Effect of liming on the soil P:Al ratio and P fertilizer recommandation for potato

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PRESENTATION

- P fertilizer recommendation for potato
- Effect of liming on P, Al, and the $(P/Al)_{Mehlich\ III}$

P CHART: POTATO

- **P Saturation index is better : $(^{P}/_{Al})_{MIII}$ compared to $P_{M\text{-}III}$**
  - **Accounts for soil P retention and buffering capacities**
  - **Improved P response models**

Khiari et *al.*, 2000
Pellerin et *al.*, $2006_{a,b}$

P/Al chart: Potato

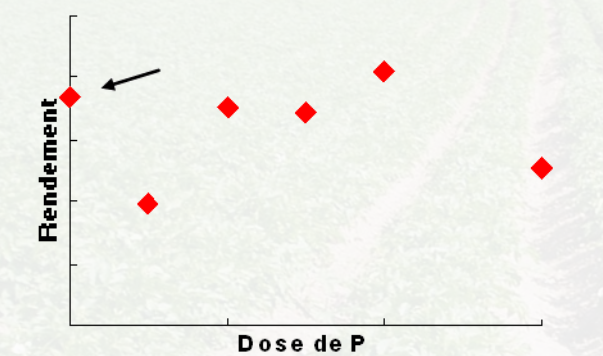
Physical and chemical properties of soil (110 SITES)

	Min	Max	mean	St. Dev.
pH (water 1:1)	4,7	6,9	5,8	0,5
Organic matter (%)	0,5	11,9	3,8	1,6
Clay (%)	0,6	32,3	10,1	8,2
$P_{M\text{-}III}$ (mg/kg)	3,1	707	141	149
$Al_{M\text{-}III}$ (mg/kg)	435	4072	1545	545
$(P/Al)_{M\text{-}III}$ (%)	0,1	71,5	10,4	12,0

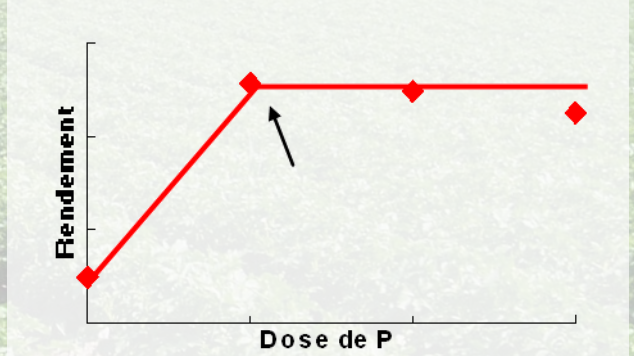
- **25 cultivars**
- **3 to 6 P rates including control and P max rates : 45 to 300 kg P ha^{-1}**
- **3 ou 4 on-site replications**

P/Al chart: potato

- **Response models**

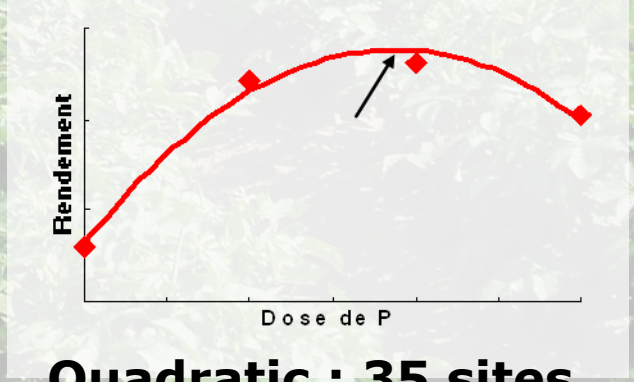


No response: 11 sites



Linear plateau: 48 sites

Linear : 16 sites



Quadratic : 35 sites

P/Al chart 2011: potato

New statistical approach : Meta-analysis

- **Metafiles : data on crops, soils, fertilizer rates, yields, statistical analysis …**
- **Factor grouping (P/Al, K …)**
- **Weighted effect size against control across sites of the same group**

P/Al chart 2011: potato

P recommendation chart

P saturation % (P/Al) M-III (SEP)	no sites/ class	Recomm. 2011 kg P_2O_5/ha	Recomm. 2003 kg P_2O_5/ha
0 - 2.5	23	200	225
2.6 - 5.0	19	150	180
5.1 - 10.0	18	150	150
10.1 - 15.0	16	120	100
15.1 - 25.0	21	75	30-60
> 25.1	13	50	0-30

In 2003 : 78 sites but only 12 sites >15% (P/Al)

Exportation of 1.1 kg P_2O_5/t tubers

P/Al chart 2011: potato

- **Continuous potato cropping**
  - **↘ soils quality**
    - **↘ O. M. and microbial activity**
    - **↗ Soil compaction and erosion**
  - **↗ P requirement**

- **Rotation crops tend to ↘ soil degradation and P saturation**

P/Al chart 2011: potato

- **Gravelly, acidic, and shallow soils reduce soil volume available for root growth and often require more P**
- **pH_{water} < 5,0 : Al toxicity**
- **Meta-analysis may allocate groups to interactive factors if # trials sufficient (need for networking)**

P/Al chart 2011: CONCLUSION

- **To facilitate P management in potato soils, it is suggested not to exceed $(P/Al)_{M\text{-}III}$ of 12%**

- **Fertilization may account for interactive factors if robust meta-analytical models are built from several trials (networking needed due to high cost of data collection)**

Effect of liming

Liming acid soil may increase soil P availability and decrease soluble Al

Edwards, 1991

What is the impact of liming on soil P saturation$(P/Al)_{MIII}$, le P_{MIII} and Al_{MIII}, in neutral to acid soils ?

Liming effect: incubation

- 30 silty to clayey soils and 34 sandy soils
- 4-6 rates (0 à 8 T/ha) of 100% reactive $CaCO_3$
- Incubation period: 3 months

Soil properties before incubation

		Mean	St. Dev.	Min.	Max.
pH_{water}		5,7	0,6	4,7	7,5
Clay	%	17,5	15,8	2,5	60,4
O.M.	%	3,3	1,5	1,1	9,2
$P_{M\text{-}III}^{\dagger}$	mg/kg	129	118	10	619
$Al_{M\text{-}III}^{\dagger}$	mg/kg	1321	419	552	2085
$(P/Al)_{M\text{-}III}$	%	10,2	9,7	1,0	41,1
$Ca_{M\text{-}III}^{\dagger}$	mg/kg	1580	1426	191	6787

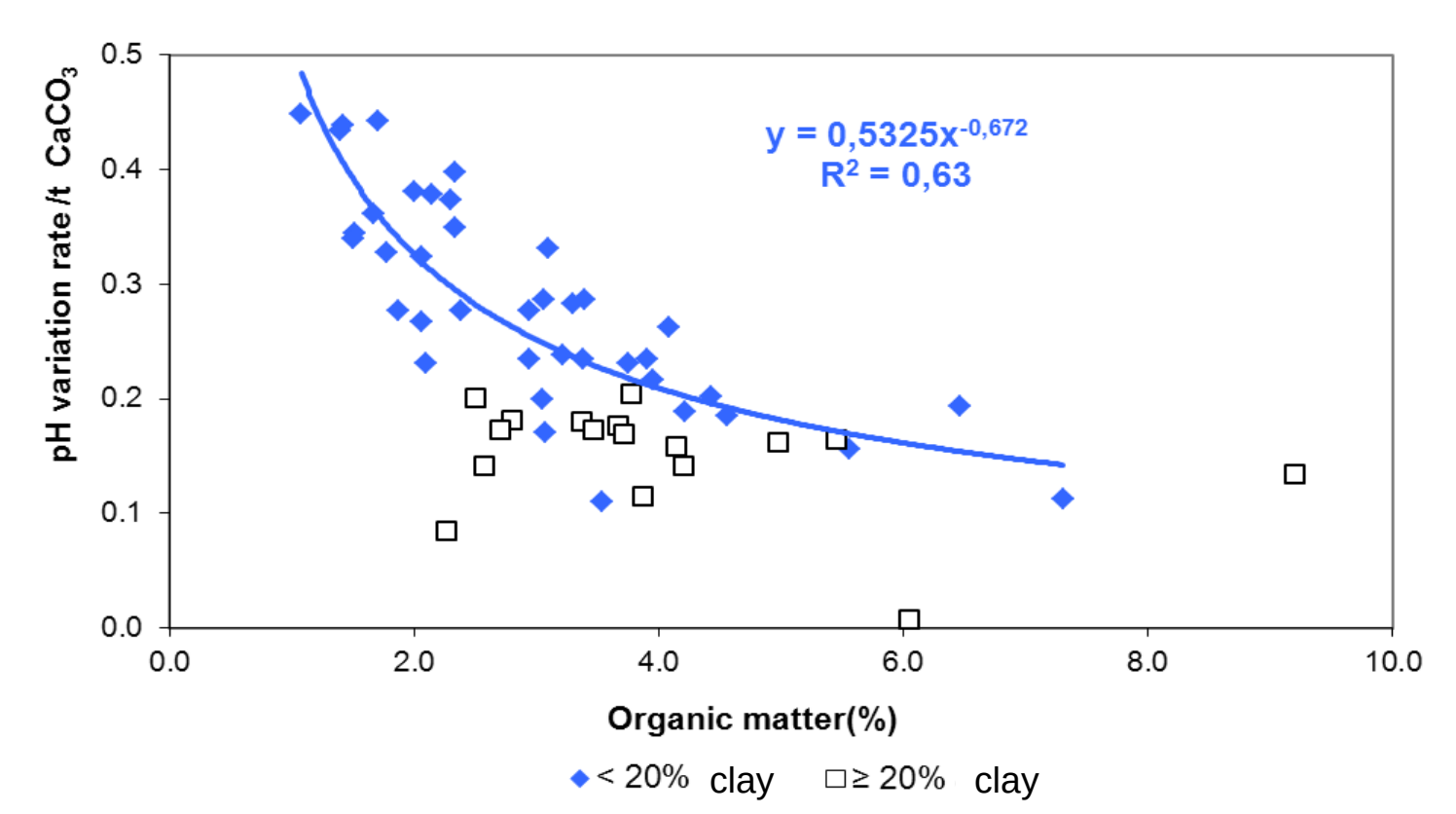
Liming effect : soil texture

- **Lighter soils react more than heavier ones to liming due to smaller buffering capacity**

pH VARIATION AFTER LIME APPLICATION

Clay	mean	Std. Dev.
%	Δ pH / t $CaCO_3$	
< 20	**0,28**	**0,12**
≥ 20	**0,16**	**0,05**

Liming effect : soil O.M.



INFLUENCE OF O.M. ON pH VARIATION

- **Light soil: O.M. influences pH variation rate**
- **Heavy soil: no significant influence of O.M.**

Liming effect : P_{M-III}

- **Sandy soil: liming may increase, decrease or have no variation on P_{M-III}**
- **Clayey soil: liming increases P_{M-III}**

pH VARIATION AFTER LIME APPLICATION

Clay	mean	Std. Dev.
%	ΔP_{M-III} (mg/kg) / t $CaCO_3$	
< 20	-0,4	2,7
≥ 20	1,3	0,7

Liming effect : Al_{M-III}

- **Podzolic soils (< 20 % clay) contain more exchangeable Al than gleysols (≥ 20 % clay).**

AL_{MIII} CONCENTRATION BEFORE INCUBATION

Clay	mean	Std. Dev.
%	mg Al_{M-III} / kg	
< 20	1446	432
≥ 20	1024	159

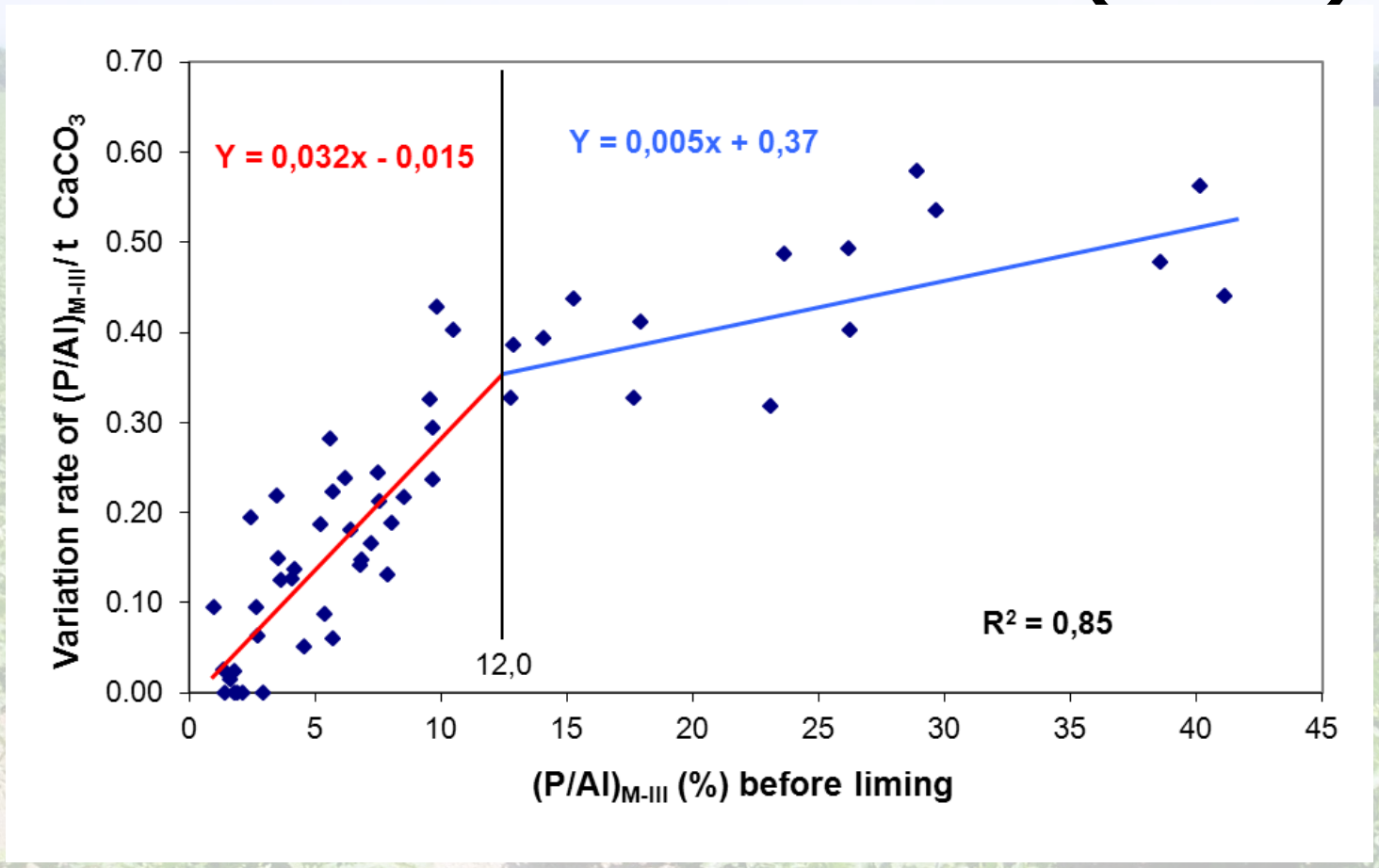
Liming effect : $Al_{(M\text{-}III)}$

- **Δ Al_{MIII} ↘ more rapidly in light than heavy soils**

Al_{MIII} VARIATION AFTER LIME APPLICATION

Clay	mean	Std. Dev.
%	Δ $Al_{M\text{-}III}$ (mg/kg) / t $CaCO_3$	
< 20	-23,5	11,3
≥ 20	-9,8	3,9

Liming effect : $P/Al_{(M\text{-}III)}$



VARIATION OF $(P/Al)_{MIII}$ PER TON OF LIME IN RELATION TO $(P/Al)_{MIII}$ BEFORE LIMING

Liming effect : $P/Al_{(M\text{-}III)}$

P SATURATION CHANGE AFTER LIMING

Before liming	After reaction of lime in soil		
$(P/Al)_{M\text{-}III}$	$(P/Al)_{M\text{-}III}$ 1,0 t $CaCO_3$/ha	$(P/Al)_{M\text{-}III}$ 2,5 t $CaCO_3$/ha	$(P/Al)_{M\text{-}III}$ 5,0 t $CaCO_3$/ha
	%		
1,0	1,0	1,1	1,1
2,0	2,1	2,1	2,3
5,0	5,1	5,4	5,7
10,0	10,3	10,8	11,5
12,0	12,4	12,9	13,9
15,0	15,5	16,1	17,3
20,0	20,5	21,1	22,3
25,0	25,5	26,3	27,5
30,0	30,5	31,3	32,7
35,0	35,5	36,4	37,8
40,0	40,6	41,5	42,9

Liming effect

CONCLUSION

- P/Al increase upon liming
- Smaller increase, if initial P/Al is low
- Soil analysis is the best way to monitor soil test variation over time

General conclusion

- Soil $(P/Al)_{M\text{-}III} < 12\ \%$
- Soil testing
- Need for networking fertilizer trials to conduct meta-analyses on nutrient, climatic, and soil interactions

P/Al fertilizer chart: potato

- **Collaborators :**
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  - **Pierrot Ferland (MAPAQ) in collaboration with Jean-Pierre Veillette, agr. (AGRECO)**

Liming effect on P saturation

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Questions?!?