Guidelines for the interpretation of soil analysis reports for vineyards

Van Schoor, L.H., Conradie, W.J. and Raath, P.J., ARC Infruitec-Nietvoorbij, Stellenbosch.

INTRODUCTION

Computer programmes are generally used to process soil analysis results and make recommendations. However, to be able to interpret the chemical results themselves, grapevine producers require more information. This article provides the most important guidelines required by producers to be able to interpret soil analyses. It is largely based on the extensive background information supplied in the book "Wingerdbemesting", compiled by Dr. W.J. Conradie (1994).

Almost all soil analysis results look like the example in Table 1. If requested, some also contain the amount of organic material. All the information in the table should be considered in order to make sensible recommendations.

INTERPRETATION OF RESULTS FROM ANALYSIS

Given below is the step-by-step process to determine the fertilisation recommendations.

Texture

Since soil texture influences potassium and phosphor norms in particular, it is essential to make a distinction between sandy, loamy and clayey soils. This also serves as an indication of the expected leaching tempo of nutrients such as nitrogen, magnesium and potassium.

pH

The pH of soil is determined in potassium chloride (KCl) or water (H_2O). Most laboratories in the Western Cape use the KCl method. When the soil solution has a pH(KCl) below 5,5 (pH (H20) < 6,5), it means that the amount of active hydrogen ions (H^+) is too high, which causes soil to be overly acid and to have a negative effect on root growth. Lime should therefore be applied to make a correction. Using information from the analysis table, the lime requirement is calculated as follows:

Given the Ca (cmol/kg) > Mg (cmol/kg), as in the case of Table 1 , the amount of lime per hectare that has to be applied for each 300 mm depth, will be calculated as follows using information from the analysis table:

ton lime/ha = [(H^+ x 10) - Ca - Mg] x 0,727
and given the Mg (cmol/kg) ? Ca (cmol/kg):
ton lime/ha ³ [(H^+ x 10) - (Ca x 1,25)] x 0,727

The two kinds of lime that may be applied, are calcitic lime ($CaCO_3$) and dolomitic lime ($CaMg(CO_3)_2$). Dolomitic lime only has to be applied if the Ca:Mg ratio is higher than 5. A mixture of the two (1:1) is sometimes recommended if the ratio is around 4. Lime is not easily soluble in water and therefore moves very slowly in the soil. Consequently it should be applied during soil preparation so that it can be worked into and mixed with the soil at a depth of up to 900 mm. If the pH is lower than 5,5 in existing vineyards, the lime requirement should only be calculated to a soil depth of 300 mm. Lime is then worked into the topsoil with a fork, spade or wiggle plough. In order to prevent overliming in the topsoil, ten tons of lime per ha per annum is the maximum amount to be applied to an existing vineyard.

Furthermore the calculated lime requirement should be adjusted downwards depending on the stone volume percentage indicated in the table:

0 - 10% stone : no adjustment
10 - 30 % stone : apply 80 % of the calculated requirement
30 - 50 % stone : apply 60 % of the calculated requirement
50 - 80 % stone : apply 40 % of the calculated requirement

Since organic material binds aluminium in the soil and limits the negative effect thereof in acid soils, it is also necessary to adjust the lime requirement as follows:

0 - 1 % organic material : no adjustment
1 - 2 % organic material : apply 80 % of the calculated requirement
2 - 3 % organic material : apply 60 % of the calculated requirement
3 - 4 % organic material : apply 40 % of the calculated requirement

Resistance
Resistance, measured in ohm, is reciprocal to conductivity (mS/m). Salts, e.g. calcium and sodium, conduct electricity and reduce the resistance of the soil solution. A low resistance in the soil thus indicates the presence of large quantities of salts in the soil, i.e. the soil is saline.

Various kinds of brackishness are encountered in soils. Both the exchangeable sodium percentage (ESP), i.e. the percentage constituted by Na of the total amount of exchangeable cations (S-value), and the specific resistance serve as criteria for classifying the type of soil brackishness. If the resistance is below 300 ohm and the ESP more than 15 %, it means that there is an excess of sodium brackishness in the soil. Sodium brackishness is adjusted with gypsum ($CaSO_4$). The calcium ions in the gypsum displace the sodium from the soil particles, whereafter it leaches. In the event of salt brackishness (ESP < 15%, with free gypsum or lime in the soil), as well as salt sodium brackishness (with ESP > 15 %, also with free gypsum or lime in the soil), the salts may be washed out using good irrigation water. If the resistance is less than 100 ohm, the soil requires special management practices if cultivation of vines is being considered.

To determine the amount of gypsum per hectare that should be applied to saline-alkali or nonsaline-alkali (sodic) soil, the Na (cmol/kg) may be multiplied by 3,4 to determine how many tons of gypsum per hectare are required for each 300 mm of soil depth. Sometimes sodium is not indicated in cmol/kg, but in mg/kg or parts per million (ppm). In such cases the Na (mg/kg or ppm) should be divided by 230, to obtain the amount of Na in cmol/kg to be used in the formula. Water soluble Na can be washed out quite simply through effective drainage. Gypsum is only applied to displace the exchangeable Na, i.e. that which has been adsorbed onto the soil particles. Laboratory analyses usually indicate total Na, i.e. soluble as well as exchangeable Na, which means that too much gypsum is recommended. It is advisable not to apply more than 10 tons of gypsum at any one time. After a year soil analyses may be done again to determine whether additional gypsum is required.

For soil preparation the gypsum requirement should be determined to a soil depth of 900 mm. Only 50% of the gypsum should then be worked into the soil. The rest is strewn on the surface. This ensures better infiltration and leaching, since the salt content of the rain/irrigation water is increased, the calcium ions displace the sodium, and the soil does not disperse.

Due to the fact that the gypsum cannot be placed in the subsoil, it serves no purpose to calculate the gypsum requirement deeper than 300 mm as far as existing vineyards are concerned. Once again a maximum of 10 tons per hectare per annum may be applied, but only 5 tons at a time to prevent too much K and Mg from being displaced. Reconsider the situation after the first 5 tons. Preferably apply gypsum before the rainy season or before irrigation, to ensure that the gypsum is washed into the soil and the Na leached.

Phosphor (P)
In soil analysis reports phosphor is usually indicated in mg/kg. Texture is an important factor when determining the P-requirement. If the Bray II method of analysis is being used, the norms are as follows:

0 - 6 % clay (Sandy) : 20 mg/kg P
6 - 15 % clay (Loamy) : 25 mg/kg P
> 15 % clay (Clayey) : 30 mg/kg P

Depending on the clay content of the soil, the P-content should therefore be augmented to the specific norm. For soil preparation the average P-content is determined to 600 mm soil depth. To increase the P-content by 1 mg/kg in the soil for 600 mm depth, 9 kg P should be applied, which is the equivalent of 45 kg double super phosphate per hectare. On high pH soils (pH (KCl) > 7) it may be an option to adjust the recommended figure downwards and increase the annual maintenance fertilisation volumes. For production vineyards the P-content is only calculated to a soil depth of 300 mm. To increase the latter depth soil by 1 mg/kg P, i.e. 4,5 kg P (22,25 kg/ha double super phosphate) must be applied. In the case of high pH soils, where P is easily retained, it is advisable for the fertilisation requirement to be spread over three instalments throughout the season.

During the harvest 0,7 kg P is removed for each ton of grapes produced and post-harvest maintenance fertilisation should be calculated accordingly, except where soil analyses indicate the P-content to be optimal or above the norm. It is important not to apply excessive amounts of P, since this may limit potassium uptake. Phosphate contents of more than 50 mg/kg in sandy soils, 60 mg/kg in loamy soils and 70 mg/kg in clayey soils, may be problematic.

Potassium (K)
As with P, soil texture plays a role in the interpretation of soil analyses, partly because K is leached very quickly out of sandy soil, otherwise because clay mineralogy plays an important role in K-binding. On sandy soils K-fertilisation is not recommended during soil preparation, seeing that it may easily leach out on such soils. A broad norm which may be set for K-nutrition, is that the K-content of the soil should constitute 4 % or more of the total exchangeable cations (S-value in soil analysis table). This norm is not, however, applicable to soils with a history of gypsum or lime applications, or where the resistance is lower than 500 ohm, or where the pH (KCl) is higher than 6, or where the calcium ions amount to more than 5 cmol/kg. In such cases laboratory analyses show an unrealistically high "cation exchange capacity (CEC)" and if the K-content therefore has to be adjusted to 4%, very large quantities must be applied.

The following general norms may be used as guidelines for maximum K-values of non sandy soils. In the main, these norms are linked to the differences in clay mineralogical types occurring in the various regions, and are more or less representative of K-contents which constitute 4% of the total interchangeable cations:

Coastal region : 70 mg/kg
Breede River area : 80 mg/kg
Olifants River area : 100 mg/kg
Karoo : 100 mg/kg
Orange River area : 120 mg/kg

K-adjustment during soil preparation is only required in exceptional circumstances. Where shortages do occur or are expected in heavy soils, the average K-requirement is determined to a soil depth of 600 mm. Where the K-content is below the norms mentioned above, K-fertilisation should be applied. In the case of production vineyards the K-content is only determined to a soil depth of 300 mm. The requirement per hectare is 4,5 kg of K to increase the K-content in the soil by 1 mg/kg over 300 mm in depth. This boils down to 9 kg KCl per ha or 11,25 kg K2SO4 per ha. During soil preparation (to a soil depth of 600 mm) 18 kg KCl per ha or 22,5 kg K2SO4 per ha should therefore be applied for each 1 mg/kg increase required in the soil.

If K-contents in production vineyards are optimal, apply maintenance fertilisation of 3 kg K per ton of production per annum. To determine whether KCl or K2SO4 should be applied, the resistance should be taken into account. Potassium sulphate is only recommended when the resistance of the soil is less than 500 ohm. Since excessive K-contents in the soil may cause problems with colour and pH in wine, overfertilisation should be avoided.

Nitrogen (N)
Nitrogen is not applied at all during soil preparation. After establishment 30 kg N per ha may be applied to young vineyards after budding. In clayey soils this should suffice for the year. Loamy soils may receive an extra fertilisation of 30 kg N per ha after flowering, while sandy soils should receive an extra 30 kg N per ha both after flowering and in the late summer. In exceptional cases where excessively vigorous growth occurs, no N should be applied.

For production vineyards vigour is always used as a guideline for N-fertilisation (Table 2). A distinction is also made between dryland/supplementary and intensively irrigated vineyards where production is generally higher.

Micro elements (B, Mn, Zn, Cu)
Micro elements are required by the vine in small quantities and the availability thereof is directly dependent on the pH of the soil solution. Where the pH is high, manganese (Mn) and zink (Zn) are inaccessible to the plant since these elements do not remain in solution. Sometimes these elements may therefore be present in the soil, but not accessible to the plant. Consequently soil analysis is not a reliable means of determining the availability of micro elements. To ascertain whether the metals are excessive or insufficient, leaf analyses should be done. In soils with low pH, boron (B) and Zn shortages may also be expected. On the other hand, Mn in low pH soil may be so soluble that it could become toxic to the vine. Lime applications will solve these problems by making B and Zn more available to the plant and Mn less soluble.

Soil analysis reports for vineyards usually indicate Zn -, Mn -, B - and copper (Cu) - contents in mg/kg. In cases where Zn - and B - contents in the soil are below 0,5 mg/kg, and Mn - contents below 5 mg/kg, shortages may occur. In such cases the vineyard should be monitored visually for symptoms of shortages. Consult the book "Wingerdsiektes en -plae in Suid-Afrika" (Ferreira, J.H.S. & Venter, E., 1996). If there is still any doubt, leaf analyses should be done. Boron toxicity may easily occur and the soil content should not exceed 3,8 mg/kg. Copper shortages very rarely occur in vineyards due to the use of fungicides that contain Cu.

If shortages do occur, it is easy to spray the leaves. Micro element solutions should be prepared in sufficient volumes to saturate all the leaves, as per the concentrations given below:

Zn : Zinc oxide or zinc sulphate at 2 kg/1000 litres water
Mn : Manganese sulphate at 2 kg/1000 litres water
B : Sodium tetra borate at 2 kg/1000 litres water

In high pH soils, soil applications may be considered.

SUMMARY

In conclusion, Table 3 provides a summary of the most important criteria to be considered when studying soil analysis reports for vineyards.

SOIL ANALYSIS SERVICE

A soil analysis service is offered by Infruitec-Nietvoorbij at R69,00 per soil sample (incl. VAT). This service supplies a table giving detailed results of the analysis (as in Table 1) as well as complete recommendations for fertilisation.

Both books referred to in the text are available from Infruitec-Nietvoorbij. Orders may be placed with Tanja Engelbrecht, telephone number (021) 809 3169.

REFERENCES

CONRADIE, W.J., 1994. Wingerdbemesting. Handelinge van die werksessie oor wingerdbemesting, gehou te Nietvoorbij op 30 September 1994. LNR-Nietvoorbij Instituut vir Wingerd- en Wynkunde, Stellenbosch.

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Table 1. Typical exposition of a soil analysis.

Lab No	Depth (mm)	Texture	pH (KCl)	Resist (ohm)	H (cmol/kg)	Stone Vol %	P (mg/kg)	K (mg/kg)	Interchangeable cat (cmol/kg) Na	K	Ca	Mg	S-val	Cu (mg/kg)	Zn	Mn	B
828	300	Sand	4.8	1009	1.13	6	7	39	0.1	0.1	1.7	1.5	3.4	0.2	0.9	4.5	0.8
829	600	Loam	5.2	1250	0.70	4	9	44	0.3	0.1	5.8	3.4	9.6	2.9	2.0	8.1	1.3

Table 2. Amount of N-fertilisation (kg N per ha) required for vineyards, depending on vigour.

Vigour	Dryland vines/supplementary irrigation			Intensively irrigated vineyards		
	After budding	After flowering	Post-harvest	After budding	After flowering	Post-harvest
Poor	20	20	40	20	0 - 20	40
Ideal	-	-	20-40	-	-	40
Excessively vigorous	-	-	-	-	-	20

Table 3 : Summary of the most important criteria in soil analysis reports for vineyards.

Analysis	Other criteria	Critical value	Problem	Aspects that determine extent of recommendation:
pH (KCl)		< 5,5	Lime requirement	Volume % stone, % organic material, overliming, micro elements.
Resistance		< 100 ohm	Not suitable for production vineyard	Drainage
		100 – 300 ohm	Gypsum requirement	Maximum applications
Phosphor (P) (Bray II)	0 - 6 % clay 6 - 15 % clay > 15 % clay	< 20 mg/kg < 25 mg/kg < 30 mg/kg	Phosphor requirement	Method of analysis, excessive fertilisation
Potassium (K)		< 4 % of CEC	Potassium requirement	Lime/gypsum applications, Resistance, Ca-value
	Coastal region Breede River OlifantsRiver Karoo Orange River	< 70 mg/kg < 80 mg/kg < 100 mg/kg <100 mg/kg < 120 mg/kg	Potassium requirement	Texture, resistance, excessive fertilisation
Nitrogen (N)		Poor vigour	N - shortage	Vigour, irrigation, excessive fertilisation
		Excessively vigorous	N - toxicity	
Zinc (Zn)		< 0,5 mg/kg	Zn - shortage	Leaf analyses, Leaf spraying, Soil pH
Manganese (Mn)		< 5 mg/kg	Mn - shortage	
Boron (B)		< 0,3 mg/kg	B - shortage	
		> 3,8 mg/kg	B - toxicity	