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ORGANO MINERAL PHOSPHATE FERTILIZER AS ALTERNATIVE TO DI-AMMONIUM PHOSPHATE IN POTATO PRODUCTION

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SUMMARY: The P-use efficiency of ammonium phosphate fertilizers added to high-P fixing potato soils could be enhanced by combining them with pig manure solids in an organo-mineral fertilizer. We conducted four fertilizer experiments in comparing the effect on tuber yield of soil applied P_2O_5 from di-ammonium phosphate or an organo-mineral fertilizer (OMF). The OMF contained 40% of ammonium phosphate (MAP:DAP 1:1) and 60% pig manure solids obtained by slurry centrifugation and composted with bark as bulking material. There was a significant increase in tuber yield (0.8-4.5 Mg ha^{-1}) when DAP was replaced by the OMF. This has resulted in a gain of 9 to 50 kg ha^{-1} marginal tuber yield per P fertilizer unit, indicating higher P-use efficiency in intensive potato cropping.
Keywords: Organo-mineral fertilizer, pig manure solids, potato yield

INTRODUCTION

Due to high P fixation in podzolic soils used for the potato production, farmers require intensive inputs of mineral phosphate fertilizers to maintain crop productivity. In general, applied P is largely in excess of tuber removal hence potentially contributing to eutrophication of surface waters (Khiari et al., 2000). Such practice is unsustainable. One way to reduce P inputs is to enhance P fertilizer efficiency. There are synergistic effects of combining mineral and organic materials (Iyamuremye et al., 1996). The intensive pig livestock production also faces great challenge with slurry management. Sharif et al. (1974) found that premixing 33 % superphosphate with 67% farmyard manure increased P uptake by cotton crops by about 38%. After liquid-solid separation, the solids isolated from pig slurry (SPS) could be pelleted with mineral P fertilizers. Such organo-mineral fertilizer may increase P fertilizer efficiency in potato cropping. The aim of this work is to measure the effectiveness of a SPS-based organo-mineral fertilizer for potato cropping.

MATERIAL AND METHODS

A field study was conducted for one year on four potato sites in the province of Quebec, Canada (Table 1). Treatments consisted of an unfertilized P control, two or three P rates from di-ammonium phosphate (DAP) and one P rate from OMF that provided about one half (low P saturation soil) or full rate (high P saturation soils) of recommended P as DAP (CRAAQ, 2010). The pig slurry was separated into liquid and solid fractions by centrifugation using a mobile centrifuge (Asserva-300). Thereafter, the separated solids were composted for three months with bark (1:1, w/w) as bulking material. The solids were air-dried, mixed, homogeneized, and ground to pass through a 2 mm sieve. The SPS was mixed with commercial DAP (18-46-0) and MAP (11-52-0) in the proportions of 60% SPS, 20% DAP and 20% MAP. Several batches of 2000 g of organo-mineral fertilizers (1200 g SPS, 400 g DAP and 400 g MAP) were granulated using a small commercial radial extrusion granulator (model 4822, Hobart, Paris, France); 375 mL of water was added to reach sufficient cohesion. The OMF pellets were dried at 70°C for 18 h and stored in plastic containers at room temperature until field experiments. The OMF formulated with SPS contained 6.9% total N, 19.2% available P_2O_5, 0.2% soluble K_2O and 1.2% total Mg. In terms of total fertilizer primary nutrient levels ($N+P_2O_5+K_2O$) the OMF scored 2.4 times less than DAP. Total nitrogen in OMF was determined by combustion (CNS-Leco 2000). Available P and soluble K in OMF were extracted using the Newlon (2003) method. Total Mg was extracted using an acid digestion according to Barnhisel and Bertsch (1982).

Soil samples were air dried and ground to pass through a 2 mm sieve prior to analysis. Soil pH was determined in a 0.01 M $CaCl_2$ solution (1:2 ratio) (pH_{CaCl2}). Soil-buffer pH (pH_{SMP}) was determined by mixing 10 mL of soil, 10 mL deionized water and 20 ml Shoemaker-McLean-Pratt (SMP) buffer solution (Shoemaker et al., 1961). Soil texture was determined using the hydrometer method (Day, 1965). Soil P, Al, K, Ca, Mg and Fe were extracted using the Mehlich-III procedure (Mehlich, 1984). The P saturation indicator (P/Al) was calculated according to Khiari et al. (2000).

The effectiveness of OMF was calculated as follows.

$$\text{Relative } OMF_{effectiveness}\left(kg\ tuber\ kg^{-1} P_2O_5\right) = \left(\frac{OMF_{tuber\ yield}\left(kg\ ha^{-1}\right) - DAP_{tuber\ yield}\left(kg\ ha^{-1}\right)}{Same\ amount\ of\ P_2O_5\ applied\ \left(kg\ ha^{-1}\right)}\right) \quad (1)$$

RESULTS AND DISCUSSION

Potato yield response to P_2O_5 additions as DAP at each site is shown in Fig. 1. The DAP fertilizer increased considerably tuber yield up to 120 or 180 kg P_2O_5 ha^{-1}. Yield response varied from site to site. The crop response was greater in the highest yielding site 3 than in the lower yielding ones (1 and 2). The OMF was more effective than DAP in increasing tuber yield. At comparative P_2O_5 rates of 90, 90, 90 and 30 kg ha^{-1}, the OMF showed a greater differential effect of 0.8-4.5 Mg total tuber yield ha^{-1}(Fig. 1). The largest difference was at site 3 that showed the smallest P saturation index $(P/Al)_{MIII}$ of 2% (Table 1) that corresponded to extremely low P fertility (Khiari et al., 2000).

The OMF efficiency computed according to Eq. 1 was 9, 10, 50 and 50 kg tuber per kg P_2O_5 across sites. Substituting DAP for OMF thus enhanced tuber yield. The organic anions contained in SPS probably competed for P sorption sites on Al and Fe oxi-hydroxides in podzolic soils especially those showing low phosphorus saturation. Based on current market prices for DAP (700 \$ CAN Mg^{-1} or 1.1\$ kg^{-1} P_2O_5) and potato (230 \$ CAN Mg^{-1} potato), the cost-benefit ratio was ≈ 2 at sites 1 and 2 and ≈ 10.5 at sites 3 and 4. Profitability of OMF may be considerable if the cost of unit fertilizer in OMF were considerably less than 2*1.1 = 2.2 \$ CAN at site 1 and 2 and < 11.5 \$ CAN at sites 3 and 4 that corresponded to 83 and 432% of the monetary value of DAP, respectively.

CONCLUSION

A marginal and significant gain over conventional DAP ranging from 9 to 50 kg of additional tuber for each phosphorus fertilizer unit (1 kg P_2O_5) ha^{-1} was obtained by applying an organo-mineral fertilizer containing 60% SPS, 20% MAP and 20 % DAP.

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REFERENCES

Barnhisel R. and Bertsch, P.M. (1982). Digestion with perchloric-nitric acids. In *Methods of soil analysis*, A.L. Page et al. (eds.), Part 2. Soil Science Society of America. Book Series, 5, Madison, Wisconsin, United States, pp. 279-280.

CRAAQ (2010). Guide de référence en fertilisation, 2ème ed. Centre de Référence en Agriculture et AgroAlimentaire du Québec.

Iyamuremye E. and Dick, R.P. (1996). Organic amendments and phosphorus sorption by soils. *Advances in Agronomy*, 56, 139-185.

Khiari L., Parent L.E., Pellerin A., Alimi A.R.A. Tremblay C. Simard R.R. and Fortin J. (2000). An agri-environmental phosphorus saturation index for acid coarse-textured soils. *Journal of Environmental Quality*, 29, 1561-1567.

Mehlich A. (1984). Mehlich-3 soil test extractant: A modification of Mehlich-2 extractant. *Communication in Soil Science and Plant Analysis*, 15, 1409-1416.

Newlon N. F. (2003). Comparison of the ammonium oxalate extraction of fertilizer for K_2O, method 983.02, with the ammonium citrate/EDTA extraction, method 993.31. *Journal of Association of Official Analytical Chemists International*, 86, 640-642.

Sharif M., Chaudhry, F. M. and Laif, A. (1974). Suppression of superphosphate-phosphorus fixation by farmyard manure. *Soil Science and Plant Nutrition*, 20, 387-393.

Shoemaker H. E., McLean E. O. and Pratt P.F. (1961). Buffer methods suitable for determining lime requirement of soils with appreciable amounts of extractable aluminium. *Proceedings of Soil Science Society of America*, 25, 274-277.

Table 1. Soil proprieties and experimental results.

Site	1	2	3	4
	Soil properties			
pH_{CaCl2}	5.1	4.9	5.7	5.0
pH_{SMP}	6.4	6.1	6.6	6.5
Texture	Loamy sand	Sandy loam	Loamy sand	Loam
Clay	3.6	3.6	5.0	26.9
$P_{Mehlich-III}$	339	207	31	133
$Al_{Mehlich-III}$	1672	1707	1652	1071
$(P/Al)_{Mehlich-III}$	20	12	2	12
$K_{Mehlich-III}$	231	304	28	177
$Ca_{Mehlich-III}$	563	649	1788	1670
$Mg_{Mehlich-III}$	73	80	71	169
$Fe_{Mehlich-III}$	257	246	154	426
	Field experiments			
Location	St-Ubalde de Porteneuf	St-Ubalde de Porteneuf	Pont-Rouge	Isle of Orleans
Farm	Dolbec inc.	Dolbec inc.	Group Gosselin	Group Gosselin
Planting date	May 27th	May 28th	May 15th	May 15th
Cultivar	Goldrush	Chieftain	FL-1207	FL-1207
	P fertilizer treatments			
T_0: Control kg P_2O_5 ha^{-1}	0	0	0	0
T_1: kg P_2O_5 ha^{-1} from DAP*	90	90	60	30
T_2: kg P_2O_5 ha^{-1} from DAP	180	180	120	60
T_3: kg P_2O_5 ha^{-1} from DAP			180	120
T_{OMF}: kg P_2O_5 ha^{-1} from OMF£	90	90	90	30
	Other fertilizer sources			
Before planting (kg K_2O ha^{-1})	210	210	-	-
At planting (kg ha^{-1})	140N-60K_2O-30 Mg	140N-60K_2O-30 Mg	140N-80K_2O-30 Mg	144 N, 96 K2O 36 Mg
After planting (kg N ha^{-1})	50	50	-	-

* DAP: Di ammonium phosphate (18-46-0)
£OMF: organomineral fertilzer (60% solid pig slurry, 40% ammonium phosphate)

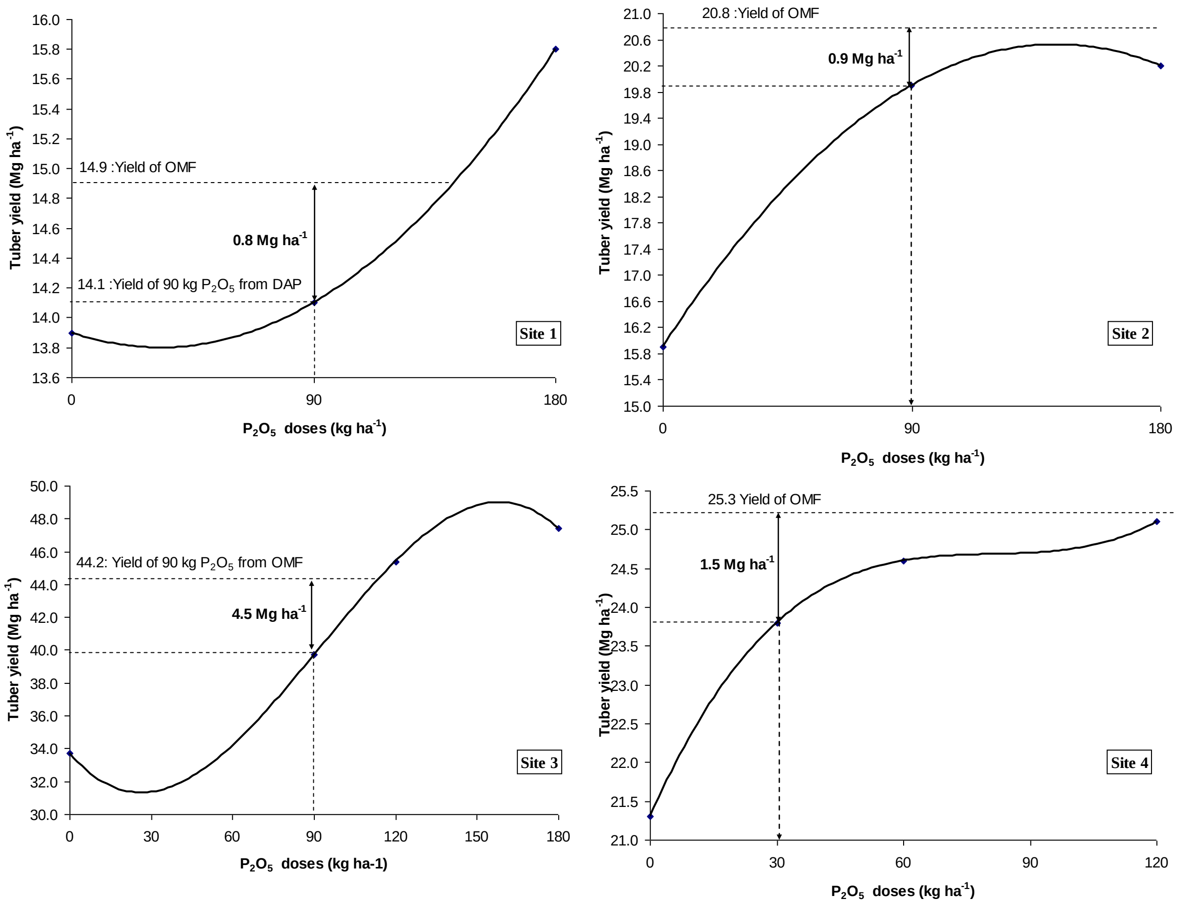

Figure 1. Potato tuber yield as influenced by P_2O_5 levels of DAP and organomineral P fertilizer at experimental sites.