes. Copper sulphate application rates of between 5 $kg.ha^{-1}$ (for sandy soils with low organic carbon) to 50 $kg.ha^{-1}$ (clays with high organic carbon) are usually sufficient.

## Organic Carbon

An estimate of organic carbon is routinely given for all soil samples analysed by the Soil Fertility Laboratory. The accuracy of the estimate is sufficient for general soil management, but a more precise measure may be obtained by requesting a total carbon analysis on submission of the soil sample.

## Nitrogen

An analysis for plant available nitrogen (N) is not offered. Although N fertiliser is usually required for optimal crop growth, it is very difficult to make cost-effective recommendations based on a soil test alone. Nitrogen moves very quickly in the environment from one form to another and, by the time it is required for crop growth, N measured at the time of soil sampling might have leached, run-off, or been lost as a gas. Nitrogen recommendations are therefore based on crop responses to N as determined in field trials.

## Further reading

Manson, A.D., Miles, N., Roberts, V.G. and V. Katušić. 2014. Soil Fertility Short Course Notes. KZN Department of Agriculture & Rural Development.

## References

Manson, A.D., Bainbridge, S.H. & Thibaud, G.R. 2020. Methods used for analysis of soils and plant material by Analytical Services at Cedara. KwaZulu-Natal Department of Agriculture & Rural Development.

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