

# 'n Kykie na Grondsuurheid

Hoe residuele suurheid  
bereken kan word

Met dank en erkenning aan  
**Dawid Saayman**



STELLENBOSCH

☎ 021 109 0000

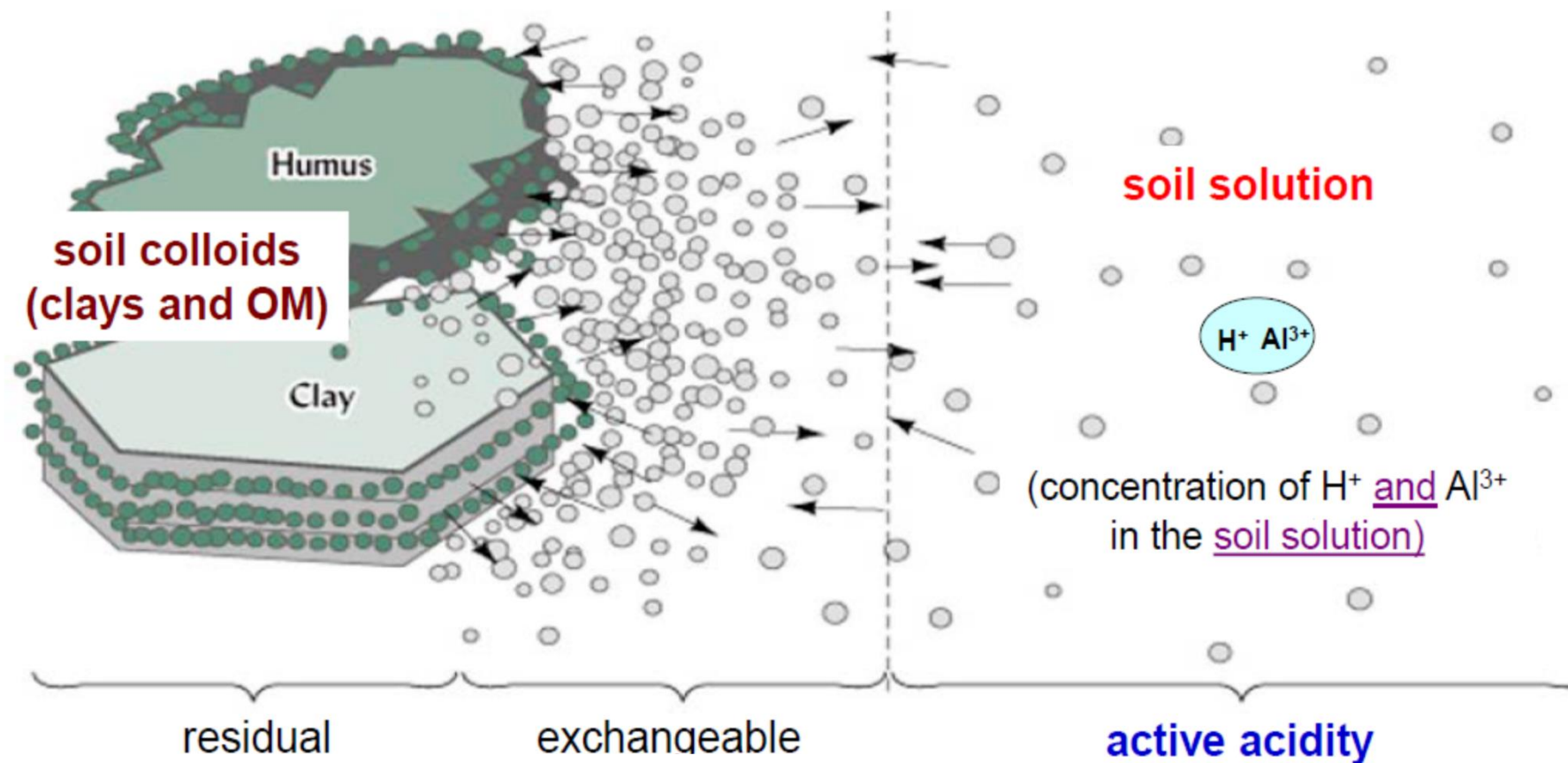
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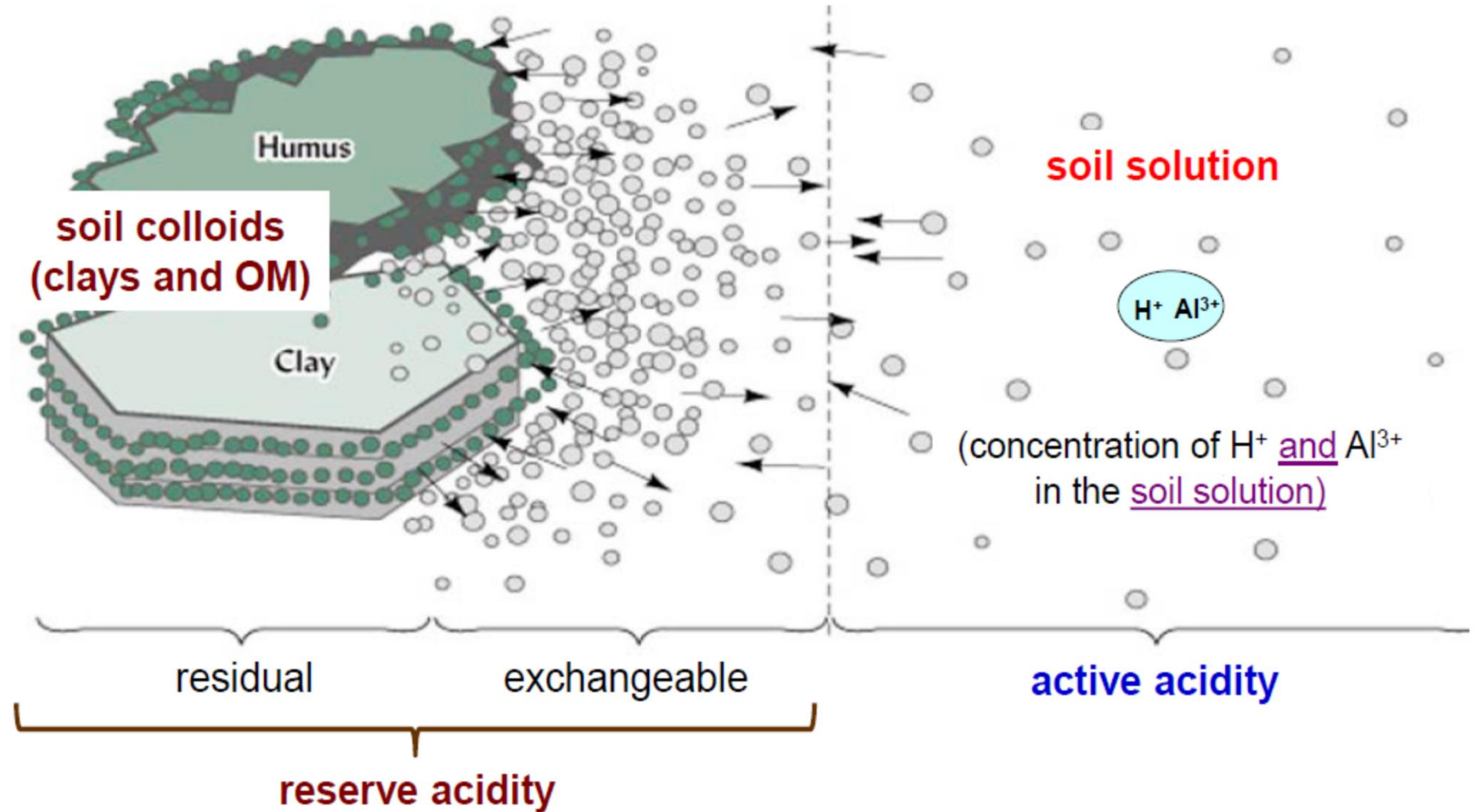
Let's take  
a closer  
look...

$$\text{total acidity} = (\text{residual} + \text{exchangeable}) + \text{active}$$



# Reserve acidity

$$\text{total acidity} = (\text{residual} + \text{exchangeable}) + \text{active}$$



## Includes acidity from:

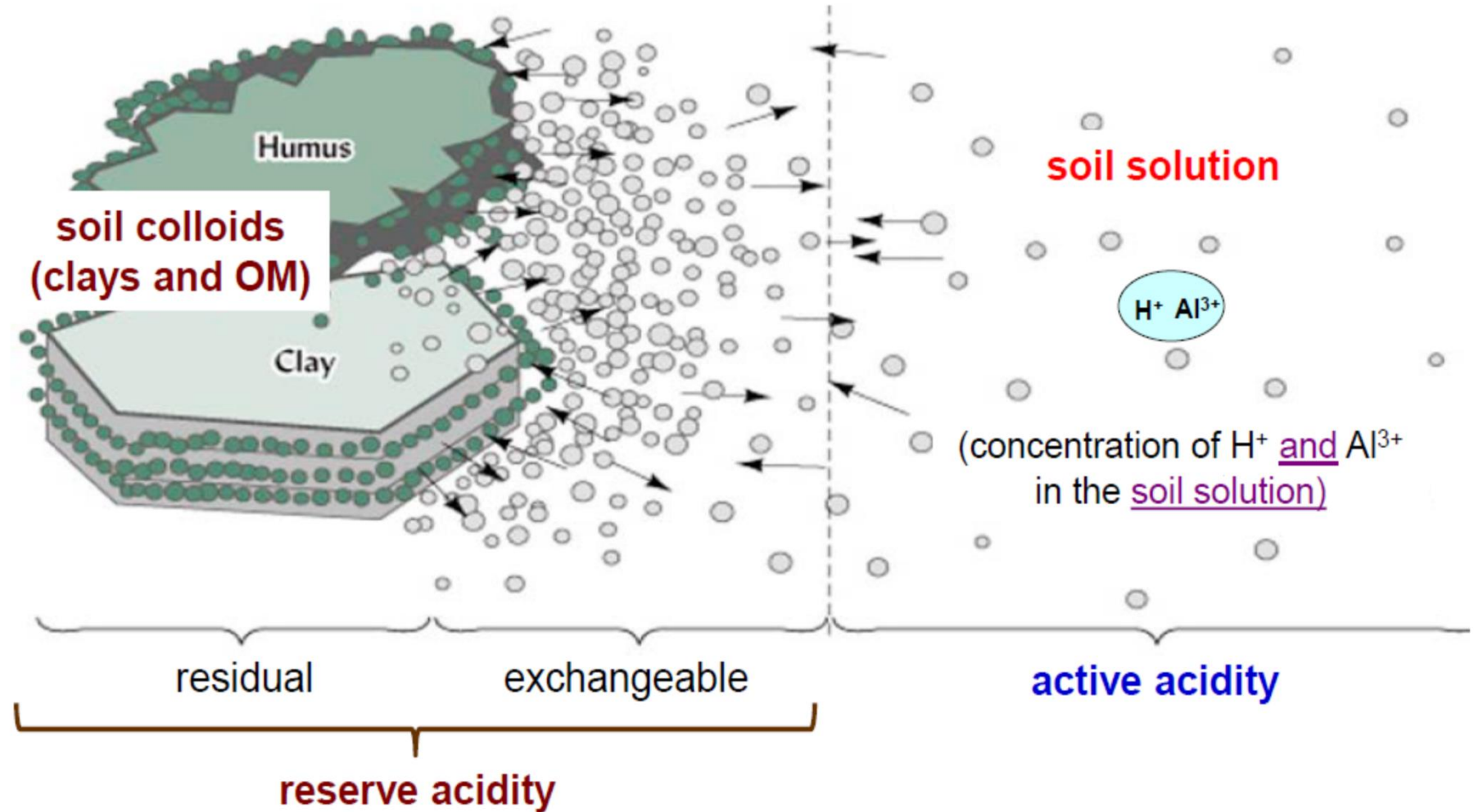
- (i) organic acid dissociation,
- (ii) hydrolyses of Al<sup>3+</sup>-organic complexes,
- (iii) exchangeable H<sup>+</sup> & Al<sup>3+</sup> through cation exchange, and
- (iv) non-exchangeable forms on mineral surfaces.

# Reserve acidity



Soil Buffering  
Capacity  
(pH)

$$\text{total acidity} = (\text{residual} + \text{exchangeable}) + \text{active}$$



Includes acidity from:

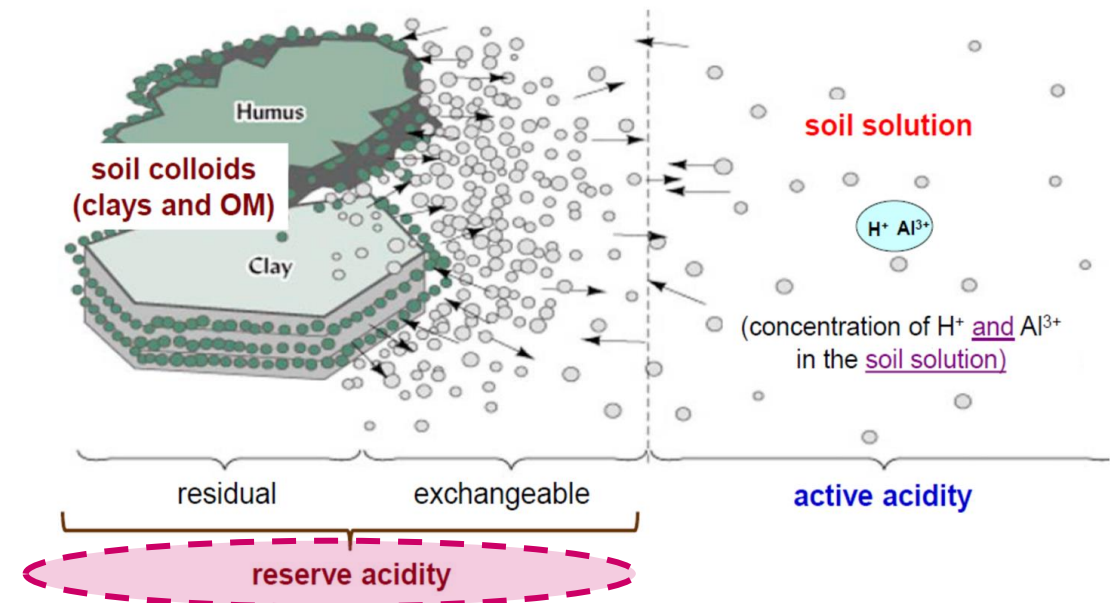
- (i) organic acid dissociation,
- (ii) hydrolyses of Al<sup>3+</sup>-organic complexes,
- (iii) exchangeable H<sup>+</sup> & Al<sup>3+</sup> through cation exchange, and
- (iv) non-exchangeable forms on mineral surfaces.

Reserve acidity = exchangeable acidity + non-exchangeable acidity (residual)

Displaced by a neutral salt,  
i.e., KCl

Displaced by a buffered salt,  
i.e.,  $K_2SO_4$

total acidity = (residual + exchangeable) + active



**Reserve acidity** = **exchangeable acidity** + **non-exchangeable acidity (residual)**

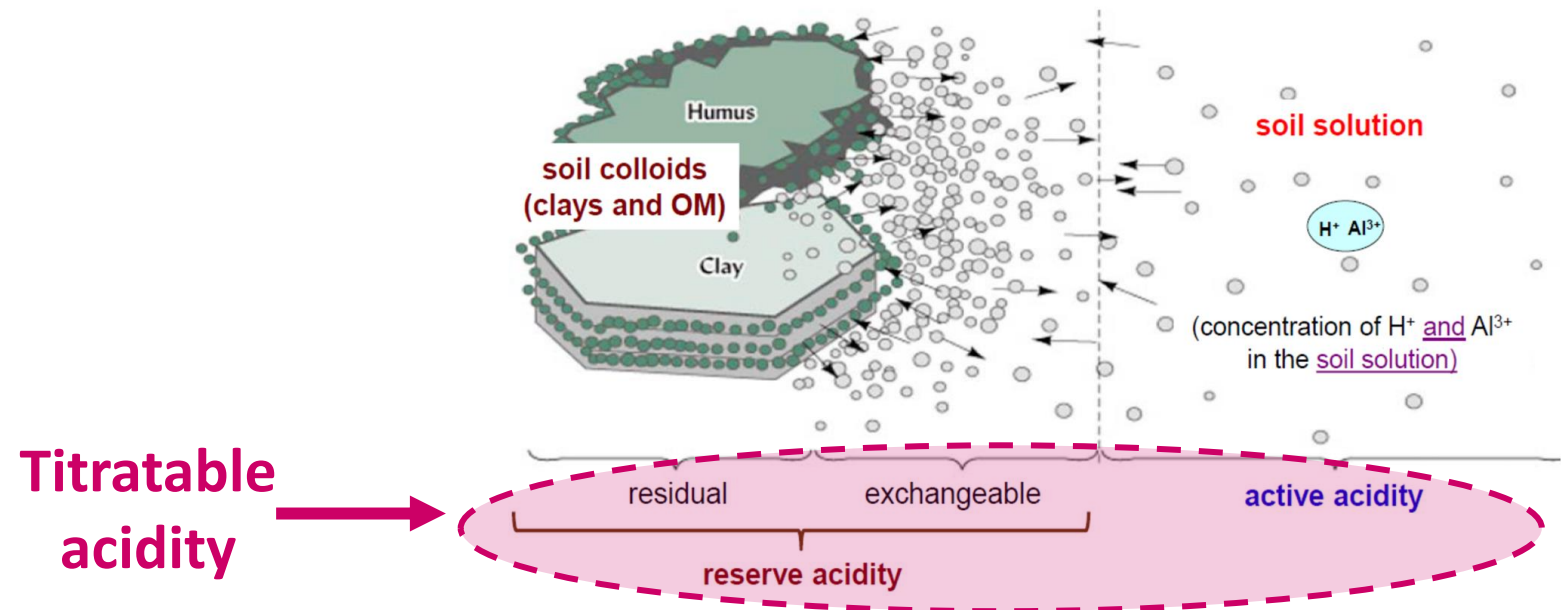
Displaced by a neutral salt,  
i.e., KCl

Displaced by a buffered salt,  
i.e.,  $K_2SO_4$

**Titratable acidity** = **active acidity** + **reserve acidity**

Obtained by *using an acetate buffered  $K_2SO_4$  solution (pH 7.0) as extractant*

total acidity = (residual + exchangeable) + active



# Eksteen Method

Lime requirement (ton/ha) =

$$(\mathbf{R} \times \mathbf{H}) - (\text{Ca} + \text{Mg}) \times 4 / (\mathbf{R} + 1) \times \text{depth} / 15 \text{ cm}$$

**Titratable acidity**  
cmol/kg



To obtain  $\text{pH}_{\text{KCl}} = 5.6$ ,  
an R-value of 10 is used.



# Problem with this report ... ?



| ROUTINE SOIL ANALYSIS              |                |                |                |                |
|------------------------------------|----------------|----------------|----------------|----------------|
| Farm Name                          | XXXXXX         | XXXXXX         | XXXXXX         | XXXXXX         |
| Sample Number                      | P1             | P2             | P3             | P4             |
| Lab Number                         | 3336373        | 3336388        | 3336384        | 3336382        |
| Crop                               | Grapes (Table) | Grapes (Table) | Grapes (Table) | Grapes (Table) |
| Hectares                           | 1.0            | 1.0            | 1.0            | 1.0            |
| Sample depth                       | Top-Soil       | Top-Soil       | Top-Soil       | Top-Soil       |
| Colour                             | Gr             | Gr             | Gr             | Gr             |
| Bulk Density (kg·m <sup>-3</sup> ) | 1236.5         | 1107.5         | 1176           | 1122.5         |
| pH (KCl)                           | 3.9            | 4.6            | 4.1            | 4.7            |
| Ex Acid                            | 0.45           | -              | 0.28           | -              |
| Acid Saturation (%)                | 10.3           | -              | 4.9            | -              |
| S (mg·kg <sup>-1</sup> )           | 36             | 27             | 21             | 16             |
| P (Bray I) (mg·kg <sup>-1</sup> )  | 134            | 90             | 120            | 128            |
| P (Olsen) (mg·kg <sup>-1</sup> )   | -              | -              | -              | -              |
| K (mg·kg <sup>-1</sup> )           | 249            | 366            | 390            | 429            |
| K(% of ECEC)                       | 15             | 13             | 17             | 15             |
| Ca (mg·kg <sup>-1</sup> )          | 529            | 1020           | 671            | 1060           |
| Ca(% of ECEC)                      | 60             | 69             | 59             | 71             |
| Mg (mg·kg <sup>-1</sup> )          | 77             | 157            | 128            | 132            |
| Mg(% of ECEC)                      | 14             | 18             | 18             | 14             |
| Na (mg·kg <sup>-1</sup> )          | 5              | 6              | 6              | 6              |
| Na(% of ECEC)                      | 0              | 0              | 0              | 0              |
| ECEC (cmolc·kg <sup>-1</sup> )     | 4.4            | 7.3            | 5.7            | 7.5            |
| Ca / Mg                            | 4.2            | 4.0            | 3.2            | 4.9            |
| Mg/K                               | 1.0            | 1.4            | 1.1            | 1.0            |
| (Ca + Mg) / K                      | 5              | 7              | 4              | 6              |

# Problem... ?

## Eksteen Method

Lime requirement (ton/ha) =

$$\{(R \times H) - (Ca + Mg)\} \times 4 / (R+1) \times \text{depth} / 15 \text{ cm}$$

Not titratable acidity...



| ROUTINE SOIL ANALYSIS              |                |                |                |                |
|------------------------------------|----------------|----------------|----------------|----------------|
| Farm Name                          | XXXXXX         | XXXXXX         | XXXXXX         | XXXXXX         |
| Sample Number                      | P1             | P2             | P3             | P4             |
| Lab Number                         | 3336373        | 3336386        | 3336384        | 3336382        |
| Crop                               | Grapes (Table) | Grapes (Table) | Grapes (Table) | Grapes (Table) |
| Hectares                           | 1.0            | 1.0            | 1.0            | 1.0            |
| Sample depth                       | Top-Soil       | Top-Soil       | Top-Soil       | Top-Soil       |
| Colour                             | Gr             | Gr             | Gr             | Gr             |
| Bulk Density (kg·m <sup>-3</sup> ) | 1236.5         | 1107.5         | 1176           | 1122.5         |
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| Mg/K                               | 1.0            | 1.4            | 1.1            | 1.0            |
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# Problem... ?

## Eksteen Method

Lime requirement (ton/ha) =

$$\{(R \times H) - (Ca + Mg)\} \times 4 / (R+1) \times \text{depth} / 15 \text{ cm}$$

Not titratable acidity...

$$\{(10 \times 0.45) - (2.65 + 0.64)\} \times 0.727 = \dots$$



| ROUTINE SOIL ANALYSIS              |                |                |                |                |
|------------------------------------|----------------|----------------|----------------|----------------|
| Farm Name                          | XXXXXX         | XXXXXX         | XXXXXX         | XXXXXX         |
| Sample Number                      | P1             | P2             | P3             | P4             |
| Lab Number                         | 3333333        | 3333333        | 3333333        | 3333333        |
| Crop                               | Grapes (Table) | Grapes (Table) | Grapes (Table) | Grapes (Table) |
| Hectares                           | 1.0            | 1.0            | 1.0            | 1.0            |
| Sample depth                       | Top-Soil       | Top-Soil       | Top-Soil       | Top-Soil       |
| Colour                             | Gr             | Gr             | Gr             | Gr             |
| Bulk Density (kg·m <sup>-3</sup> ) | 1236.5         | 1107.5         | 1176           | 1122.5         |
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| S (mg·kg <sup>-1</sup> )           | 36             | 27             | 21             | 16             |
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2.65 cmol/kg

0.64 cmol/kg

# Problem... ?

## Eksteen Method

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$$\{(R \times H) - (Ca + Mg)\} \times 4 / (R+1) \times \text{depth} / 15 \text{ cm}$$

Not titratable acidity...

$$\{(10 \times 0.45) - (2.65 + 0.64)\} \times 0.727 =$$

0.9 ton/ha/30 cm



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| Lab Number                         | 3336373        | 3336386        | 3336384        | 3336382        |
| Crop                               | Grapes (Table) | Grapes (Table) | Grapes (Table) | Grapes (Table) |
| Hectares                           | 1.0            | 1.0            | 1.0            | 1.0            |
| Sample depth                       | Top-Soil       | Top-Soil       | Top-Soil       | Top-Soil       |
| Colour                             | Gr             | Gr             | Gr             | Gr             |
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| Ca / Mg                            | 4.2            | 4.0            | 3.2            | 4.9            |
| Mg/K                               | 1.0            | 1.4            | 1.1            | 1.0            |
| (Ca + Mg) / K                      | 5              | 7              | 4              | 6              |

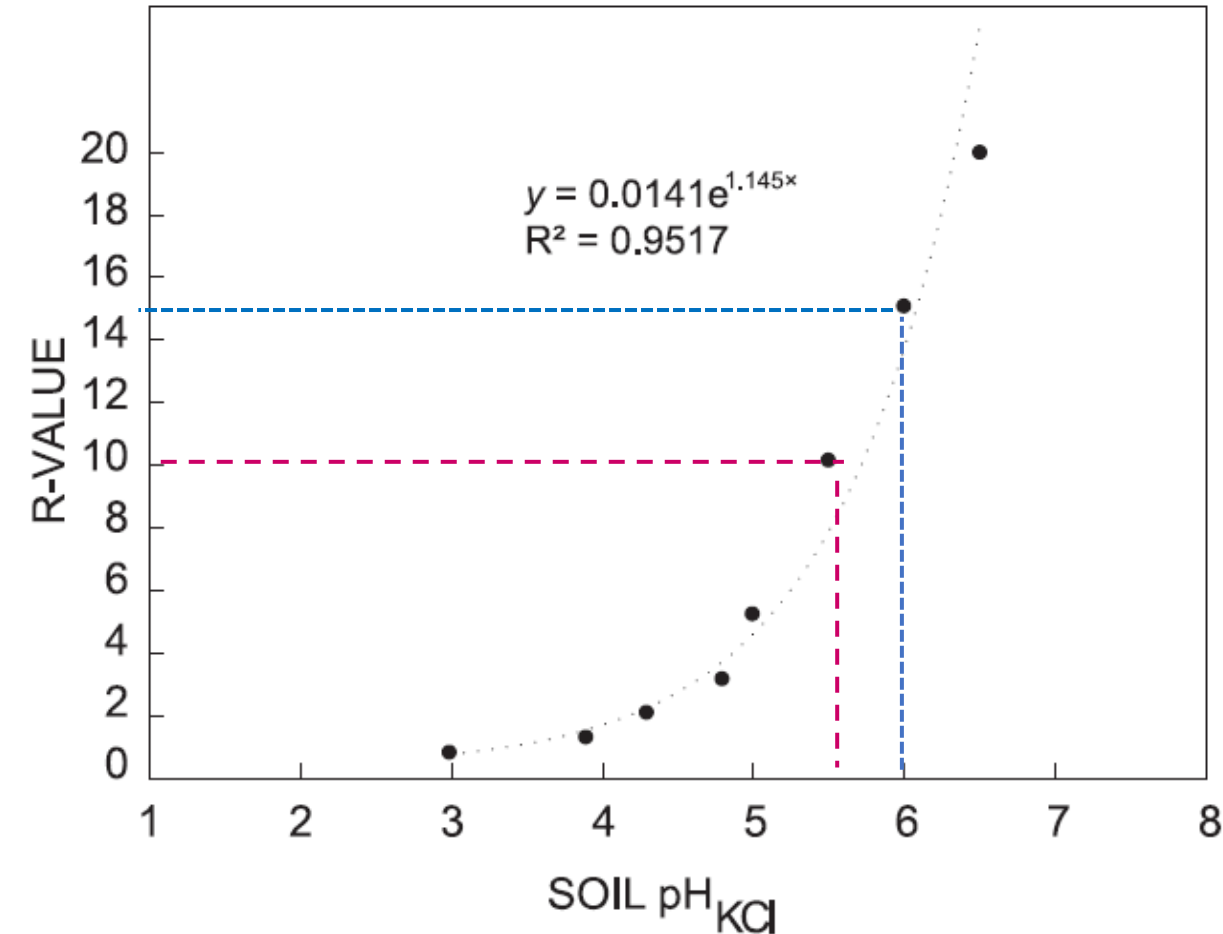
2.65 cmol/kg

0.64 cmol/kg

# Now what ... if you are stuck with such a report?



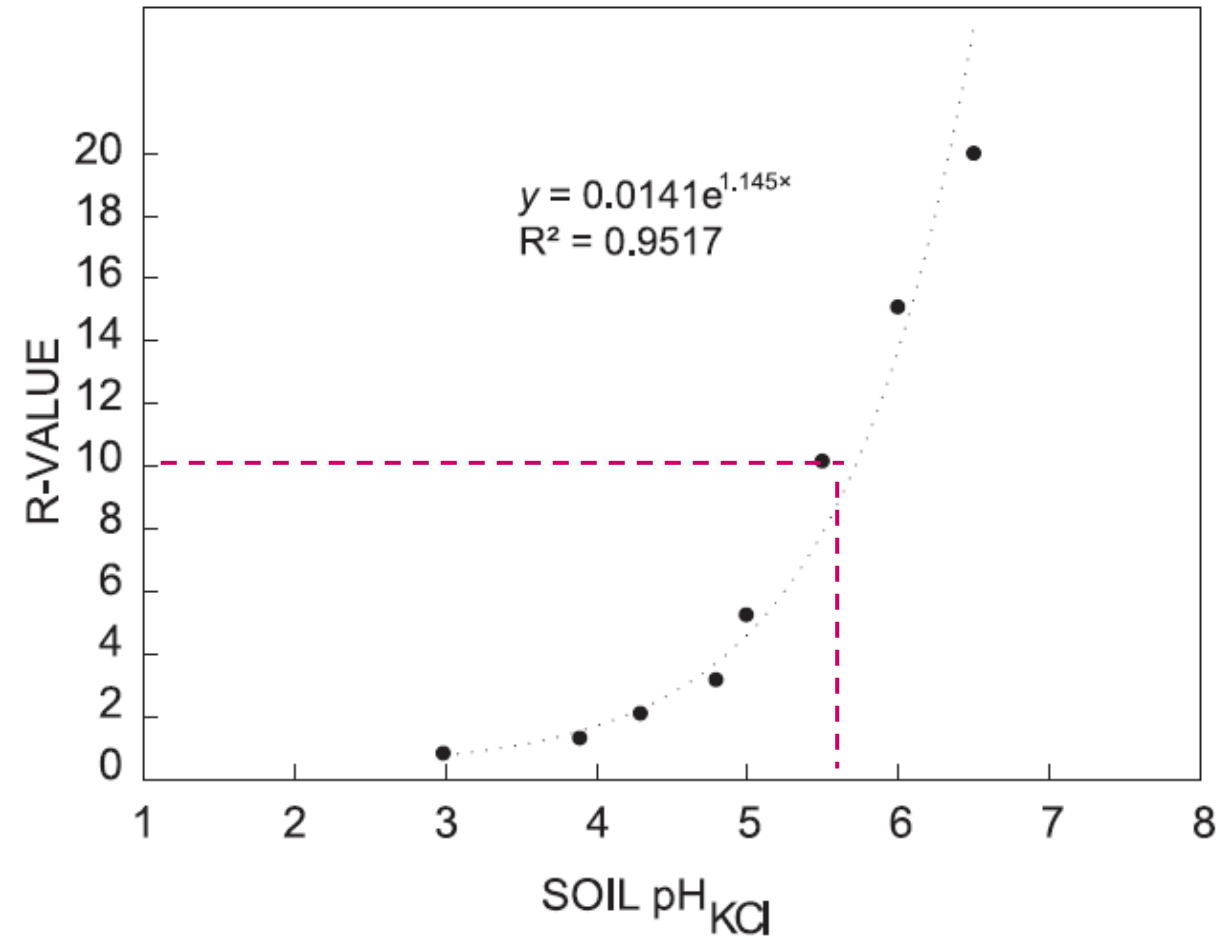
# Verband tussen $\text{pH}_{\text{KCl}}$ en 'n R-waarde (Eksteen, 1969)



Eksteen L. 1969. The determination of the lime requirements of soils for various crops in the winter rainfall region. Fertilizer Society of South Africa Journal 2: 13–14.

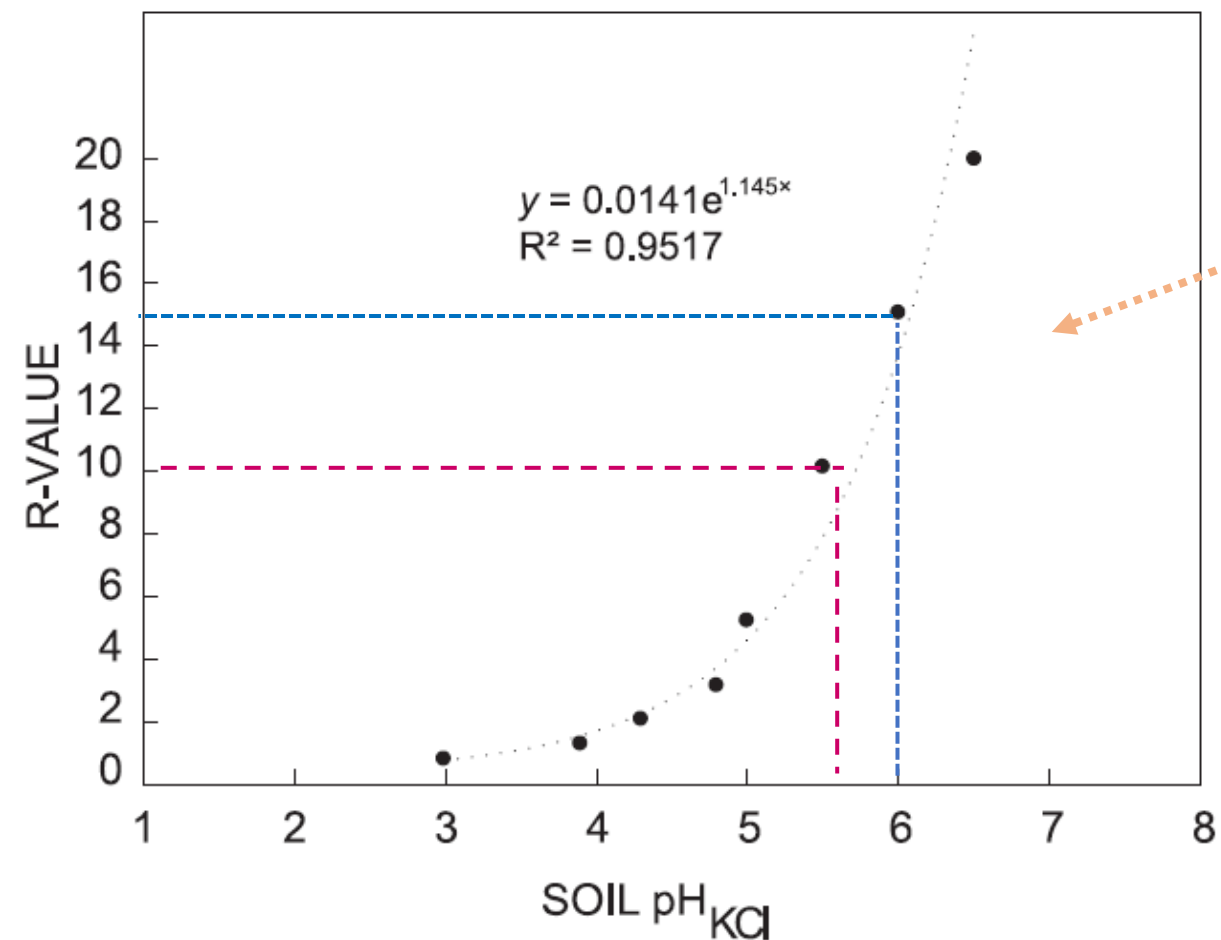


$$R = \text{Ca} + \text{Mg} / \text{H}$$



Eksteen L. 1969. The determination of the lime requirements of soils for various crops in the winter rainfall region. Fertilizer Society of South Africa Journal 2: 13–14.





$$R = Ca + Mg / H$$

$$H = Ca + Mg / R$$

Eksteen L. 1969. The determination of the lime requirements of soils for various crops in the winter rainfall region. Fertilizer Society of South Africa Journal 2: 13–14.



# Inisiatief deur CRI, Labserve & US Dept. Grondkunde

$$H = Ca + Mg / R$$

*met erkenning aan Dawid*



# Inisiatief deur CRI, Labserve & US Dept. Grondkunde



## LabserveMycro Stellenbosch se databasis

5 915 grondmonsters waarvan titreerbare  $H^+$  (TS) bepaal is

## Verskeie modelle uitgetoets

Om teoretiese TS te bepaal vs werklike TS

$$H = Ca + Mg / R$$



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## LabserveMycro Stellenbosch se databasis

5 915 grondmonsters waarvan titreerbare  $H^+$  (TS) bepaal is

## Verskeie modelle uitgetoets

Om teoretiese TS te bepaal vs werklike TS

## Uitkoms - Betekenisvolle korrelasie tussen werklike TS en:

- Teoreties bepaalde TS
- Grond pH,
- Org. C,
- Ca & Mg



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# Inisiatief deur CRI, Labserve & US Dept. Grondkunde

Die volgende vergelyking kan gebruik word om die **TS** te bereken met  $\approx 80\%$  akkuraatheid:

$$TS_{\text{bereken}} = 5.75 - 1.65^{\text{pH}} + 1.01^{\text{Ca}} + 1.009^{\text{Mg}} + 1.55^{\text{OC}} + 1.023^{\text{Rwaarde}} + 1.01^{\text{TSEksteen}} + 1.25^{\text{DeltapHC}}$$

$\underline{H} = \text{Ca} + \text{Mg} / \text{R}$



# Inisiatief deur CRI, Labserve & US Dept. Grondkunde

Die volgende vergelyking kan gebruik word om die **TS** te bereken met  $\approx 80\%$  akkuraatheid:

$$TS_{\text{bereken}} = 5.75 - 1.65^{pH} + 1.01^{Ca} + 1.009^{Mg} + 1.55^{OC} + 1.023^{Rwaarde} + 1.01^{TSEksteen} + 1.25^{DeltapH^C}$$

Problematies, want **OC**  
noodwendig gedoen nie

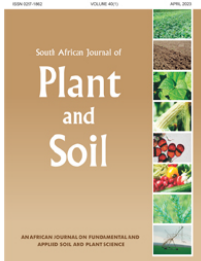
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South African Journal of Plant and Soil

ISSN: (Print) (Online) Journal homepage: <https://www.tandfonline.com/loi/tjps20>

Calculating soil titratable acidity from routine soil analyses of cultivated South African soils using various model structures

VG White, PJ Raath, AG Hardie, V van der Berg & GF Sutton

Link to this article: <https://doi.org/10.1080/02571862.2023.2212191>



# A Simpler Approach...



# A Simpler Approach...



| ROUTINE SOIL ANALYSIS |                           |                |
|-----------------------|---------------------------|----------------|
| Farm Name             |                           | XXXXXX         |
| Sample Number         |                           | P1             |
| Lab Number            |                           | 3556575        |
| Crop                  |                           | Grapes (Table) |
| Hectares              |                           | 1.0            |
| Sample depth          |                           | Top-Soil       |
| Colour                |                           | Gr             |
| Bulk Density          | (kg·m <sup>-3</sup> )     | 1236.5         |
| pH                    | (KCl)                     | 3.9            |
| Ex Acid               |                           | 0.45           |
| Acid Saturation       | (%)                       | 10.3           |
| S                     | (mg·kg <sup>-1</sup> )    | 36             |
| P (Bray I)            | (mg·kg <sup>-1</sup> )    | 134            |
| P (Olsen)             | (mg·kg <sup>-1</sup> )    | -              |
| K                     | (mg·kg <sup>-1</sup> )    | 249            |
| K(% of ECEC)          |                           | 15             |
| Ca                    | (mg·kg <sup>-1</sup> )    | 529            |
| Ca(% of ECEC)         |                           | 60             |
| Mg                    | (mg·kg <sup>-1</sup> )    | 77             |
| Mg(% of ECEC)         |                           | 14             |
| Na                    | (mg·kg <sup>-1</sup> )    | 5              |
| Na(% of ECEC)         |                           | 0              |
| ECEC                  | (cmolc·kg <sup>-1</sup> ) | 4.4            |
| Ca / Mg               |                           | 4.2            |
| Mg/K                  |                           | 1.0            |
| (Ca + Mg) / K         |                           | 5              |

# A Simpler Approach...

Lime requirement (ton/ha) =

$$\{(\mathbf{R} \times \mathbf{H}) - (\text{Ca} + \text{Mg})\} \times 4 / (\mathbf{R} + 1) \times \text{depth} / 15 \text{ cm}$$

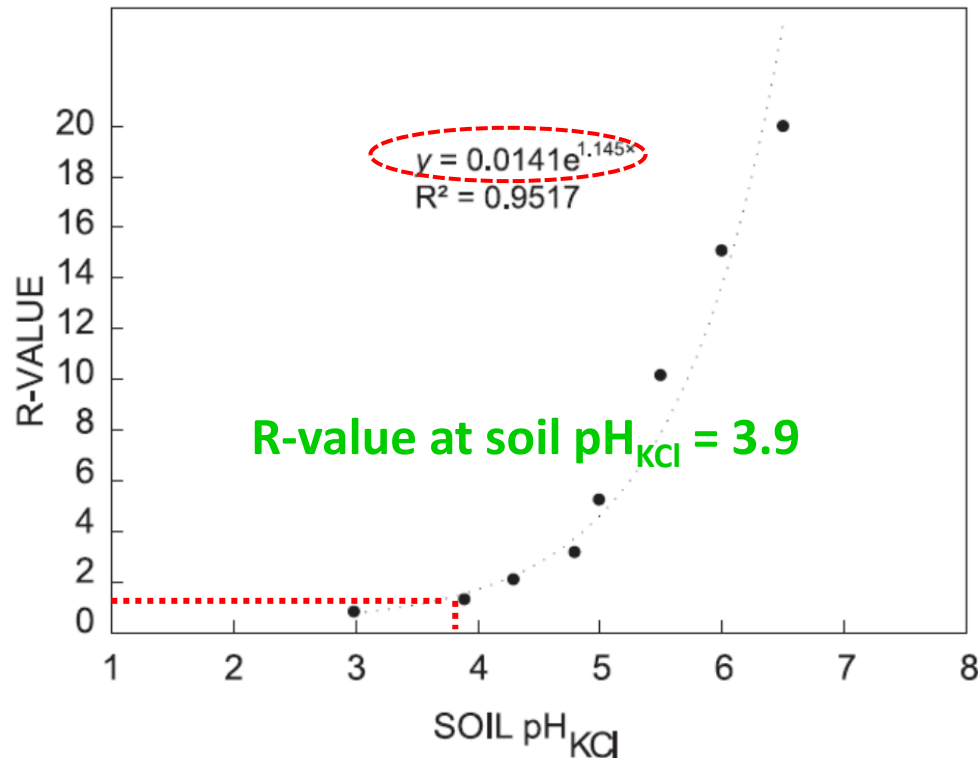
H = Ca + Mg / R



| ROUTINE SOIL ANALYSIS |                           |                |
|-----------------------|---------------------------|----------------|
| Farm Name             |                           | XXXXXXXXXX     |
| Sample Number         |                           | P1             |
| Lab Number            |                           | 3556575        |
| Crop                  |                           | Grapes (Table) |
| Hectares              |                           | 1.0            |
| Sample depth          |                           | Top-Soil       |
| Colour                |                           | Gr             |
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| Ca / Mg               |                           | 4.2            |
| Mg/K                  |                           | 1.0            |
| (Ca + Mg) / K         |                           | 5              |

# A Simpler Approach...

$$\begin{aligned}
 \underline{R} &= 0.0141e^{1.145\text{pH}} \\
 &= 0.0141 \times 2.718^{(1.145 \times \boxed{3.9})} \\
 &= \underline{1.27}
 \end{aligned}$$



| ROUTINE SOIL ANALYSIS |                           |                |
|-----------------------|---------------------------|----------------|
| Farm Name             |                           | XXXXXXXXXX     |
| Sample Number         |                           | P1             |
| Lab Number            |                           | 3556573        |
| Crop                  |                           | Grapes (Table) |
| Hectares              |                           | 1.0            |
| Sample depth          |                           | Top-Soil       |
| Colour                |                           | Gr             |
| Bulk Density          | (kg·m <sup>-3</sup> )     | 1236.5         |
| pH                    | (KCl)                     | <b>3.9</b>     |
| Ex Acid               |                           | 0.45           |
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| Ca / Mg               |                           | 4.2            |
| Mg/K                  |                           | 1.0            |
| (Ca + Mg) / K         |                           | 5              |

# A Simpler Approach...

$$\begin{aligned}
 \underline{H} &= \text{Ca} + \text{Mg} / R \\
 &= (2.65 + 0.64) / 1.27 \\
 &= \underline{2.02 \text{ cmol/kg}}
 \end{aligned}$$



| ROUTINE SOIL ANALYSIS |                           |                |
|-----------------------|---------------------------|----------------|
| Farm Name             |                           |                |
| Sample Number         |                           | P1             |
| Lab Number            |                           | 3556575        |
| Crop                  |                           | Grapes (Table) |
| Hectares              |                           | 1.0            |
| Sample depth          |                           | Top-Soil       |
| Colour                |                           | Gr             |
| Bulk Density          | (kg·m <sup>-3</sup> )     | 1236.5         |
| pH                    | (KCl)                     | 3.9            |
| Ex Acid               |                           | 0.45           |
| Acid Saturation       | (%)                       | 10.3           |
| S                     | (mg·kg <sup>-1</sup> )    | 36             |
| P (Bray I)            | (mg·kg <sup>-1</sup> )    | 134            |
| P (Olsen)             | (mg·kg <sup>-1</sup> )    | -              |
| K                     | (mg·kg <sup>-1</sup> )    | 249            |
| K(% of ECEC)          |                           | 15             |
| Ca                    | 2.65 cmol/kg              | 529            |
| Ca(% of ECEC)         |                           | 60             |
| Mg                    | 0.64 cmol/kg              | 77             |
| Mg(% of ECEC)         |                           | 14             |
| Na                    | (mg·kg <sup>-1</sup> )    | 5              |
| Na(% of ECEC)         |                           | 0              |
| ECEC                  | (cmolc·kg <sup>-1</sup> ) | 4.4            |
| Ca / Mg               |                           | 4.2            |
| Mg/K                  |                           | 1.0            |
| (Ca + Mg) / K         |                           | 5              |

# A Simpler Approach...

Lime requirement (ton/ha) =

$$\{(R \times \underline{2.02}) - (Ca + Mg)\} \times 4/(R+1) \times \text{depth}/15 \text{ cm}$$



To obtain pH<sub>KCl</sub> of 5.6, the R-value used = 10

$$\{(\underline{10} \times \underline{2.02}) - (2.65 + 0.64)\} \times 0.727 =$$

12 ton/ha/30 cm

*versus* 0.9 ton/ha/30 cm

| ROUTINE SOIL ANALYSIS |                           |                |
|-----------------------|---------------------------|----------------|
| Farm Name             |                           | XXXXXXXXXX     |
| Sample Number         |                           | P1             |
| Lab Number            |                           | XXXXXXXXXX     |
| Crop                  |                           | Grapes (Table) |
| Hectares              |                           | 1.0            |
| Sample depth          |                           | Top-Soil       |
| Colour                |                           | Gr             |
| Bulk Density          | (kg·m <sup>-3</sup> )     | 1236.5         |
| pH                    | (KCl)                     | 3.9            |
| Ex Acid               |                           | 0.45           |
| Acid Saturation       | (%)                       | 10.3           |
| S                     | (mg·kg <sup>-1</sup> )    | 36             |
| P (Bray I)            | (mg·kg <sup>-1</sup> )    | 134            |
| P (Olsen)             | (mg·kg <sup>-1</sup> )    | -              |
| K                     | (mg·kg <sup>-1</sup> )    | 249            |
| K(% of ECEC)          |                           | 15             |
| Ca                    | 2.65 cmol/kg              | 529            |
| Ca(% of ECEC)         |                           | 60             |
| Mg                    | 0.64 cmol/kg              | 77             |
| Mg(% of ECEC)         |                           | 14             |
| Na                    | (mg·kg <sup>-1</sup> )    | 5              |
| Na(% of ECEC)         |                           | 0              |
| ECEC                  | (cmolc·kg <sup>-1</sup> ) | 4.4            |
| Ca / Mg               |                           | 4.2            |
| Mg/K                  |                           | 1.0            |
| (Ca + Mg) / K         |                           | 5              |

# Conclusion(s)

- Don't use  $H^+(KCl)$  for lime requirement calculations
- You can make a much better lime recommendation by using a theoretically calculated  $H^+$ , using the R-value
- **LABSERVE MYCRO** will soon provide a **FREE** calculator on our Website for use by our clients



**BAIE  
DANKIE**

**THANK  
YOU**



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