Improving Fertilizer Phosphorus Use Efficiency with Fertilizer Applied AVAIL® (Polymers) for Brazil and Idaho Soils

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ABSTRACT

The role of fertilizers has had a great and respected role in the area of food production. The significant role has been documented with long-term field trials in both England and North America. With many years of research and observations it has been estimated that the overall contribution of fertilizer to yield is between 50 and 60 %. Therefore, as cereal production increases approaching more of their attainable yields, fertilizer consumption should also increase (FAO and IFA). This has become apparent with world consumption of NPK over the last 50 years moving from 30 Mt in 1960 to about 180 Mt/year in 2012. However, this increase is not necessarily coming from "industrial" nations, but rather from developing regions like East and South Asia, Southern Africa as well as Latin America.

Improvements in P fertilizer efficiency have been researched over 50 years with benefits in placement, timing, rates as well as sources of P fertilizer. The limited availability of phosphorus (P) in calcareous and acidic soils can be a major factor that limits crop production. It has been observed that liquid P fertilizer is more mobile and available for plant uptake in highly calcareous soils than granular P fertilizer containing the same P rate.

The objectives of this study were to investigate mobility and availability of P from monoammonium phosphate (MAP), diammonium phosphate (DAP) and ammonium polyphosphate (APP) fertilizers alone or with AVAIL®, (dicarboxylic acid co-polymer) used as a fertilizer enhancement product, on different soil (high pH and low pH) types, and to examine the relationship between both P reaction products and improvements in soil available P. All soils were incubated in petri dishes containing five replicates of each fertilizer treatment at the center for five weeks at 25° C. At the end of the incubation period, four concentric sections of soil surrounding the P fertilizer placement point from each dish were removed and individually analyzed. Measurements included soil pH, total P, resin extractable P, scanning electron microscopy-energy dispersive x-ray analysis of granules and P reaction products using synchrotron based x-ray absorption near-edge structure spectroscopy. The data indicates enhanced diffusion and/or solubility of some P sources in a number of soils and increased P availability in P reaction products which are more soluble and plant available. It could be stated

that by increasing soil available P by with the AVAIL polymer, could decrease environmental considerations of P entering surface water.

INTRODUCTION

Nutrient management issues associated with production agriculture are becoming more of a concern and a focal point of discussion. Phosphorus fertilizer management strategies are no longer focused on just meeting yield goals or improved crop performance, but now include questions on how their use on agriculture lands impacts surface water, watersheds, soil quality, long-term health benefits and economic viability for the producer. Much of the P fertilizer being applied is retained by high P "fixing" soils. The geographies where high retention of P fertilizer is a high concern is provided (Fig. 1). These areas are most widely associated with tropics.

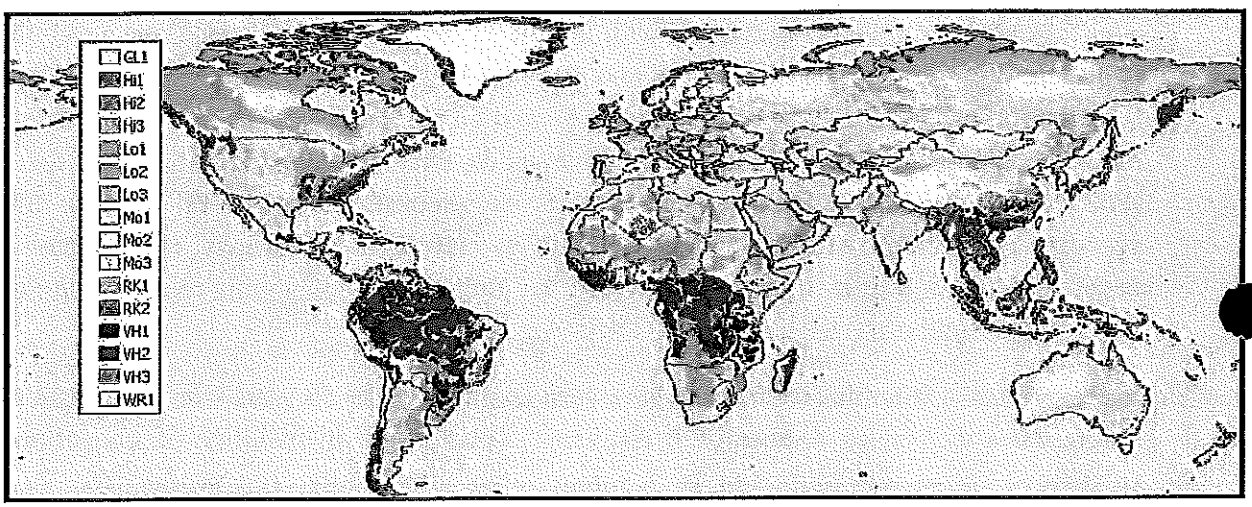

Figure 1. World soils map with high P retention potential for applied fertilizer P.

It has been estimated that 30 to 40 % of production inputs are associated with purchasing and applying commercial fertilizers. Inputs of commercial P fertilizer are essential to meeting food requirements of North America and the global community whose population continues to increase at an alarming rate.

METHODOLOGY

Two soils in high P retention areas were obtained for evaluation. Table 1 indicates the physical and chemical characteristics of a high pH calcareous Idaho soil and low pH acidic Brazil soil. Each soil was treated with a uniform granule (by weight) of the three most common sources of P: dry MAP or DAP and liquid APP. These same P sources were then treated with the AVAIL® liquid polymer (dicarboxylic acid) developed by Specialty Fertilizer Products of Leawood, KS and utilized as a P fertilizer "enhancer". Application rates for AVAIL were 0.25 % by weight for MAP and DAP and for APP was .5% by volume.

Table 1. Soil Characteristics of two soils evaluated with X-ray Absorption Near-Edge Structure Spectroscopy (XANES) Analysis.

Sample	pH	Ca ppm	CEC meq /100g	OM %	Fe ppm	Mn ppm	Al ppm	N ppm	P ppm
Alkaline Soil Idaho	8.0	3376	19.6	0.6	2.4	3.6	ND	403	468
Acid Soil Brazil	4.3	49	12.4	3.7	52.9	2.2	79.5	1243	237

Each fertilizer source with and without AVAIL was placed into the center of a moist soil sample and incubated for a 35 days (Fig 2). Soil analysis for each treatment included: pH, resin extractable P, total P, and P retention. These basic measurements were then followed by a more comprehensive analysis that included X-Ray absorption near edge spectroscopy (XANES) at the Argonne National Laboratory. The data set was then analyzed using Principle Component Analysis, followed by linear combination fitting, scanning electron microscopy, as well as X-Ray analysis.

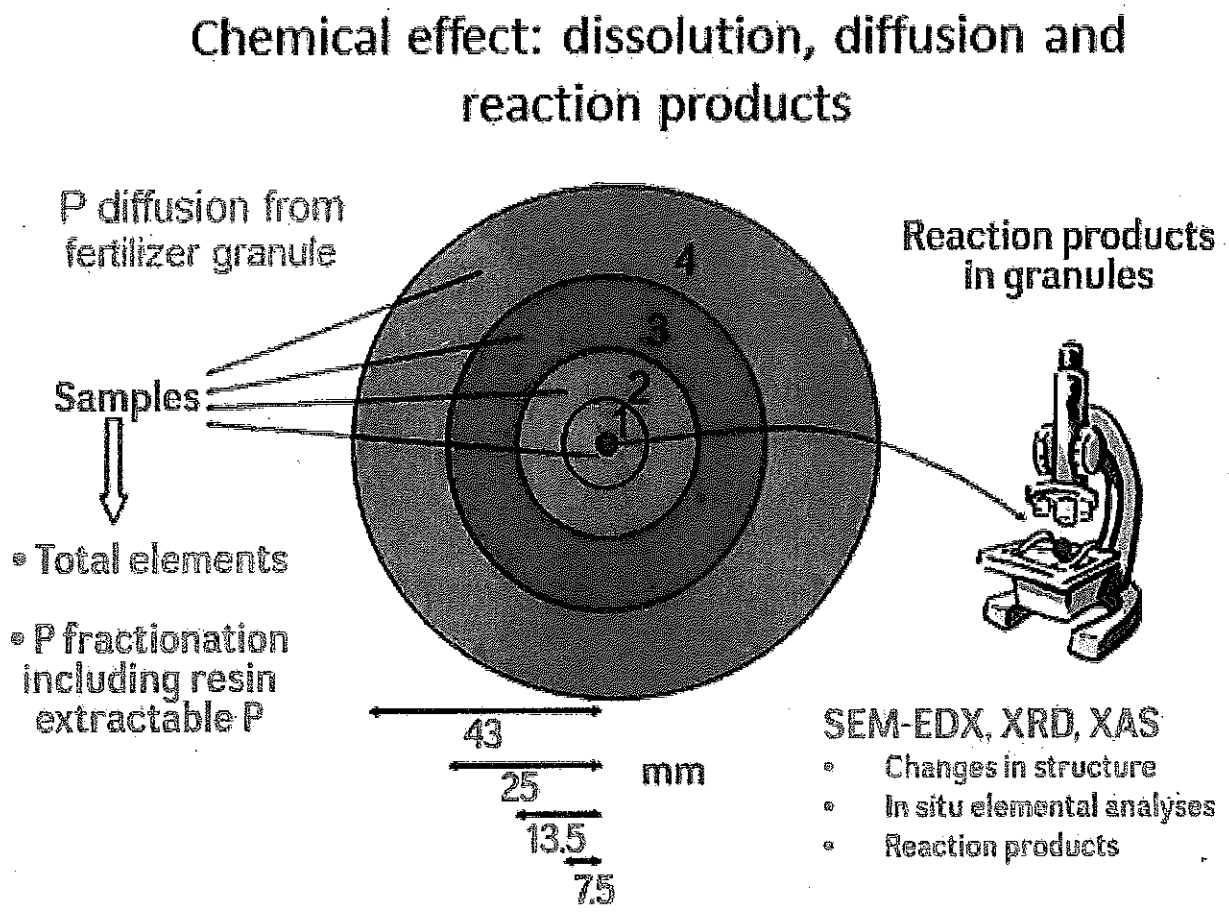

Figure 2. Methodology for evaluation of P reaction products from different P fertilizer sources with and without AVAIL® on high P retention soils (Brazil and Idaho).

Table 2. Effect of three phosphorus sources without and with AVAIL copolymer on XANES analysis results (inner-most section, 0-7.5 mm radius from the point of application) on a strongly acid soil (Brazil).

Treatment	Aluminum Phosphate	Alumina Adsorbed P	Ferrihydrite Adsorbed P	Strengite	Vivianite	Red. Chi Square
Control	13.9	-	64.1	-	21.9	0.27
MAP	-	-	72.1	-	27.9	0.32
DAP	-	47.3	-	-	52.7	0.04
APP	-	43.6	-	-	56.4	0.02
MAP + AVAIL	-		24.1	-	75.9	0.02
DAP + AVAIL	-	33.7	-	-	66.3	0.01
APP + AVAIL	-	21.4	-	78.6	-	0.00

Phosphorus sources act very differently when they are applied in either an acidic soil environment vs an alkaline soil environment or whether the source of P is dry or liquid. P reaction products and chemical changes can be identified as either being relatively soluble or relatively insoluble depending on the precipitate formed (Figures 3 and 4). Comparisons can also be made between P sources and when the AVAIL polymer was applied. AVAIL influences the solubility of P forms that are commonly applied to acid and alkaline soils in this study.

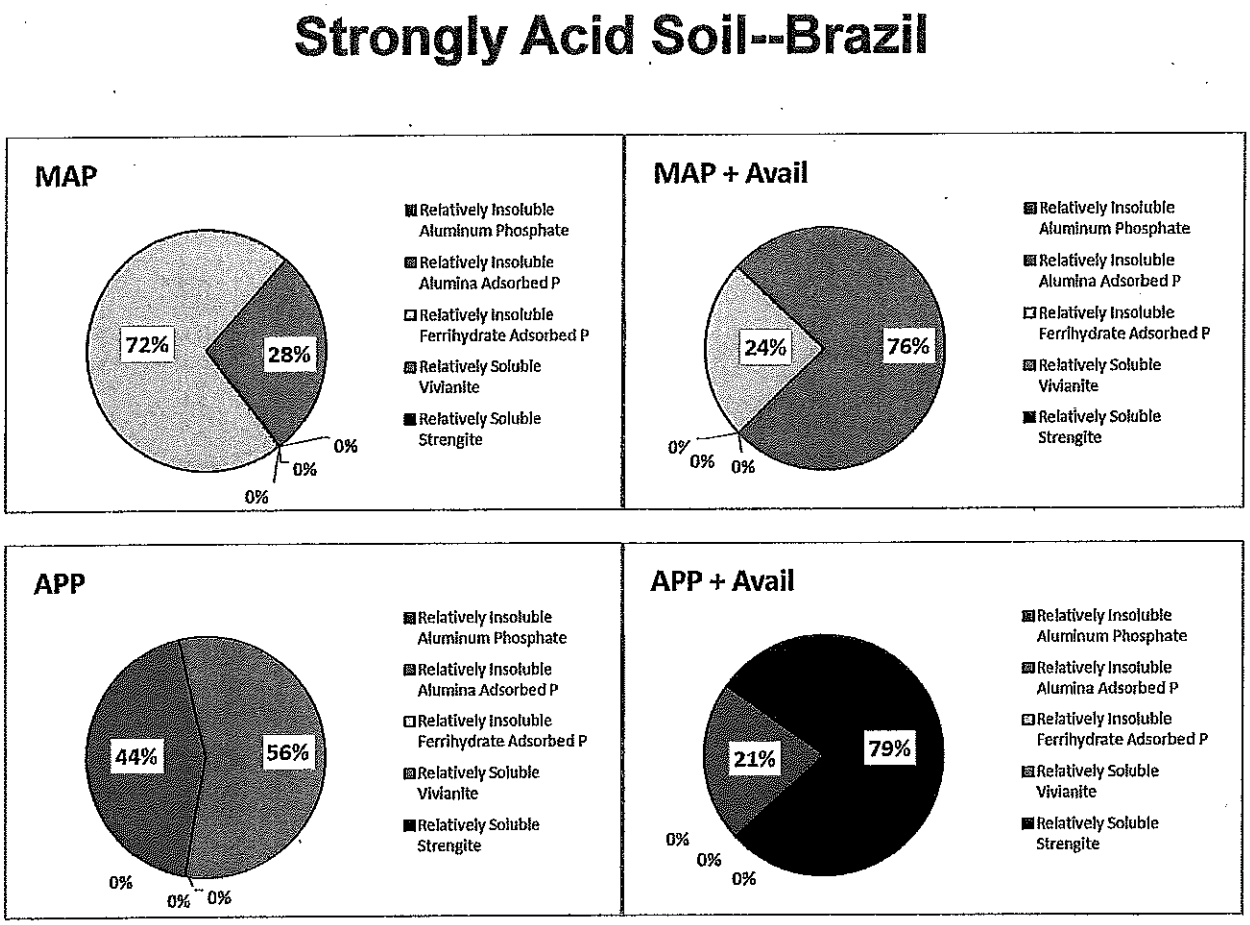

Figure 3. Change in relative solubility as influenced by the AVAIL polymers applied to a dry or liquid form of P to a highly acid soil (Brazil). G. Hettiarachchi and J. Pierzynski, Kansas State University.

Table 3. Effect of three P sources with and without AVAIL polymer on XANES analysis results (inner-most section, 0-7.5 mm radius from point of application) on an alkaline soil (Idaho).

Treatment	Apatite	Hydroxy Apatite	Aluminum Phosphate	Ferrihydrite Adsorbed P	Vivianite	Red. Chi Square

Control	20.4	48.2	-	31.4	-	0.1
MAP	59.2	-	-	31.0	9.8	0.0
DAP	64.1	-	-	35.9	-	0.0
APP	27.8	-	-	48.2	24.0	0.0
MAP + AVAIL	37.7	5.5	-	36.6	20.2	0.1
DAP + AVAIL	57.1	-	-	42.9	-	0.1
APP + AVAIL	32.0	-	7.1	61.0	-	0.2

Alkaline Soil—Idaho

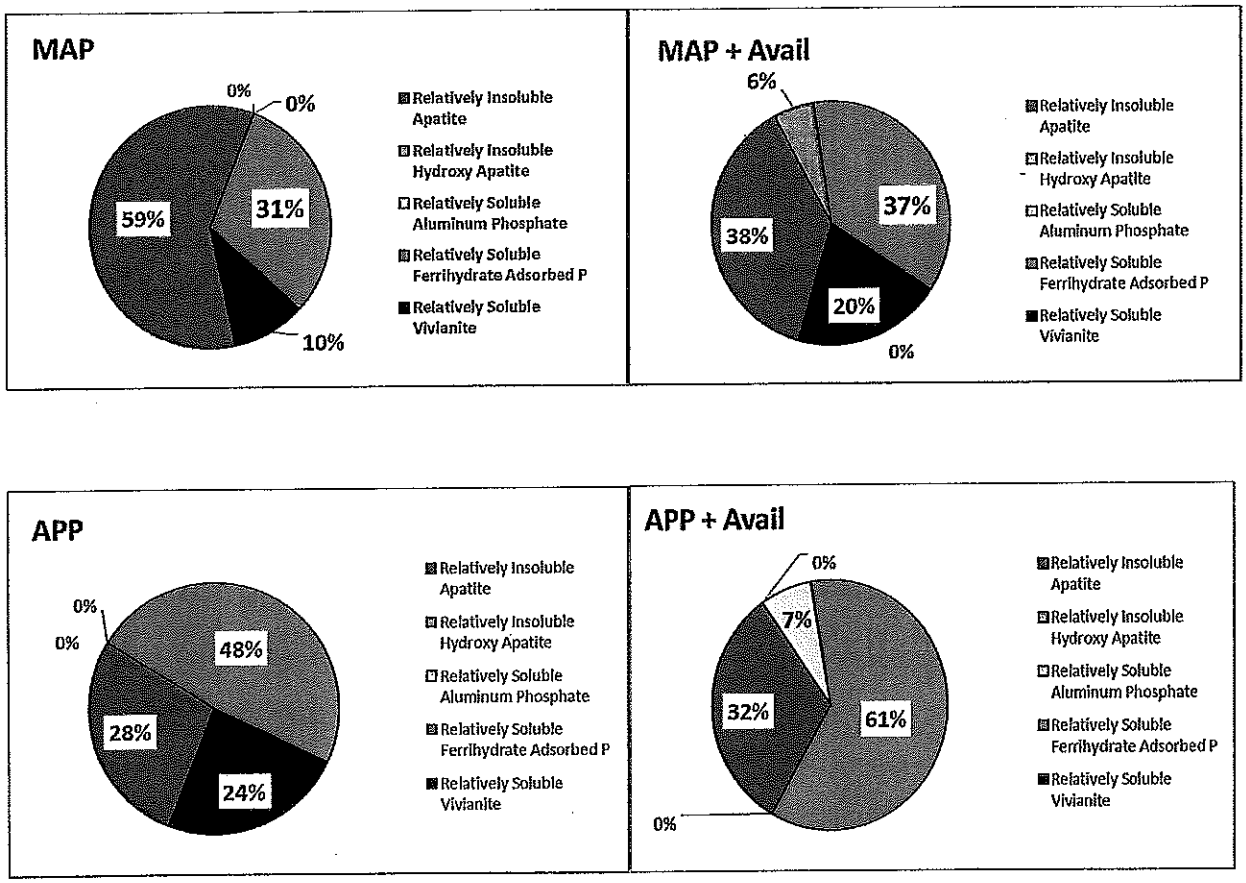

Figure 4. Change in relative solubility as influenced by the AVAIL polymers applied to a dry and liquid form of P to an alkaline soil (Idaho). G. Hettiarachchi and J. Pierzynski, Kansas State University.

SUMMARY

Phosphorus fertilizer sources are impacted by creation of both insoluble and relatively soluble P reaction products. Differences were observed for high P

retention soils for both Brazil and Idaho (low soil pH vs high soil pH). Fluid sources of P may contribute to greater soil P availability within both soil environments. AVAIL treated P fertilizers appears to be a viable alternative for improving P solubility for both soils evaluated. These improvements can benefit both growers using AVAIL as well as environmental considerations associated with P fertilizers. Other high P retention soils are currently being evaluated in a similar manner.