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Is Superphosphate really all that Super?

Superphosphate is one of the most widely used fertilisers in the world not because it is best for the environment neither is it best for the crop producer but the prime reason for its promotion is that it is cheap & easy to make with a good profit margin for the fertiliser manufacturers.

The basic process in making superphosphate is first of all make concentrated sulphuric acid by burning elemental sulphur and capturing the sulphur dioxide fumes with water sprayed into the smoke stack. Next spray the sulphuric acid onto finely ground Rock Phosphate in a horizontal revolving cylinder with one end elevated about 20 degree. The raw materials enter at the top end and the fuming superphosphate granules leave at the lower end. After being left to mature for a week or two, the product is ready for sale.

The price of superphosphate per unit of soluble P is without doubt the cheapest fertiliser available. However we must not confuse units of soluble P with units of P utilised; for once the fertiliser is in the soil, complex reactions take place which frequently renders a high percentage of the phosphorus unavailable for plant growth. (see fig 12.6 below copied from chapter 12 “Principles and Practice of Soil Science” R.E White.

What is not told to fertiliser users is that superphosphate is a product that is 100 times more acid (pH1.5) than vinegar (pH3.5) Remember that the pH scale is log10. On a moist soil superphosphate releases most of its soluble P in 24 – 36 hours and much of the free Phosphorus becomes immobilised by being fixed by either aluminium or iron (dissolved from the soil minerals by the product’s acidity) The resulting products are insoluble minerals including the Aluminium phosphate Varisite or the Iron phosphate mineral Strengite.

The micro environmental changes around a superphosphate (MCP) granule after application to a moist soil.

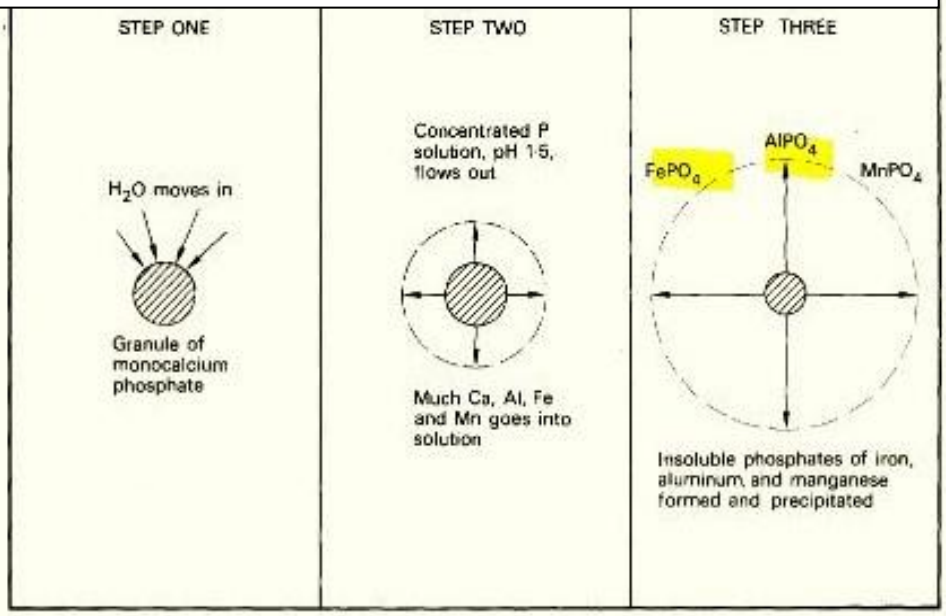


Figure 12.6. Successive stages in the dissolution of an MCP granule in soil (after Tisdale and Nelson, 1975).

When this issue is raised with the fertiliser manufacturers the answer we often receive is that "these resulting phosphate minerals are reserve phosphate" However on the graphs below (fig 21.3 copied from "Russell's Soil Conditions & Plant Growth") depict the relative solubility of both Varisite (a) and Strengite (b) .

You will note that when the soil pH is less than pH5.0, the solubility of these minerals is significantly reduced. The only commercial crops I know of which do well at pH5.5 or less is Blueberries, therefore purely from an economic point of view it is better to use non-acid alternatives to superphosphate.

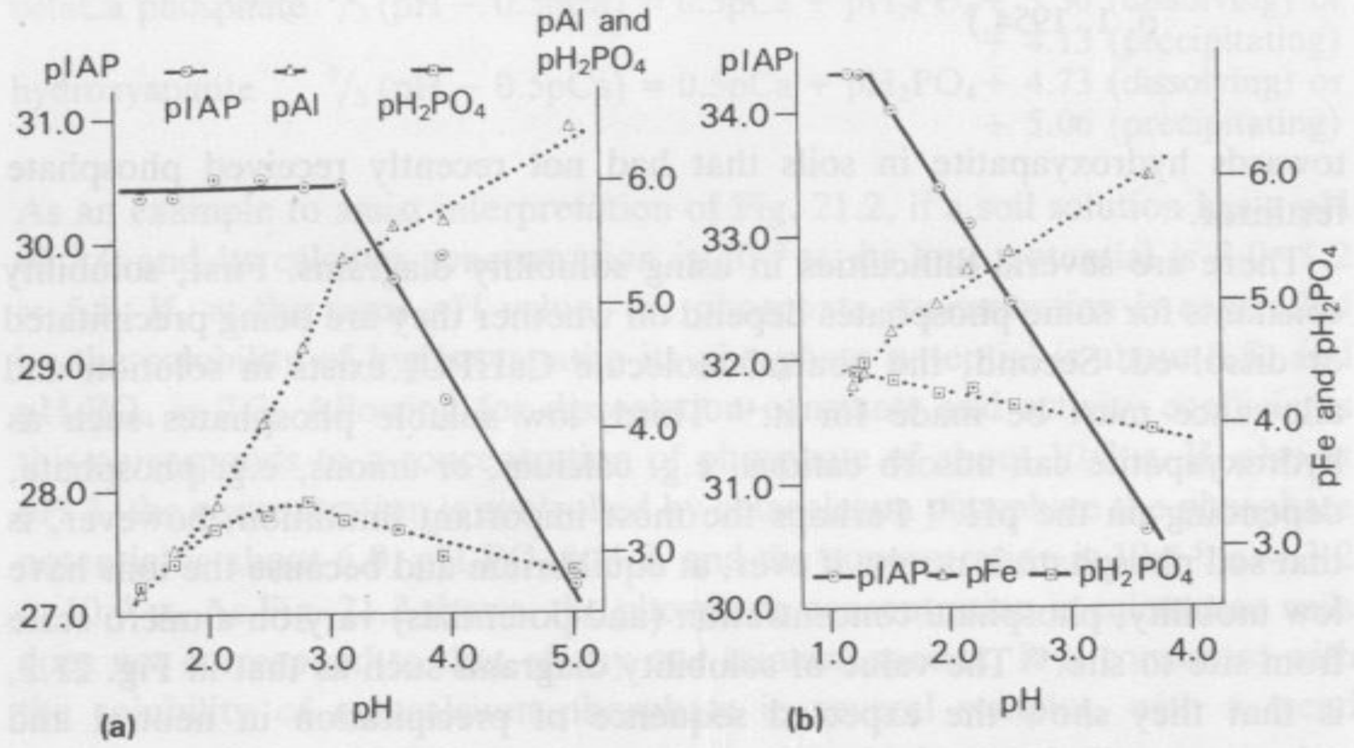


Fig. 21.3 Effect of pH on the solubility of (a) variscite and (b) strengite. pIAP = negative log. of ion activity product. For variscite, $pIAP = pAl + pH_2PO_4 + 2POH$. For strengite, $pIAP = pFe + pH_2PO_4 + 2POH$.

What are the cumulative effects of using highly acidic phosphate products over decades?

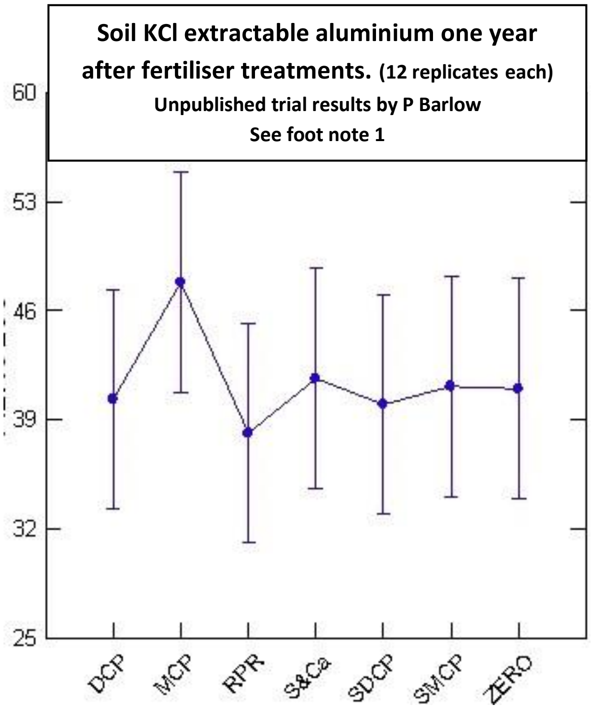
If we were to apply 200 to 400 Kg/Ha/year acid superphosphate over decades what happens to all of that acid. The advocates of superphosphate say that the bulk soil pH is unchanged with the use of superphosphate and they are almost correct in this when simply using a pH test for the bulk soil. However clay minerals that are being dissolved in the micro-environment around each fertiliser granule are neutralising the fertiliser acidity – But at what cost?

a) These destroyed minerals provide the surfaces which comprise the cation nutrient holding ability of the soil known as the CEC (cation exchange capacity). Therefore the prolonged use of superphosphate is reducing the CEC making the soil more prone to leach potassium and magnesium, compared to soils that have not used acid superphosphate and therefore in recent years we need to apply more and more potash and magnesium fertilisers.

b) The acidic Superphosphate (MCP) dissolving of soil clay minerals releases mobile aluminium in to the soil solution (see graph on right) where it is drawn in the water flow towards the roots. Plant roots actively exclude this aluminium so that aluminium accumulates to the point of phyto- toxicity. It is visible as a blackened surface layer on the roots which is a barrier which soluble phosphorus cannot pass.

c) For legumes there is an additional issue as Relatively low levels of free aluminium in the soil very strongly shuts down nitrogen fixation by preventing the formation of rhizobium nodules of the roots.

d) There are fertiliser alternatives that do not release aluminium (see graph on right). You will note that RPR (Reactive Rock Phosphate) reduced free aluminium and this is because RPR has a 20% liming potential.


Soil KCl extractable aluminium one year after fertiliser treatments. (12 replicates each)
Unpublished trial results by P Barlow
See foot note 1

Fertilisers used in trial:
[DCP Di-calcium Phosphate pH6.5] [MCP Mono-calcium Phosphate Superphosphate pH1.5 to 2.5] [RPR Reactive Rock Phosphate 25% liming potential] [S & Ca Gypsum pH7] [SDCP Like DCP but with added Serpentine dust ≈pH6] [SMCP Superphosphate that had serpentine dust added before the fuming granules leave the revolving cylinder ≈pH6] [Zero = no treatment]

When we use Superphosphate we are becoming dependent on applying more and more fertiliser. We apply superphosphate in order to deal with a phosphate deficiency but then we lock ourselves into a system where we have to keep on using soluble phosphate and worse we have created a need for us to need to use magnesium, potassium and nitrogen fertiliser. Have we been conned I ask? In discussing these matters with the renowned New Zealand soil scientist Prof Tom Walker his response was “that before using Superphosphate the soil should be limed until the ideal soil pH is reached and then the problems with aluminium are reduced”. Prof Walker was a keen proponent of Superphosphate and one key reason was that when he arrived in NZ from Britain in 1952 the New Zealand soils were starving for any phosphate fertiliser and huge responses were seen. Here we are more than sixty years later still using the same unchanged product and we have to ask -- **surely it is now time to move on and use something better?**

What does superphosphate do for animal life?

For soil microbes: This question has been explored scientifically and you can compare virgin soil severely deficient in calcium & phosphorus with a enriched pasture limed and fertilised with superphosphate and yes the enriched pasture did have greater microbial life. But if you were to make the same comparison using non-acid fertilisers the result is even better. With earthworms this is an easy experiment for you to prove for yourself, I have ---- poor earthworms!

For Human health: All phosphate rock contains fluoride (about 4.5%) and cadmium to various amounts depending on the quality of the mineral. The level of cadmium entering the human food chain as phosphate fertilisers has cause much alarm amongst food scientists and in the year 2000 the European Commission published “A Possible EU Wide Charge on Cadmium in Phosphate Fertilisers: Economic and Environmental Implications” The document clearly showed that it is not sustainable for us to continue to use phosphate fertilisers with the same recklessness and abandon as we have since Bennett Lawes first manufactured superphosphate fertiliser in Deptford, England in 1842. Therefore we need to use phosphate fertilisers so that we get the maximum amount of P content fully utilised either by the target crop or by the grass sward growing under Fruit trees so that a high percentage the phosphorus enters an organic cycle. Doing this will increase fertiliser efficiency and minimise the amount of fluorine and cadmium entering the soil and human food chain.

What non-acidic alternative phosphate fertiliser can we use?

Option 1:
Use high quality soft rock phosphate (RPR) dust as a directly applied fertiliser. There is a huge variation in the quality of different sources of rock phosphate therefore you need to know the solubility of the rock and to assess this we use three extraction processes:

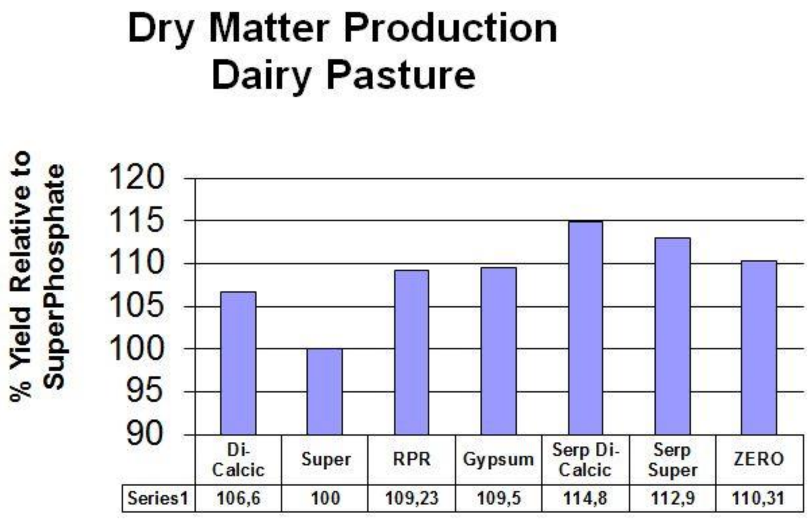
i) Nitric/perchloric acid. Measures the Total P
ii) Citric acid extractable P. Measure the fraction which is not water soluble but still plant available Phosphorus due the the natural acids secreted by the plant roots. This is the key measurement and ideally the result should be a high percentage of the P found in the Total P extraction.
iii) Water Soluble P. This should be a fairly low percentage ideally about half a Percent.

We offer for our clients a comprehensive analysis of rock phosphate to our clients that will assess P content, P solubility and also the Fluoride & Cadmium content.

Option 2:
Make your own non-acid di-calcium phosphate (DCP) by reacting superphosphate with moist lime, maturation takes about one or two weeks. The product then screened for lumps & then used or sold with a profit for the maker. The end product is about 4.5% P, which does not sound great but when you express it as utilised P then it is better than Superphosphate. The pH of the finished product is usually about pH6 to pH6.5 which is very similar to the ideal soil pH. If it is of interest to you we also provide analytical service for monitoring product quality.

Do these alternative work:

For evidence we present the results of a Fertiliser trial Waihi NZ 1997/98. (Courtesy of Northfert Ltd)
A one year duration 84 block fully replicated trial, including precision before and after soil analysis. Herbage dry matter production was measured by cut and weigh procedure throughout one year. Leaf analysis was included. The release of aluminium measured using the KCl extraction showed that superphosphate did release aluminium and reduce soil CEC.
When compared to superphosphate Herbage dry matter productivity was superior in all treatments including zero application (see graph on right).
The products which contained magnesium as serpentine dust gave the greatest results, indicating that magnesium was restricting pasture growth to a greater extent than phosphorus. The Superphosphate treated blocks produced a strong flush of growth shortly after fertiliser application, but after a few weeks growth lagged behind all other treatments.



Perhaps Superphosphate is not so Super after all !