A comparison of the amount of phosphate leaching from a citrate soluble, low water soluble, phosphorus fertilizer and a conventional superphosphate fertilizer in a sandy soil under simulated inundation

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Abstract

A citrate soluble, low water soluble, phosphate fertilizer (fused magnesium phosphate FMP) and a conventional phosphate fertilizer were subjected to a simulation of 10 years rain (700 mm/yr) in which 1 week of inundation was taken to be the equivalent of one year. The FMP lost 6.4% of its phosphorus as leachate and the conventional fertilizer lost 77%. If the results of the simulation carried through to field conditions the FMP would benefit the agricultural productivity of Western Australia while minimising the accumulation of phosphorus in groundwater and the lower strata of the soil. The long term result will add to the mitigation of the eutrophication of the waterways that drain both the urban and rural areas of SW Western Australia.

Introduction

Most of the agricultural land on the coast of the South West of Western Australia is on sand or sandy soils. As such they require frequent applications of fertilizer to sustain crop and pasture production. The fertilizers are generally soluble in water and dissolve after heavy rain. They are lost from the root of the plant they were supposed to support in run-off water or as the leachate that infiltrates the lower strata of the soil. The soluble phosphates enter the groundwater which, in turn, fills the aquifer system and inland waterways. This is a major problem for farmers, who need to maintain the productivity of their land, and for other stakeholders who value the quality of the waterways of Western Australia. The nutrient balance of the streams, rivers, and estuaries is unbalanced and impacts the normal flora and fauna (eutrophication), to the extent that blooms of blue green algae appear (ref 1,2,3).

Not all fertilizers are water soluble. There is a class of phosphorus providers that supply nutrients via the organic acids that are part of the organic component of soil. Fused magnesium phosphate (FMP), supplied as FertAg 0-8-0, is a member of the so-called citrate soluble fertilizers (Ref 4). The experiment described here, which was managed by D M Weaver, Department of Agriculture and Food, Albany Western Australia, compares the rate of phosphate loss from this product with that of a conventional (water soluble) superphosphate fertilizer. Both products contain about 8% elemental phosphorus that is all potentially available to plants. The test lasted for 10 weeks and simulated the effect of 10 years of inundation (700 mm rainfall per ‘year’) on the leaching of different application rates of the test and the conventional fertilizers through a Western Australian sand soil.

Materials and Methods

The soil was a 'sand, by definition, typical of the problem soils in question. The samples were applied to columns of soil at rates of elemental phosphorus spanning those that may be adopted by farmers managing pasture or cereal growing enterprises. A ten year period was condensed into 10 weeks.

At the start of the experiment fertilizer was applied to the surface of soil packed into 10 cm deep, 9.3 cm diameter leaching columns. There was one column with no fertilizer as a control. Deionised water was applied to each column with a peristaltic pump at the same rate, so that each column received the equivalent of 700 mm rain in 7 days. This is similar to the annual rainfall on the coastal plain in the region. The volume of water + leachate that collected in drainage vessels was measured daily, and a subsample was retained for analysis of dissolved phosphorus by the standard colorimetric method. The applications of fertilizer were repeated on the eighth day and at subsequent 7 day intervals until 10 weeks (= 'years') had elapsed.

Results and Discussion

Even under these intensive conditions the FMP product released very little of the phosphorus (6.4%) into the water that flowed through the soil column, compared to the superphosphate (77%) (Figure 1 and Table 1).

Figure 1 Indication of the degree to which the FMP product (FertAg) was retained in the soil column in comparison to water soluble superphosphate

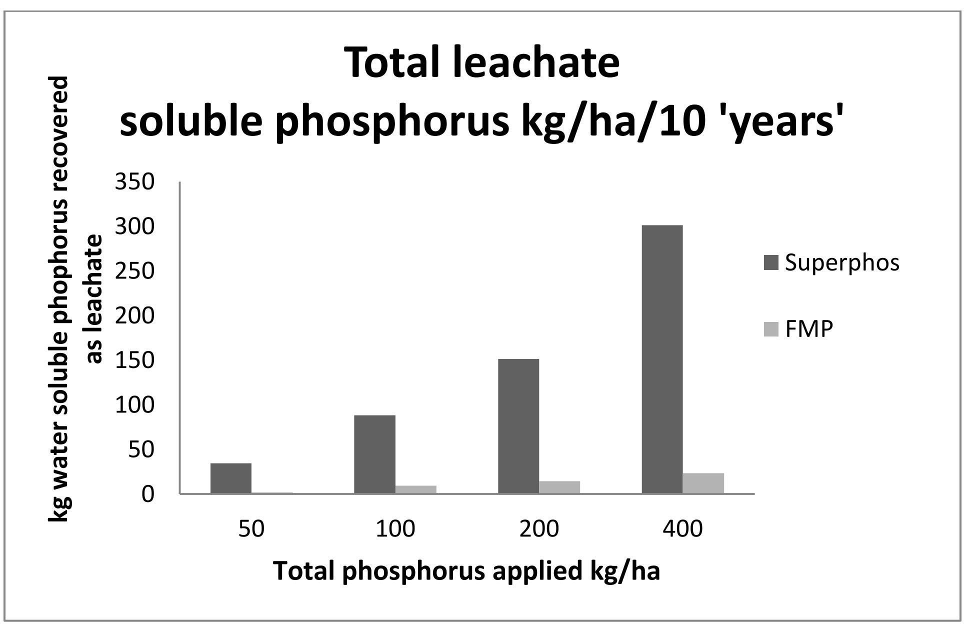

Table 1 Results of a simulation of the effect of persistent rainfall on the retention of elemental phosphorus supplied by a citrate soluble (fused magnesium phosphate FMP) product and a conventional superphosphate fertilizer when applied annually to a sandy soil at four rates.

Citrate soluble/ FMP Fertilizer kg P/ha/yr	mm 'rainfall'*	Total P applied (kg/ha/10 'years')	Cumulative kg P leached /ha/10 'yr'	Leachate less control kg P/ha/10 yr	Leachate as a percentage of total P applied	FMP leachate as a percentage of 'super' leachate
0	7252	0	3.7			
5	7012	50	5.4	1.7	3.4	5.0
10	7026	100	13	9.3	9.3	10.5
20	7179	200	18	14.3	7.2	9.5
40	7163	400	27	23.3	5.8	7.7
Mean	7126				6.4	8.2

Superphosphate (‘super’) kg P/ha/yr	mm 'rainfall'*	Total P applied (kg/ha/10 'years')	Cumulative kg P leached /ha over 10 'years'	Leachate less control kg P/ha/10 yr	Leachate as a percentage of total P applied	Factor by which ‘super’ leachate exceed FMP leachate
0	7252	0	3.7			
5	7064	50	38	34.3	68.6	20.2
10	7166	100	92	88.3	88.3	9.5
20	7132	200	155	151.3	75.7	10.6
40	7058	400	305	301.3	75.3	12.9
Mean	7134				77.0	13.3

The average amount of phosphorus lost by the superphosphate was 13.3 times more than the phosphorus lost by the FertAg product. In addition, there was no indication that the rate of application influenced the amount of phosphorus that was leached from the soil.

The data could be interpreted to indicate that the phosphorus in the FMP is retained in the soil, however, citrate solubility is a relatively good indicator of plant availability. The mechanism of availability is through exchange of organic acids with the fertiliser and subsequent uptake by the plant. The exact effectiveness of this for plant growth has not been investigated here. After dissolution the plant roots can access the phosphorus and the other nutrients (Table 2) they require from this interaction in the rhizosphere that are present in the FMP.

Also, the simulation involved only soil and water. In real life there are plants and microbes in the soil, and they also remove the phosphorus they need. Although impossible to quantify from the data presented, the demonstration that the FMP product retains phosphorus when exposed to heavy ‘rain’ implies that the elemental phosphorus it contains remains available to plants for much longer than the phosphorus that is supplied by the conventional, water soluble fertilizer.

Table 2 Analysis of the FMP tested in the leaching simulation.

FMP constituents	Content
Phosphorus	8%
Calcium	23%
Magnesium	12%
Plant available silicon	11%
Iron	3%
Potassium	0.2%
Sulphur	0.2%
Cobalt	38 ppm
Zinc	7 ppm
Copper	10 ppm
Manganese	0.4%
Cadmium	<5 ppm
Fluorine	<0.2%
(Citrate Solubility)	5%

Conclusion

The phosphorus in the citrate-soluble (FMP) phosphate source has been shown here to be less likely to leach from the root zone of plants after heavy rain than the phosphorus in a conventional superphosphate fertilizer when exposed to persistent rainfall in a sandy soil. The implication is that when an FMP fertilizer is applied to the soil, the phosphorus and any other nutrients it contains will remain available to the plant until they have been absorbed by the roots. This will not eliminate phosphorus leaching because there will be a transfer of nutrients into the root systems and debris of the plant and micro-organisms which will be available for use by the plant and also for subsequent leaching after a summer drying cycle. Despite this, the proportion that is lost to the subsoil or groundwater will be greatly reduced through less immediate dissolution and reductions in requirements from increased efficiency due to the minimised leaching. Routine soil testing prior to land preparation or the normal growing season will indicate how much FMP needs to be applied to meet the needs of a given crop or pasture. This is likely to be less than when a water-soluble fertilizer is applied.. This being the case the region-wide adoption of FMP fertilizer has the potential to reduce the eutrophication in the downstream waterways and estuaries of SW Western Australia. Further testing is required to assess the effectiveness of the fertilizer for plant productivity relative to ordinary superphosphate.

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