Evaluation of polyhalite in soybean, maize and wheat in Pampean soils of Argentina

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After long time being recognized as a major macronutrient in South American grain production, the supply of sulfur (S) in fertilizer programs does not represent a big challenge for farmers. Single superphosphate (12 %S), or gypsum (17 %S) are commonly used to fertilize major grain in Argentina and Brazil, either as single applications or in blends with more concentrated phosphate products. On extensive and widespread crop production areas like Pampean Region of Argentina, the need for more balanced S fertilizers with potassium and magnesium contents is of most importance to minimize the impact of extraction of these nutrients and maintain a more equilibrated balance. Fertilizer practices do not include K or Mg among the regular programs for extensive crops, like soybean, maize and wheat, by far the most important grains produced in Pampean region of Argentina. However, several decades of ever increasing unitary yields fertilized with N, P and lately S, has been clearly demonstrated the exploitation and land depletion of cationic nutrients when compared with pristine situations. Soil reserves are still above sufficiency levels, however, for K and Mg, but some soil types in some locations has been started to show some responses, although not statistically significant or economically appealing. On the other hand, sulfur is part of the regular program as well as P and N for cereals. Polyhalite is one of a number of evaporate minerals containing potassium. The content of impurities is low, and is almost entirely sodium chloride at a maximum inclusion of 5%. Polyhalite (dehydrate) is a single crystal complex with 2 molecules of water of crystallization. It is not a mixture of salts. The chemical formula is: $K_2Ca_2Mg(SO_4)_4 \cdot 2(H_2O)$. The main agronomic advantage is to have soluble forms of sulfur, as sulfate (19% of S) plus an additional natural content of other macronutrients: Potassium (14 % as K_2O), magnesium (6% as MgO), and calcium (17% CaO). The objective of this study is to evaluate the direct effect of Polyhalite on the grain yield of soybean, maize and wheat and the residual effect on the following crops and compare it with other fertilizing options to supply S.

Four field trials were conducted in Mollisols of Pampean region of Argentina in 2016-2017 season, one in Nueve de Julio with wheat and maize, and another in Mercedes with soybean and maize. All are being followed to evaluate the fertilizer residual effect on the succeeding crop. The experiment compared six treatments based on MAP plus different sources of sulfur in order to apply at sowing a single rate of P and S with several fertilizer combinations. (1) A control of regular MAP with no S applied; (2) single superphosphate (SSP, 0-20-0-12S), which supply P and S but no K nor Mg; (3) a bulk blend of MAP (0-52-0-

0S) with gypsum (0-0-0-17S); (4, 5 and 6) as Polyhalite, that was evaluated at three rates (100, 200 and 300 kg/ha) as bulk blends with MAP at different proportions, which supplied increasing amounts of K and Mg, but all the same N and P_2O_5. All fertilizer treatments were applied at sowing along the seed line with a planter. The maize and wheat received a banded fertilization with N as urea or UAN at V-6 and at tillering stage of each crop respectively. All crops were conducted with proper weed, pest and disease control according to normal practice of the area.

Significant increases in grain yields in response to sulfur (S) fertilization were found for the four grain crops, cultivated on soils low in available sulfur ($S\text{-}SO_4$) in the two locations. However, the contribution of K and Mg to give yields above the S applied treatments varied among the site and crops. No differences were found among S sources in Nueve de Julio for either wheat, or maize. On the other hand, in Mercedes, there were statistical differences for both maize and soybean among the polihalite and the other S sources treatments. The average response to sulfur was 19 %, but the contribution of Polyhalite over the other treatments that received S was about 7 %.

Treatment	Mercedes				Nueve de Julio			
	Maize		Soybean		Wheat		Maize	
	kg/ha	Rel. Yield	kg/ha	Rel. Yield	kg/ha	Rel. Yield	kg/ha	Rel. Yield
Control - No S	5356c	76%	1917d	62%	4719a	74%	13531a	87%
Single Superphosphate	5878bc	83%	2146dc	69%	5934b	94%	15222b	98%
MAP + Gypsum	7060a	100%	2406c	78%	6165b	97%	15183b	98%
MAP + Polyhalite 37/63	7029a	100%	2719b	88%	5919b	93%	15546b	100%
MAP + Polyhalite 22/78	6910a	98%	2993ba	97%	6089b	96%	15484b	100%
MAP + Polyhalite 16/84	6417ab	91%	3089a	100%	6345b	100%	15328b	99%
$p>F_{Treatment}$	0,007		<0,001		<0,001		<0,001	
$DLS_{5\%}$	945		296		474		706	
CV %	9,7		7,7		5,4		2,6	

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