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Agriculture and Agriculture et Agri-Food Canada Agroalimentaire Canada



Optimizing Phosphorus Use

Judith Nyiraneza, Steve Watts and many others 2023 PEI Potato Conference February 13th 2023



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- Daniel Savoie
- Co-authors: Rim Benjannet, Lotfi Khiari, Xiaoyuan Geng, Juanxia He, Sheldon Hann, Keith Fuller
- Research assistants: Danielle Murnaghan, Jessica Matheson, Dorothy Gregory, Irene Power, Barbara Enman, many summer students

P recommendations for potato in acidic soils should take into account aluminum levels

Sa	mple Information				Soil Tes	st Values and	Ratings		
Lab Sample #	Field Number	Organic Matter (%)	рН	Phosphate $P_2 O_5$ (ppm)	Potash K ₂ O (ppm)	Calcium Ca (ppm)	Magnesium Mg (ppm)	Boron B (ppm)	Copper Cu (ppm)
1 2 3 4	203 207 211 238			658 H+ 697 H+ 563 H+ 554 H+	138 M+ 248 H 191 H 174 H	2127 H 841 L 613 L 589 L	86 M 117 M 48 M 45 M	.7 H .7 H .6 H 5 H	2.8 H 7.4 H+ 3.2 H+ 2.5 H
5	242			571 H+	126 M+	2190 H	102 M	.6 H	2.8 H

Soil P test fall within high or high plus class for many fields across PEI.

Lab		%	Ratio	м	S	CEC		Ba	se Satur	ation		Total
Sample	Field Number	P/AI	Ca/Mg	а	0	(Meq/100g)	%	%	%	%	%	% Base
#				n	u		r	ivig	Ga		ina	Saturation
1	01 Wheat	6.82	16:1	0	0	11	2.3	7.0	68.1	21.9	0.7	77.4
2	02 Alfalfa	3.74	6:1	0	2	10	1.5	16.9	61.0	19.9	0.7	79.4
3	03 Gefee 2017	7.76	9:1	0	0	13	3.9	12.4	65.1	18.0	0.6	81.4
4	04 Gefee 2017	4.85	8:1	0	2	6	2.2	16.9	79.6		1.3	98.7

PEI Analytical Laboratory has included P/AI ratio into soil test reports.

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Explaining the concept of environmental and agronomic P threshold P saturation index (PSI)



Courtesy: Juanxia He

Courtesy: Juanxia He

Agronomic threshold PSI for potato, P/AI = 10, above which the potato response to P application is unlikely. Environmental PSI threshold value, P/AI = 14 when pH >5.5, above which P transport to the environment increases.

Phosphate rock reserves: not a renewable resource Distribution of world phosphate rock reserves



Note: DAP = diammonium phosphate. MOP = muriate of potash. Last observation is April 2022.

The quantity of extractable P does not imply its availability to crop

50

40

30

20

10

0

%

46.6

27.7

Si

ο

8.1

AI

3.6

Ca

2.8

Na

2.6

К

2.1

Mg



Eight Most Abundant Elements in the Earth's Crust, by weight



Fe

Steila and Pond, 1989

http://www.agro-systemes.com/fichiers-pdf/1-jc-fardeauconference-phosphore-sept-2010-resume.pdf http://nmsp.cals.cornell.edu/publications/factsheets/factsheet12

Factors contributing to fixing P based on soil pH



P availability is bound to aluminum (AI) and iron (Fe) in acidic soils.

http://msue.anr.msu.edu/news/the_peaks_and_valleys_of_phosphorus_fixation



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Agro-environmental P indices

Water extractible P: the potential to enrich runoff with dissolved P (Sissingh 1971, 1:10 soil to solution ratio). Independent to soil types

P sorption saturation: level of saturation of P binding sites Traditional methods used uncommon and time-consuming procedures Examples: Ammonium oxalate extraction in the dark (McKeague and Day 1966). Degree of P saturation (P/(AI+Fe) of **25%** was identified

In acidic soils, P sorption saturation estimated successfully from Mehlich 3 extractible Fe and AI (Beauchemin&Simard, 1999; Kleinman and Sharpley, 2002; Nair and Graertz, 2002) Used also as an agronomic index: P fertilizer recommendations based on P/AI or P/(AI+Fe)

Identifying environmental critical PSI



https://doi.org/10.1139/cjss-2017-0076

Using 141 soils from across PEI with contrasted P levels 9.7 mg L⁻¹ (water extracted P), the environmental critical value

Two environmental critical PSI based on soil pН 30 25 pH > 5,5y = 0.73x - 0.66 $R^2 = 0.85$ 20 $P_{W}(mg L^{-1})$ 15 <u>pH < 5,5</u> y = 0.60x - 1.83 10 9,7 mg P_w L⁻¹ $R^2 = 0.87$ 5 0 10 19,2% 30 14,2% -5 $ISP_1 = (P/AI)_{M3}$ https://doi.org/10.1139/cjss-2017-0076

40

Critical PSI =14 (soil pH > 5.5); PSI =19 (soil pH < 5.5)

Should P saturation in PEI soils include iron?



Including or removing iron (Fe) in the equation does not make a difference. Iron is poorly extracted with Mehlich-3 solution. Simplified PSI = P/AI

Environmental P risk classes

Table 1. Environ	mental P risk	classes for	PEI.
------------------	---------------	-------------	------

Risk Class	P-Saturation Index (% P/Al)					
	For soils with pH < 5.5	For soils with pH > 5.5				
Very Low Risk	0-7	0-4				
Low Risk	7-11	>4-7				
Moderate Risk	11-19	>7-14				
High Risk	19-21	>14-16				
Very High Risk	21-30	>16-23				
Extremely High Risk	>30	>23				

https://www.princeedwardisland.ca/sites/default/files/publications/af_nmp_p_fertilization_recommendation.pdf

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New potato P recommendations based on P saturation



42 field trials in 3 provinces



Conceptual soil test response curve



The critical level:

https://osunpk.com/category/phosphorus-2/

Below which a crop response to a nutrient application may be expected.

Above which no crop response is expected.

At very high soil test levels crop yield may decrease, harm to the environment (water pollution).



OPTIMUM VERSUS MAXIMUM YIELD

Optimum nutrient rate allows higher economic return, it takes into account nutrient fertilizer price and crop value at harvest.

https://www.grainews.ca/2017/04/07/maximum-versus-optimum-economic-yield-2/

Potato yield standardized

Converted potato yields into relative yields (RY)

Relative Yield = [(average yield in the check / maximum yield on a site) x 100]

RY of 100% = fertilizer addition does not translate in yield increases

RY < 100% = there is a response to fertilizer addition



Agronomic critical P saturation



https://doi.org/10.2134/agronj2017.

Agronomic critical P saturation (P/AI)=10. Above the critical value: potato yield response to P application is unlikely.



Optimum P rate versus P saturation



Only one site with P/AI < 2.5



Strong response to P fertilizer application at very low PSI.

Updated potato P recommendations based on P saturation index for soil with pH > 5.5

Updated P Recommendations (2018 onward, based on P- Saturation Index)					
P-Saturation Index Recommended Rat (P/Al %) (kg P ₂ O ₅ /ha)					
0-2.5	240-300				
> 2.5-5	185				
> 5-10	160				
> 10-14	100				
> 14-16	75				
> 16-23	50				

https://www.princeedwardisland.ca/sites/default/files/publications/af_nmp_p_fertilization_recommendation.pdf

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Phosphorus demo trial in commercial field in 2017 (by Kyra Stiles, PEI Department of Agriculture and Land, PEI Department of Fisheries and Communities)

Total yield Marketable Yield Specific Total P_2O_5 Applied (lb/ac) (CWT/acre) (CWT/acre) Gravity 40 318 312 1.08 80 371 369 1.09 160 346 342 1.08 **GSP** 343 337 1.08 **Effect of P rates** NS NS NS

Post-Harvest Soil P₂O₅ Levels





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Conclusions



- Significant savings in P fertilizers are possible without impacting crop yields
- Environmental and economic benefits
- Two factsheets available online
- Agronomic threshold PSI = 10 for potato.
- Environmental threshold PSI = 14 (soil pH> 5.5);
- Environmental threshold PSI=19 (soil pH < 5.5)



Thank you for listening.

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bout P-Fertilize	er Additives?
ic substances and er organic acids	Some examples of P enhancement in Dr Alan Blaylock
orrhizal inoculants	Seems logical for mycorrhizal crops, t benefits seldom observed PEISCIA AGM Feb 9
ciency enhancers	Benefits seem limited to low-P soils with low application rates.
bilizing organisms	Some early indications of benefits, but many questions remain.
– a slow-release P mineral	Some indication of response in certain conditions, but data is limited.
	February 9, 2023

The 4R's of Nutrient Stewardship.....



- RIGHT RATE
- RIGHT SOURCE
- RIGHT TIME
- RIGHT PLACE



GENESIS CROP SYSTEMS JAN 23





Nutrient Removal Calculator | Loveland Products - Dry Fertilizer (cropfertility.com)

Current PEI GSP P rate150 – 175 – 200 - ??? Lbs/acre

GENESIS CROP SYSTEMS JAN 23



RIGHT RATE RIGHT SOURCE RIGHT TIME RIGHT PLACE



GENESIS CROP SYSTEMS JAN 23

Rhizotron (root observation chamber) showing rapid root growth of potato plants. Note absence of any roots near fertilizer band.(potato seed piece planted Jan . 8, 2001, photo taken 17 days later, root growth >1" per day!!!). The salt concentration near the fertilizer band is too high for root growth, The nutrients move to the roots by diffusion and mass flow.



Band of 15-15-15 fertilizer





Agronomy



Reducing Fertilizer Rates

USING SCIENCE AND LOCALLY VALIDATED TRIALS TO DETREMINE OPTIMUM RATES

- Yield/Quality
- Profitability
- Need to consider environmental impacts

Liquid P History

		ALPIN	E G24 er/Engrais liq	® uide
		Guaranteed Minimum Anal	ysis/Analyse minimale ga	rantie
Y	Total Nitrogen (N) Available Phospho Soluble Potash (K	ric Acid (P ₁ 0 ₃)	Azote total (N) Acide phosphorique assim Potasse soluble (K ₂ O)	iilable (P ₂ O ₂)
alpin	E®			
	Bulk Shipment/ Expédition en vrac See fill of Ladag for Viture & Net Vegat	Dig/Cruche : 10 litres Net Weight: 13.4 kg Poids net : 13,4 kg	Case/Caisse : 20 litres Net Weight: 26.8 kg Poids net : 26,8 kg	Volume : Volume : Net Weight /Poids net :
	Volume et poids net indiqués sur le cansaissement			
Manufacturer/Supplier : Fabricant/Fournisseur :	Weren et posts net indiquis sur le cancassement NACHURS ALPINE SOLUTIONS 30 Neville St., New Hamburg 20 case Merille	S ^a 800.265.2268 g. ON N3A 467	Lot Number/Numéro de lot	1



- GCS started liquid P trials with Kyra & team 2014/2015 – Alpine G24, Agro Liquid, NXT
- Learnings...we could attain reasonable/similar yields without the dry box; very good response adding
 G24 liquid P to the standard GSP as an incremental investment (3:1 ROI)
 THEN...series of trials to credit the +/- 25
 Ibs of P2O5 in the liquid.....no negative crop impact; further increase the ROI!
 Can we apply more credit???

Prospect potatoes 2014





Liquid P program no dry fertilizer in planter

YOU HAVE TO START SOMEWHERE...

Low Hanging Fruit P Trial

To qualify (Round 1)

- pH > 6
- PSI >10



5 sites in 2022

- GSP P2O5 ranged 75-160 lbs/acre
- Lo P treatments ranged 37.5 100 lbs/acre
- 4 reps/field graded for yield, quality, etc

EFFECT OF P RATE ON MARKETABLE YIELD cwt/acre



Genesis Crop Systems Feb 23

CONCLUSIONS

- There appears to be a substantial amount of room to reduce P rates
- The source and placement R's definitely play a role in this
- Farmers and their advisors have to figure it out
- Be cautious of product selection....they are not all the same! eg warnings on labels : Do not apply directly to seed in coarse textured soils

Price of P2O5 in 2022....\$1.25-1.50/lb; reported to be

again this year

QUESTIONS

