The Authority in Potassium and Magnesium

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Cations in Ecuadorian tropical soils: different extraction methods and interpretation of the analysis

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Introduction

- **Calcium, Magnesium and Potassium as cations are fixed on organic matter and clay particles**

- **This fraction is exchangeable and always in balance with nutrients in the soil solution**

- **Soil analysis should analyze these two fractions – concentration in the soil solution and buffer capacity**

Introduction

- **Weak extractants such as water or sodium bicarbonate reflect mainly the concentration in the soil solution, whereas strong extractants primarily indicate the capacity of the soil to supply nutrients to the soil solution (buffer capacity);** **Marschner and Rengel (2012)**

- **strong extractants measure additional cations from the soil => cations which are not interchangeable (e.g. in the case of Mg and Ca free carbonates)**

Introduction

CEC = Adsorption and desorption of cations

Two groups:

Acid forming group	Basic-forming group
H^+ and Al^{3+}	Mg^{2+}, Ca^{2+}, K^+ and Na^+

Cation-Relation: Why it is important in Latin America?

- Information from soil testing is a guideline for fertilizer recommendations

- there are two methods:

a) SLAN – sufficient level of available nutrients (optimum level in the soil, it is plant specific)

b) BCSR – mineral balancing in soils (Albrecht papers)

Cation relation in soil	
Ca	60
Mg	30
K	10

Ancupa (2013) reports an optimal cation relation in soils specific for oil palm

„Amarillamiento secamiento“ in oil palm

„Yellowing“ and „Drying“ of leaves in oil palm

60:30:10 **80:15:5**

Ca:Mg:K

Source: ancupa 2013

Example from Ecuador (Olsen „Modified“)

Soil analysis:

organic matter 9.1%, sand 48%, lime 43%, clay 9%

	Mg	Ca	K	Total
mg/ kg	163	1614	322	2099
	Medio	M-A	Alto	
	7,76%	76,9%	15,3%	

Interpretation (according to ancupa, Ecuador):

Strong Mg-deficiency due to high Ca content!

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Example from Ecuador

Soil sampling and Mg-deficiency in Oil plam

Source: own data

Hypothesis

It might be that there is a specific cation ratio which is favorable to plants, especially for oil palm.

If the extraction of cations from the exchange complex depends of the “strongness” of the extractant the total amount of Ca, Mg an K differs on the method used.

And

Are the extraction methods comparable?

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Methods for soil analyses in Latin America

In Ecuador the “Olsen modified” method is the standard method for Ca, Mg and K but it is originally a method for phosphorous

Different methods for soil testing in Latin America:

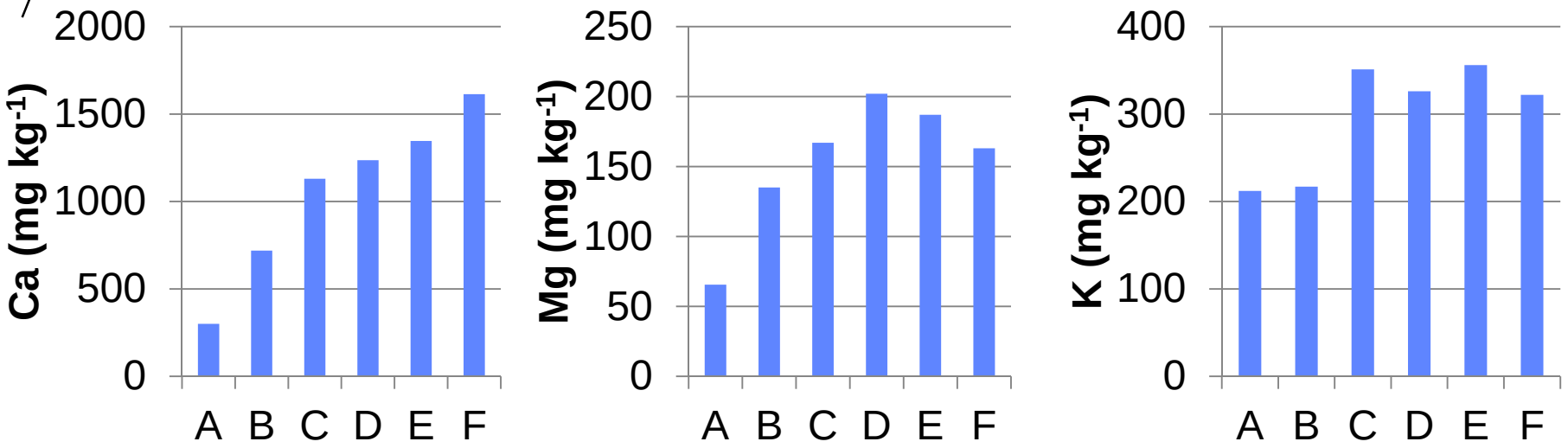
Extractant	Extraction time	Dissolution
Water	**1 h**	**1:5**
NaCl 0.1M	**1 h**	**1:10**
KCl 0.1M	**1 h**	**1:10**
$CaCl_2$	**1 h**	**1:10**
Mehlich-3	**15`**	**1:10**
Ammonium-Acetate 1M	**1 h**	**1:20**
Sodium-Acetate 1M	**1 h**	**1:20**
Olsen Modified (Olsen + EDTA 0.05M)	**30`**	**1:20**

Ecuadorian Soils analyzed

Soil	Organic Matter (%)	Sand (%)	Lime (%)	Clay (%)
Franca arcillosa	6.9	28	32	40
Arcilla	5.7	23	30	47
Franca arenosa	9.1	48	43	9
Franca	7.7	40	44	16
Franca arenosa	10.8	45	46	9

Soil sampling: 13.8.2014 in Ecuador at different oil palm plantations

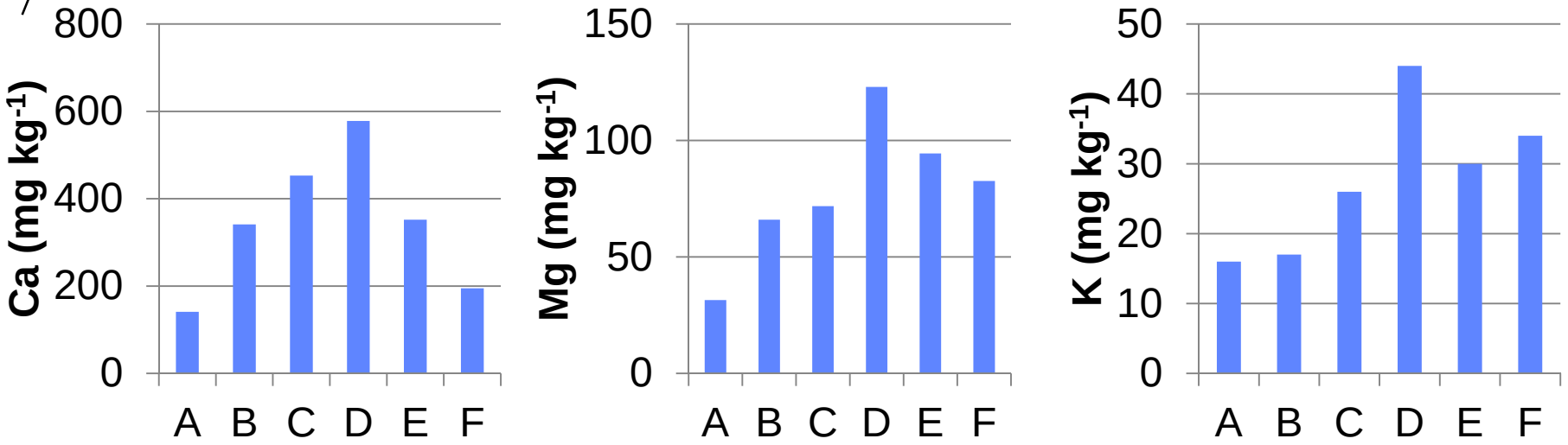
Soil sample 3



A (NaCl); B ($KCl/CaCl_2$), C (Mehlich-3), D (Ammonium-Acetate), E (Sodium-Acetate) and F (Olsen Modified)

Soil	Organic Matter (%)	Sand (%)	Lime (%)	Clay (%)
Franca arenosa	**9.1**	**48**	**43**	**9**

Soil sample 5



A (NaCl); B ($KCl/CaCl_2$), C (Mehlich-3), D (Ammonium-Acetate), E (Sodium-Acetate) and F (Olsen Modified)

Soil	Organic Matter (%)	Sand (%)	Lime (%)	Clay (%)
Franca arenosa	**10.8**	**45**	**46**	**9**

Conclusion of different methods used

- **The total amount of interchangeable cations of Ca, Mg and K (mg kg^{-1}) found by each method are highly different**

- **Ammonium-Acetate showed the highest Mg levels in both soils; similar trend was found by the other methods**

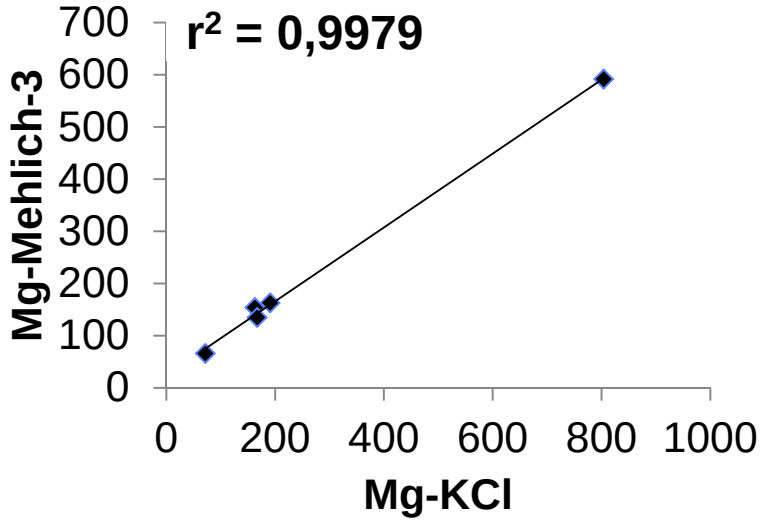
- **Important is the interpretation of the analysis to give soil nutrient levels**

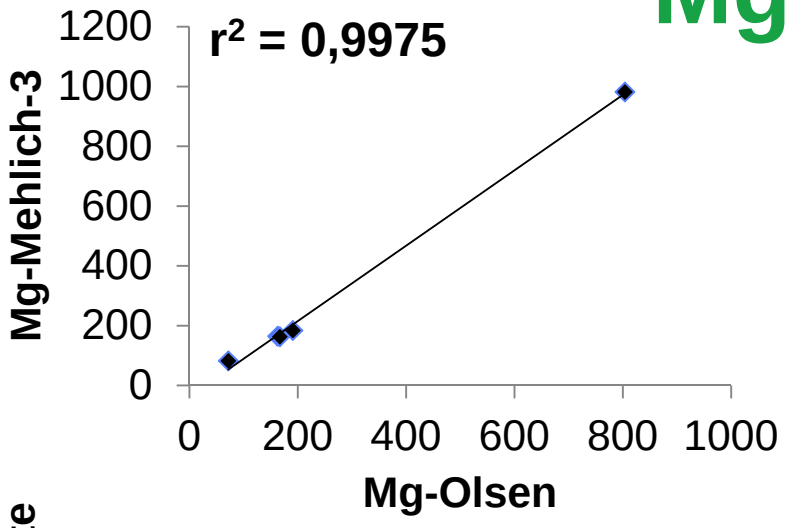
But

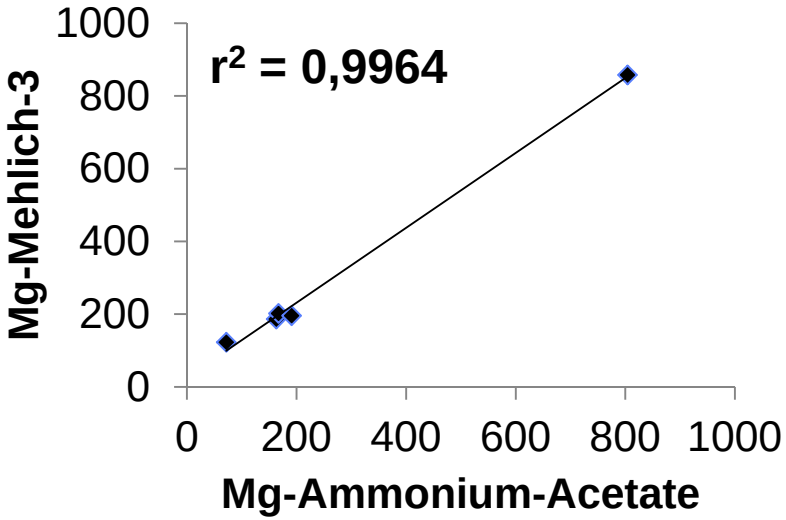
Are the different methods comparable?

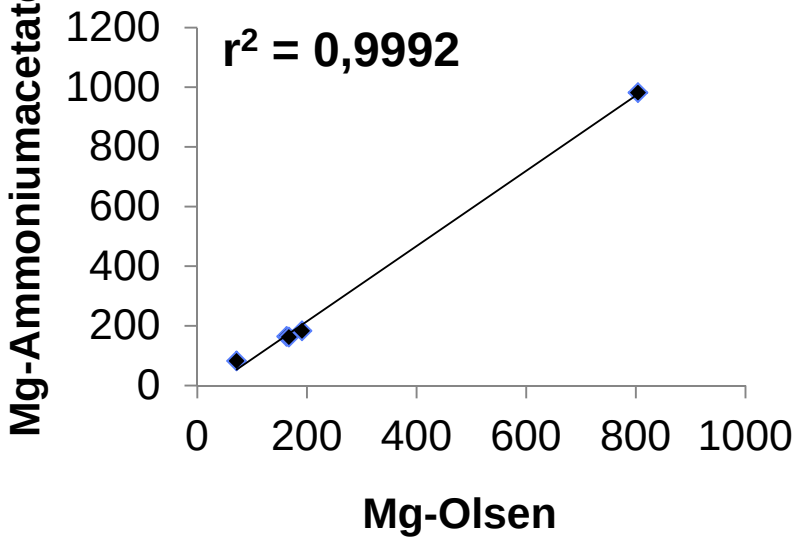
Comparison of different soil extraction methods

Mg^{2+}









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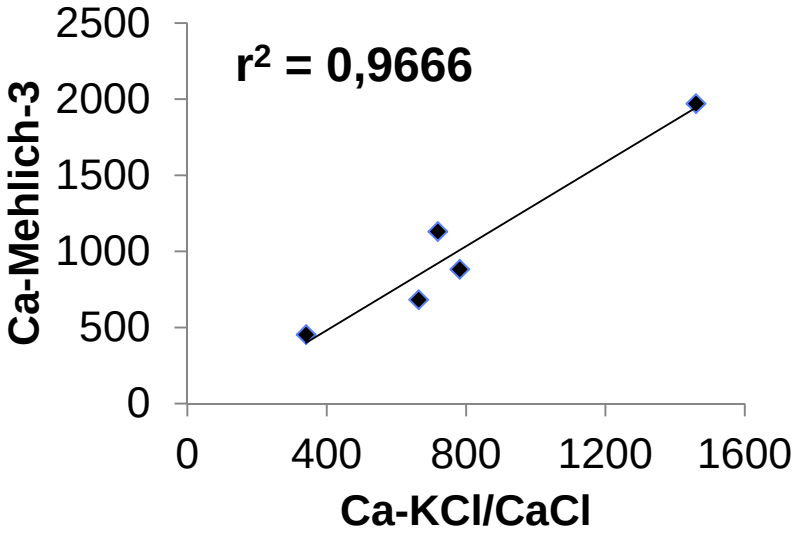
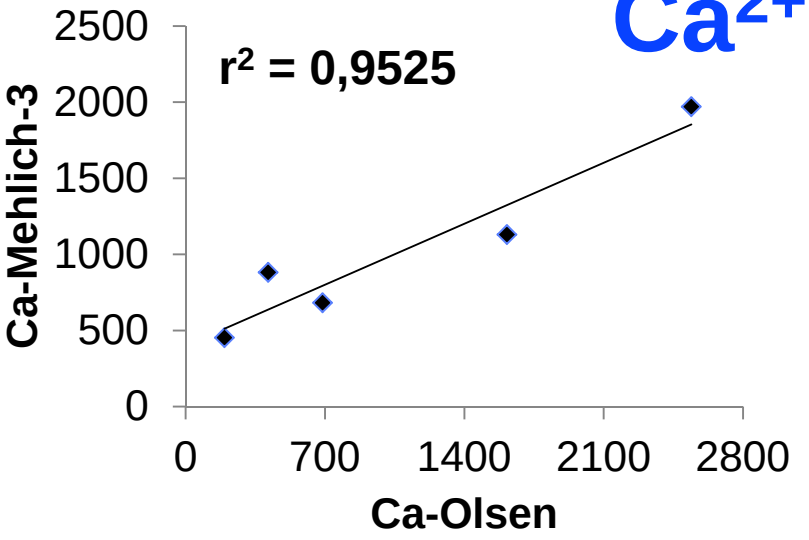
Comparison of different soil extraction methods

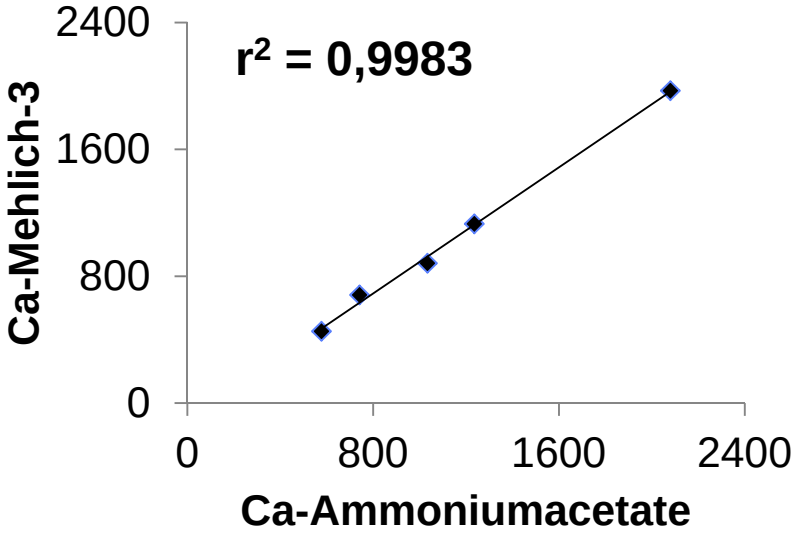
Mg^{2+}

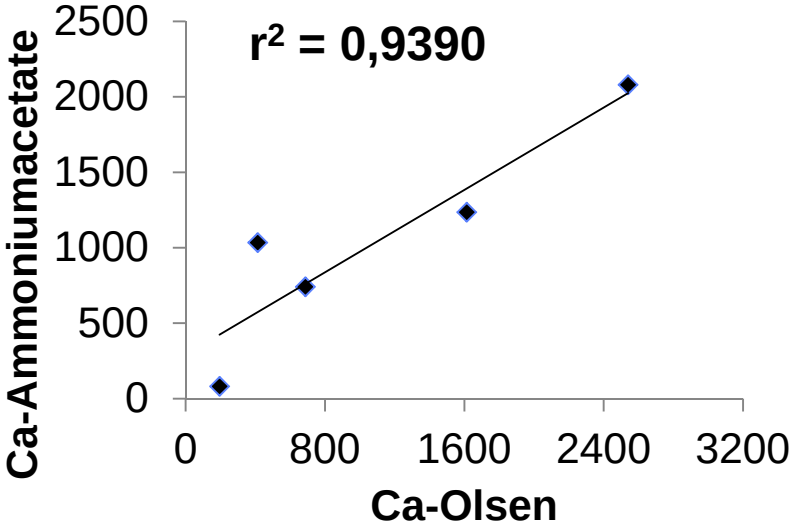
	KCl	NaCl	Mehlich-3	Ammonium-Acetate	Sodium-Acetate	Olsen "Modified"
KCl	x					
NaCl	0.9917	x				
Mehlich-3	0.9979	0.9839	x			
Ammonium-Acetate	0.9910	0.9681	0.9964	x		
Sodiumacetate	0.9944	0.9756	0.9989	0.9990	x	
Olsen Modified	0.9935	0.9713	0.9975	0.9992	0.9988	x

Comparison of different soil extraction methods







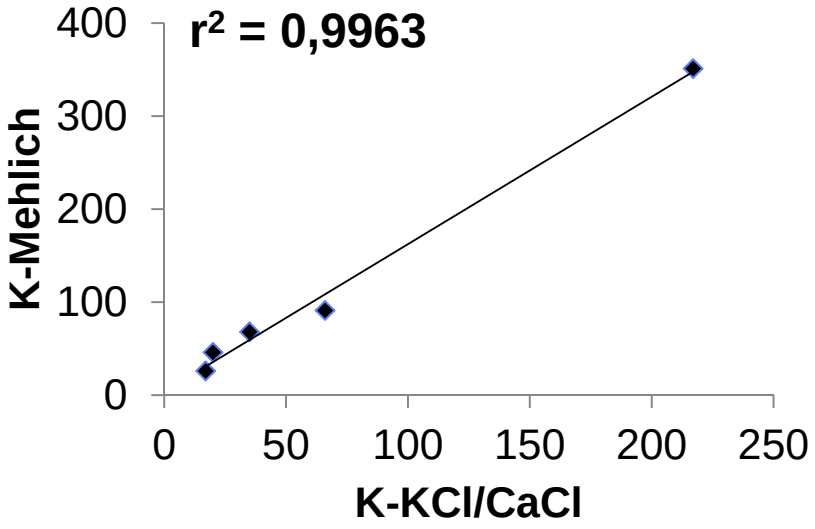


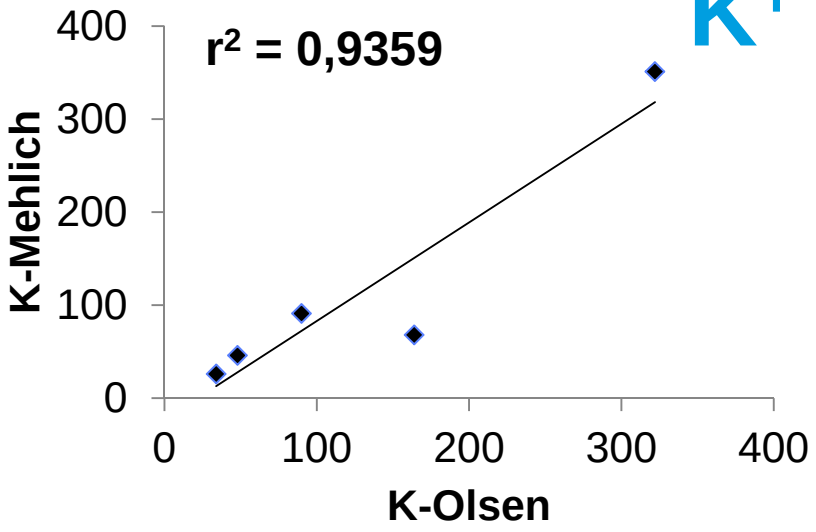
Comparison of different soil extraction methods

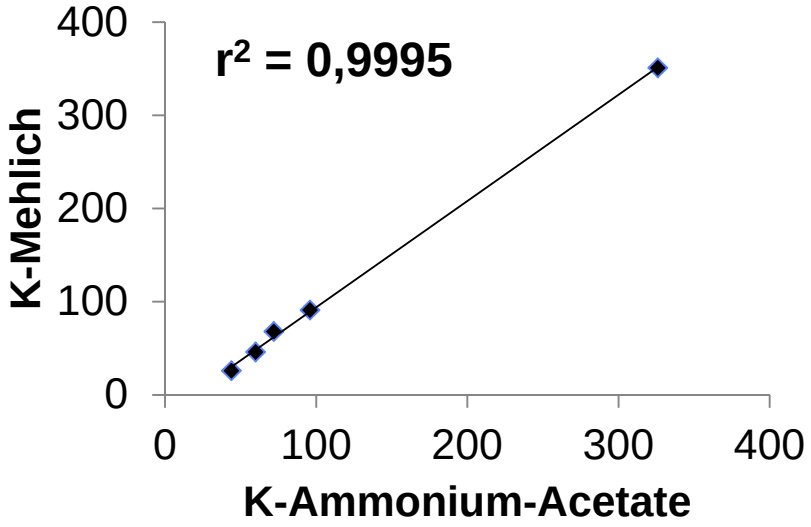
Ca^{2+}

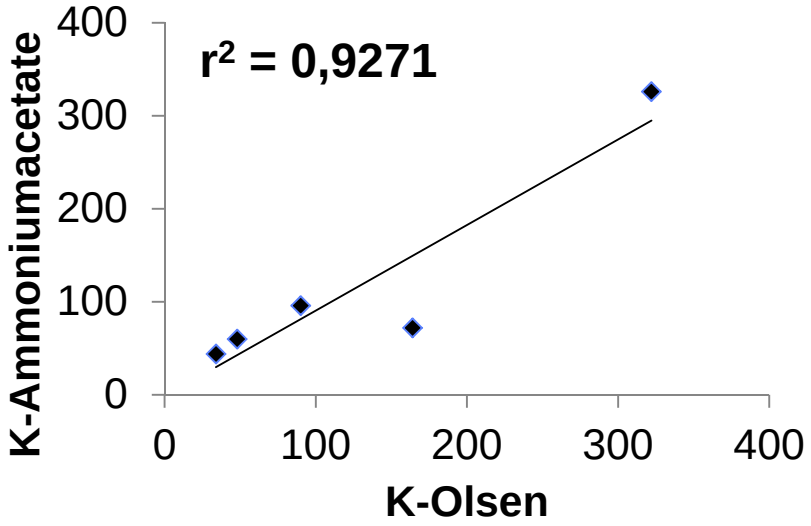
	KCl	NaCl	Mehlich-3	Ammonium -Acetate	Sodium-Acetate	Olsen „Modified“
KCl	x					
NaCl	0.9379	x				
Mehlich-3	0.9666	0.9430	x			
Ammonium-Acetate	0.9097	0.9407	0.9983	x		
Sodiumacetate	0.8850	0.9106	0.9728	0.9691	x	
Olsen Modified	0.8720	0.8838	0.9525	0.9390	0.9845	x

Comparison of different soil extraction methods









Comparison of different soil extraction methods

	KCl	NaCl	Mehlich	Ammonium-Acetate	Sodium-Acetate	Olsen „Modified“
KCl	x					
NaCl	0.9951	x				
Mehlich	0.9963	0.9965	x			
Ammoniumacetate	0.9961	0.9978	0.9995	x		
Sodiumacetate	0.9965	0.9988	0.9991	0.9995	x	
Olsen Modified	0.9198	0.9196	0.9359	0.9271	0.9320	x

Comparison of different soil extraction methods

For Magnesium all methods show a high significance to each other (r^2 = 0,98 – 0,99)

For Calcium only Ammonium-Acetate vs Mehlich-3 and Sodium-Acetate vs Olsen „Modified“ show a high significance (r^2 = 0,98 – 0,99)

For Potassium only the method Olsen „Modified“ is not significant to all other methods

Relation between cations in soil solution and interchangeable part

How is the nutrient availability with water in comparison with the interchangeable cations of each extraction method?

Is there a relation between cations in the soil solution and the interchangeable part?

Relation between cations in soil solution and interchangeable part

Water versus	Ca (r^2)	Mg (r^2)	K (r^2)
NaCl	0,4444	0,4402	0,9724
KCl	0,4303	0,4992	0,9856
Mehlich 3	0,6182	0,5365	0,9692
Ammonium-Acetate	0,6436	0,5609	0,9679
Sodium-Acetate	0,7064	0,5564	0,9715
Olsen „Modified“	0,6210	0,5024	0,8944

Conclusiones

- **Water shows poor correlations of measured Mg and Ca contents to all extraction methods, only the measured K showed a good correlation**

- **The extracted amount of cations differ from the method used**

- **For Magnesium all methods showed a high significant correlation, in the case of Calcium the correlation was not as good as Mg and K**

Conclusiones

- **In the case of Mg the Ammonium-Acetate method showed the highest interchangeable nutrient content**

- **the nutrient level found was „very high“ compared to „low“ (with KCl and Olsen „Modified“)**

- **Nevertheless the Ammonium-Acetate method showed highly significant correlations to the other methods**

- **For fertilizer recommendations based on soil tests the interpretation of the results is very important and should analyzed carefully => a comparison of the leaf nutrient-level is recommended**

The End

Thank you very much !

Acknowlegdement

Thanks to Diego Monteros from FERMAGRI S.A. for providing me the soil samples analysed in this investigation