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Fluids Beat Granular in Soil Trials

Granular fertilizers found to be inferior to fluids in calcareous soils.

Summary: *Data indicate that fluid fertilizers are superior to granular for delivery of phosphorus (P) for crop nutrition in calcareous soils. Field and glasshouse experiments have demonstrated in southern Australian soils the benefits of fluid formulations for crop nutrition. Experiments were performed using similar fertilizer products delivered either in fluid or granular form to calcareous soils. Isotopic and spectroscopic techniques were used to characterize reactions. Granular fertilizers were found to be inferior to fluids (even with the same formulations) due to the precipitation of insoluble Ca/Al phosphates similar to crandallite in the fertilization zone (i.e., in and around the granule). As determined by isotopic dilution studies, P diffusion from the incorporation zone was inhibited with granular applications and the ability of P in the fertilized zone was also reduced when P was applied in granular form. Fixation of applied P is minimized when fertilizers are supplied in fluid form. Some formulations may have the added advantage of liberating fixed P in the soil-to-plant available forms.*

Alkaline soils, abundant throughout the world, constitute a major soil type for agricultural use in South Australia (SA). For example, calcareous soils in SA (5 to 90% $CaCO_3$) cover an arable area greater than 2.5 million acres and produce 40 percent of SA's wheat crop. Previous work has indicated that fluid fertilizers are highly efficient in calcareous soils of SA and Victoria, two of the most southern states in Australia. Large areas of both these states are characterized by low annual rainfall (between 9 and 14 inches) and calcareous and alkaline soils account for large percentages of the annual cereal production area.

This study was focused specifically on the reactions of granular and fluid products in these soils, using isotopic dilution and spectroscopic techniques to identify reaction products and to characterize the solubility of these nutrient sources and their availability to plants.

Improved diffusion

Results from this study show that granular MAP (one of the two most common fertilizers used in SA cereal production) is an extremely inefficient source of P in highly calcareous soils, due to poor dissolution of the granule.

Petri dish. Examination of total P concentrations on the various zones around the granule or fertilized zone indicated a very different distribution of P in the zones, depending on whether MAP was supplied in granular or liquid form (Figure 1). When MAP was supplied in granular form, much more of the P in the petri dish system was concentrated in the first zone around the granule itself (Section 1).

Supply of MAP in the fluid form (TGMAP) allowed much more of the P to diffuse away from the fertilized zone (Section 1) into outer sections of soil (Sections 2 and 3). In fact, over 80 percent of the P supplied as granular MAP is still within 0.25 inches from the center of the petri dish. In contrast, when P was applied TGMAP, over 40 percent of the total P applied was found between 0.25 and 0.5 inches from the center of the petri dish (Figure 1).

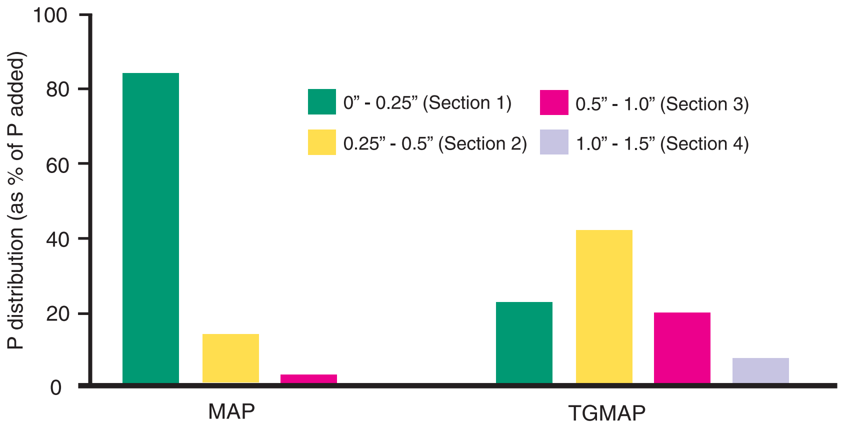

Figure 1. Percentage of P from fertilizers at different distances from the point of application of granular MAP and liquid MAP (TGMAP).

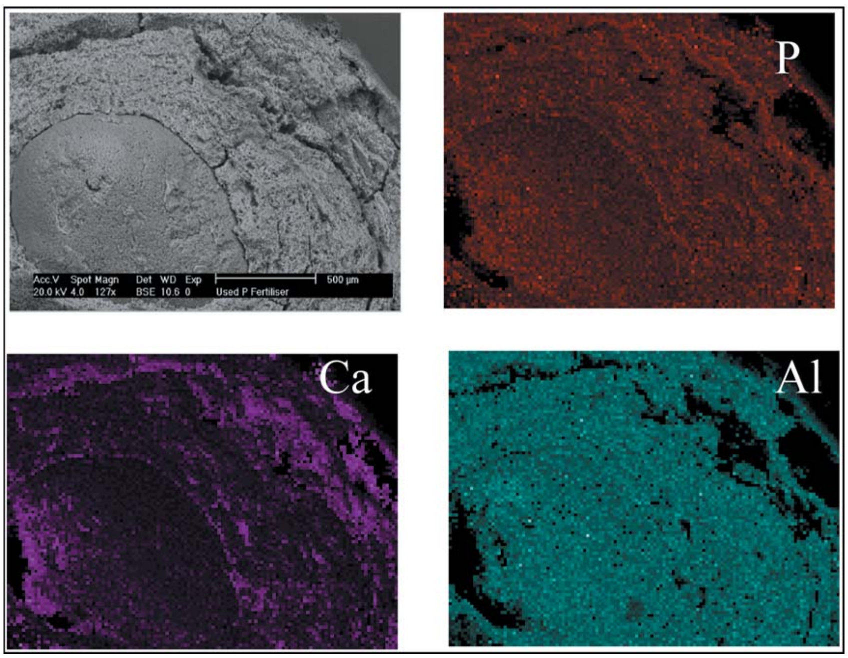

Figure 2. Scanning electro micrograph of a MAP granule incubated to 5 weeks in a gray calcareous soil and the corresponding EDXMA dot maps of P, Ca, and Al.

Isotopic dilution. Using an isotopic dilution technique it was also found that relatively more P was isotopically exchangeable when applied as TGMAP than as MAP. Therefore, it appears that P not only diffuses farther from the injection point but also remains more available (isotopically exchangeable) when applied as a fluid than as a granular.

A reason for this may be related to the fact that after an initial rapid dissolution of the granules, a significant percentage of P (10 to 20%) does not appear to diffuse out of the granules within 12 weeks. This was evidenced using EDXMA of granules exposed for different periods of time to a gray and red calcareous soil maintained at 60 percent of the water holding capacity. Dot maps representing the distribution of P, Ca, and Al in a granule exposed for 5 weeks in a gray calcareous soil are shown in Figure 2.

It is clear that all these elements are present in large concentrations in the exposed granule. At the moment, it is not yet clear what is the proportion of Ca and Al that originates from the soil and from the fertilizer granule itself.

The crystalline form of P in the granules after incubation was examined using X-ray diffraction. Several crystalline phases were identified, including the poorly soluble crandallite ($CaAl_3(PO_4)_2(OH)_5.(H_2O)$). It is likely that crandallite is a poor source of P for crop production in calcareous soils, even in the long term.

Additional data from the isotopic dilution studies indicated that when P was supplied at different rates as granular MAP, a large portion of P was rapidly fixed. By contrast, application of APP was less pronounced and mobilization of native P may have occurred. However, due to the complexity of the system and of the methodologies used, further experimentation is required in order to ascertain whether, and to what extent, mobilization of native P occurs.

Conclusions

Differences in P-bioavailability measured in the plant uptake experiment are likely to be due to a slower rate of dissolution of MAP in highly calcareous soils, or to rapid immobilization of the dissolved P. Data in Figure 1 certainly seem to indicate that P from fluid fertilizers diffuses through the soil better than when P is supplied in granular form.

The application of liquid fertilizers may facilitate more homogeneous distribution of soluble orthophosphate (or polyphosphate) ions in the soil, avoiding precipitation of solid phase calcium phosphates (or calcium polyphosphates) in the zone of fertilization. However, preliminary results obtained measuring diffusion and lability of various sources of P in petri dishes containing calcareous soils indicate that both dissolution and diffusion are key factors in controlling the differential efficacy of granular and fluid fertilizer in these soils.

The presence and formation of poorly soluble sources of plant P (e.g., crandallite) in granular formulations applied to calcareous soils indicates that the efficiency of fluid fertilizers may be explained through the different reaction products formed in the fertilizer zone. This indicates that crop nutrition in calcareous soils may need special formulations to minimize the stabilization of fertilizer P in forms not accessible by plants. The possibility of using fluid sources of P that not only minimize fixation reactions but also may release P to available forms needs further investigation.

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