Phosphorus (P) Version 2.8 14 May 2013

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Introduction

Phosphorus is the correct spelling of the element in phosphate fertilisers. Phosphorous and phosphoric are adjectives.

Phosphorus is a non-metallic element, occurring widely in all soils and in living matter. After calcium (lime), P has more influence on the long term growth rate of mixed grass and clover pastures than any other element. P is one of the least understood by users, and by some scientists and researchers, both of whom are sometimes sponsored so paid to promote superphosphate.

Phosphorus is in all living things, including bone formation, the construction of DNA and cell membranes. As it is relatively rare in the Earth's crust, a lack of phosphorus is often the limiting factor in the growth of plants and algae.

There are many forms of phosphorus which have many uses, but that used in farming is from naturally mined phosphates that usually contain about 13% P. Reactive phosphates can be used as is, if in a reactive form, and applied to acid soils which makes it become available to plants. The less available forms of raw phosphates are processed with sulphuric acid to become water soluble superphosphate. Depending on the soil's requirements, adding 10% to 20% of 100% elemental sulphur to the more reactive phosphates such as Sechura and Gafsa, can make them more available.

Superphosphate use since the 1980s has increased by about 100% and DAP use has increased by 550% over the same period. Other phosphate fertilisers annual applications of close to 200,000 tonnes per year adds up to more than 1.5 million tonnes of phosphate fertiliser applied to NZ farms per year. In the same time the application of lime has decreased. It should be the other way around.

With the recent huge price increases in phosphate fertiliser costs, the research statistics need correcting based on current costs of P at about $400 and lime at $15 to $25 per 1,000 kg at mines.

There is concern about the environmental effect of the increase in fixed P in our soils. It is so high that many farmers have applied LimeMagPlus (agricultural lime with its synergisms and needed elements, based on pasture analyses) and no P for four years, and pasture tissue P levels have remained at optimum, or even increased.

If your farm or fertiliser adviser continues to recommend the application of P when pasture levels are adequate, seek unbiased advice, because in 99% of cases from my 500 clients since 1960, Ca has been below 0.8% in ryegrass leaves and stem which slows the growth of young stock to almost zero in bad cases, especially if cobalt is also low. See Elements > Calcium > Te Puke.

If your soil P test result is high (substantially above the target Olsen P 20 to 30 for most soil types), is your advisor prepared to recommend no fertiliser P application, but calcium to raise the ryegrass Ca level to 0.8%? If not, change him.

If your soil pH is adequate (slightly above 6.0) does your advisor wrongly recommend no lime application? pH can be high from excess potassium which is common in parts of New Zealand, or high sodium, also common near the cost and in some areas.

The New Zealand fertiliser industry has a strong tie up with P fertiliser because it has massive factories manufacturing superphosphate, so much so that Environment Waikato made the following statement based on data collated comparing that from 1988 to 1996 with 1997 to 2001, "Phosphorus fertility on many dairy farms is near the maximum needed for high production, so many soil samples, especially from volcanic and sedimentary soils, show excessive phosphorus levels."

Waikato County Council showed that excessive, optimum and low levels between 1988 and 1996 were 49%, 20% and 31%, and from 1997 to 2001 were 75%, 15% and 10%.

I don't have more recent data, but annual fertiliser P applications have risen, so the proportion of samples that will be rated as 'high or excessive' is likely to have increased.

This is likely to apply to other pastoral farming regions where soil tests are used and calcium leaf tests are ignored. The excess use of P is partly because soil tests are inaccurate, favouring the sales people, some of whom get commissions of up to $12 a tonne.

If pasture tissue analyses were used, none of the above deceptions would occur, and animals would be healthier and farmers better off.

In New Zealand and much of the world, 'greed' has replaced 'honesty', so some people use figures (soil tests) that favour their income and some twist other figures for the same reason, such as - surface application of agricultural lime on peat doesn’t work. Read Elements > Calcium for the honest information on the misquoted 1954 MAF research figures, which were wrong then, and more so now that most peats are like ordinary soils with earthworms and other forms of life.

What some call Reactive Phosphate Rock (RPR) is not supplied in a rock form and some never were rocks, so it should not be called that. It should be referred to just as reactive phosphate (RP) or low-reactive phosphate.

There are single superphosphates (9% P), triple superphosphate (21% P), PAPRs, DAP (20% P), MAP (20% P), liquids and foliar sprays in an extremely competitive and large agricultural market. The liquids don’t contain enough P to be called fertilisers, but some have other attributes.

Correctly fertilised grasses have P tissue levels of between 0.3% in Timothy and 0.45% in Cocksfoot and Kikuyu. See the ‘Free Items’ Spreadsheet > called Pasture Mineral Analysis. Some farmers aim for lower P levels, but animals, especially growing calves and alpacas, can suffer from low P levels, and suffer more from low Ca and low Co levels.

Misinformation is spread about the use of reactive phosphates by some fertiliser companies and some who call themselves scientists but are so in title only. One is that reactive phosphate doesn’t release P fast enough for crops, but look at this maize on our Greenhill Road, Hamilton, 2nd farm in 1986, sown with a 1,000 of Sechura RP mix described on page 15 and in the Forage Crops > Maize chapter. Our son-in-law/ share farmer Ian Dobbs, is not short. In 1986 this was the best grain crop I saw in the Waikato, and the harvester and grain buyer agreed. It was on consolidated one metre deep peat that had been starved for agricultural lime and trace elements. It got 8,000 kg of lime/ha chisel ploughed in to 40 cm and fertiliser chisel ploughed in to 40 cm. Our previous maize crop was harvested for grain and the stubble strip grazed, so turned into animal manure.

This hungry looking maize not even two metres high was typical of many fertilised with superphosphate, and on our farm when we bought it.

Another source of confusion is soil testing. Terms such as ‘Fixation’, ‘Retention’ and Base Saturation add to the confusion of fertilising. Another confusing item that affects fertiliser buyers is the fact that soil P measuring systems vary and are inconsistent. When confused, people do nothing. An example is the Olsen P test, developed by a German scientist in early 1900. He found that it had serious faults so gave it up. It was later used in USA in high pH soils. All have acknowledge that it doesn't measure RP or organic phosphate accurately.

The Olsen P level doesn’t increase until quite a lot of P has been applied, even with superphosphate, sometimes not for three years, and doesn’t decrease until a few years after application stops, and until after the actual P level in soils drops and after the pasture yield decreases. This causes P levels in pastures to get too high, which I’ve seen hundreds of times. It can cause animal high P health problems about a month after applying too much superphosphate. See Animal Excesses of P.

The same amount of P in DAP (20% P) increases Olsen P levels faster and higher than the same amount of P applied in single superphosphate (0-9-0-11) or RP. In organic soils (peats) Olsen P measurements can be 500% wrong. An LIC consulting officer told me that the Olsen P level was 80 in a heap of poor fluffy dry peat out of a peat drain that could only grow small weeds. The accurate P level would be close to zero. The New Zealand so-called soil scientists who have been sponsored by fertiliser companies for decades don’t know the reasons for these inaccuracies.

Another mistake some farmers and scientists make is to apply nitrogen to try to grow more pasture, when low Ca and P are the limiting elements. The requirements for growing plenty of good pasture are correct drainage, correct calcium, phosphorus, sulphur levels with other lacking elements and earthworms, then N if needed, in that order.

Under or over-drainage are obvious growth restrictions, but it is not well known that low Ca means P will be less available. Earthworms won't thrive until all elements in soils are balanced. They are animals and need the same minerals for optimum health, growth and activity.

Measuring P

Methods of measuring phosphorus in the soil (Bray, Olsen or Resin) indicate only the amount of available phosphorus ions at the time. Measuring pasture tissue levels by-passes this problem and indicates how much is being released over time, and how much the plants are actually getting, which is what matters. If available-P is lacking in the soil they get little, if available-P is adequate they get sufficient, and either way they show it, so plant leaves (tissue) is a far more accurate measuring system.

P is essential for photosynthesis, the process by which plants harvest energy from the sun to produce carbohydrate molecules, i.e. sugars. To work best P needs sulphur with it, but superphosphate has too much, and being in the water soluble sulphate form, it leaches and takes some other elements with it, especially selenium and potassium.

A deficiency of phosphorus affects not only plant growth and development and crop yield, but also the quality of the fruit and the formation of seeds. Deficiency can also delay the ripening of crops, which can set back the harvest, risking the quality of the produce. In animals a lack of phosphorus not only affects bone structure, but also appetite, but is rare in New Zealand pasture-only diets when correctly fertilised.

To successfully produce the next generation of plants, seeds and grains must store phosphorus so that seedlings have enough to develop their first roots and shoots. Then, as the root system develops, the growing plant will be able to take up the phosphorus it requires from the soil, provided it is there.

For optimum pasture growth and animal health, aim for mixed pasture tissue levels of 0.4% for most; however, levels vary between plants and soil types, with pumices giving higher pasture levels than ash soils at the same soil levels. Fertiliser application rates need to allow for the future removal by grazing until the next application, so if the level is optimum, enough has to be applied to keep it at that level until the subsequent fertilising.

P moves very slowly through the soil, especially in dry conditions. Water soluble P, however, can wash (run off) down even gentle hills and into valleys and down cracks in soils and peats, if heavy rain falls after application, especially on very dry soil when runoff is usually high (except in sandy soils), and very wet soils, where runoff occurs because the soil is saturated.

Superphosphate spread evenly on Grant Sefton's Reporoa pumice soil washed off the steep slopes into valleys and then to waterways. The green areas are either flats where the fertiliser remained or gentle sloping valleys where lots was deposited. This farm turned an even green after using reactive phosphate, elemental sulphur and other needed elements, based on pasture analyses.

Our environmental councils have complained about P pollution, but to my knowledge have done nothing about informing farmers of solutions. A USA conservationist wrote, "Soluble phosphate wash-off is a BIG problem in USA. Our farmers use mostly DAP and MAP which, like superphosphate are water soluble." Where possible, reactive phosphate should be used. It contains Ca which is essential for animal health.

The P in reactive phosphate fertilisers is not water soluble, so doesn't wash at all, unless in erosion with the soil it has fallen on, which in pasture is rare, so, where conditions suit it, use the best value reactive phosphate, which is usually cheaper than other forms of P. Non-reactive P is even cheaper, but has to be acidified to become available to plants.

Most organic P is extremely stable. Some say that it is unable to be taken up by plants unless mineralised to inorganic phosphate ions. Others say that the acid that plant roots use to go through soft rocks, make it available, and take it up. Mineralisation of organic P is a slow process, dependent on many factors, such as humus, soil life, aeration, temperature, moisture content, the calcium to phosphorus ratio and acid levels.

P is most available at pH 7, but is adequately available at pH 6.2 There is ample P in some soils which continues to be released. Most (especially peat and pumice) need large capital dressings before giving good yields of pastures or crops, and then they need regular maintenance applications.

P loss by leaching is usually less than one kg per hectare per annum in average soils and peats, but is higher in sandy soils under high rainfall.

From about 1920, relatively cheap superphosphate became available in New Zealand; however, widespread use was slow to be adopted, because of man's slow learning curve, and the initial limiting factor of having to be spread by hand.

When aerial topdressing "took off" in New Zealand in the 1950's, P application was given the credit for the substantial increase in hill country pasture production. Later it was found that the sulphur also played a major part. New Zealand is free of pollution from factories, etc., has frequent winds from the seas, so air polluting S is non-existent, unless a volcano blows, which is only a few times a century and is normally limited to small areas.

During the 1960's, considerable effort was put into determining the optimum levels of nutrients in pastures, but unfortunately most of the effort was put into the main elements (N, P, K). Because trials and farmer use showed tremendous responses from phosphate, potash and lime, excessive amounts were frequently applied, to the detriment of some trace elements and soil and animal health. Most of New Zealand is low in iodine, and many areas low in selenium, and some in cobalt, copper and zinc.

P works in conjunction with sulphur, and vice versa (synergistic). Winchmore Irrigation Research Farm in 1960 did trials applying only P and only S on separate paddocks and got no responses, while applying them together gave good responses. RP without elemental S gives nowhere near the growth of that with it (NZ National Trials, farmers’ and my experiences).

The measurable Olsen P content of some soils bears little relation to the P available to plants, so fertilising should be based on fertilising history, growth responses obtained and analysing the plant tissue, rather than the the far from accurate soil test levels.

After cultivating to about 20 cm (8”) to resow a run-out (low fertility) pasture, a substantial capital dressing of at least 100 kg P/ha (90 lb/a) is necessary to establish good pasture. It should be chisel ploughed (hoed, not mouldboard or disc ploughed) in to at least 30 cm in mineral soils to bring up subsoil, and much deeper in peats. After this, normal regular dressings can be applied. However, deep chisel ploughing of fertile soils can raise the P levels for a short time because it increases soil aeration and soil life, and if lime has been applied before chisel ploughing, it reduces the adverse aluminium toxicity effects on P and pastures. This doesn’t happen on peat because there is almost no P in it - despite a reputable Hill Laboratory Olsen P test by an LIC consultant from a heap of Ngatea deep raw peat being 70. To explain why, soil samples are dried and weighed. Peat is so light that a small percentage of P gives a high reading.

Mouldboard ploughing can create a hard pan (aggravated by low Ca levels) which slows the movement of moisture and minerals down and moisture up.

Soil testing for phosphorus (P) has been a subject for extensive research. Numerous extractants ranging from strong acids to alkalis and various organic and inorganic complexing agents have been developed to evaluate P bioavailability with certain crops and soils. The most widely used soil P tests are Bray I (Bray and Kurtz, 1945), Mehlich I (Nelson et al., 1953), and Olsen (Olsen et al., 1954). Other common tests include Bray II, Mehlich II and III, and resin (Fixen and Grove, 1990). However, all these soil tests are mainly for recommendations with water-soluble P fertilisers, such as di-ammonium phosphate (DAP), single superphosphate (SSP) and triple superphosphate (TSP). Reports have shown that these conventional acid or alkaline soil tests do not work well in soils fertilised with reactive phosphate (Perrott et al., 1993; Menon and Chien, 1995; Rajan et al., 1996). Thus, there is a need to develop appropriate soil tests that reflect closely P uptake from PR over a wide range of PR sources, soil properties, and crop varieties. Furthermore, the soil tests should be suitable for PR and for water-soluble P fertilisers. This issue has become more important because of the increasing use of PR for direct application in developed and developing countries, e.g., Australia, New Zealand, Brazil, Indonesia, Malaysia and Africa.

As PRs are relatively insoluble materials, their particle size has an important bearing on their rate of dissolution in soil. The finer the particle size, the greater is the degree of contact between PR and soil and, therefore, the higher is the rate of PR dissolution. Sechura RP is recognised as the best partly because it is so fine. It is not ground, but the coarse material is removed. A 0.1 mm diameter particle of fertiliser has 722,000 particles per gram and a surface area of 227 cm2 per gram. A 0.01 mm particle has 5 million particles and a surface area of 454 cm2 per gram. A 0.002 mm particle has 90 billion particles per gram and a surface area of 8 million cm2. So don't use coarse RP, it can take up to 40 years for all to be available (AgResearch figure). Sechura has shown results in five weeks, and is mostly all available within two years - about the same as super-phosphate.

Moreover, the increase in the number of PR particles per unit weight of PR applied increases the chances of root hairs intercepting PR particles. Thus, application of PR as finely ground materials (usually less than 0.15 mm) enhances both the rate of dissolution of PRs and the uptake of PR-phosphorus in a given soil. On the negative side, because of their dusty nature, the application of finely ground materials is fraught with practical difficulties. Salt and other added elements improve the spreading.

Some NZ hill country farmers in the 90s applied finely ground DAP (diammonium phosphate 18 N, 20 P, 2 S) at very low rates in a slurry by helicopter. The application rates per hectare are about 3 N, 3 P, and 0.3 S, or about 1/10th conventional rates. This has rightly drawn criticism from MAF soil scientists, yet the farmers concerned claimed better results than they had achieved with conventional superphosphate. It is not surprising that they are getting visual responses from the nitrogen in DAP, but long term P will become deficient. There is often little clover in hill pastures and N makes them lazy, so the system is not likely to last, especially when it has to be applied several times a year, and helicopter costs use up much of the fertiliser budget. One advantage of this system is that no potassium is applied, which, in New Zealand it has been applied in excess for decades. See Elements > Potassium.

Aluminium

Where aluminium (Al) levels are high many pasture roots, especially ryegrasses, don't go below the lime-cultivated depth. A hard pan is sometimes blamed for lack of root penetration, but roots have the capacity to penetrate extremely hard soils and soft rocks. If Al is present some won't. The roots of Velvet grass also known as Yorkshire Fog (*Holcus lanatus)* penetrate high Al soils. Ryegrasses won't. Any acid fertiliser such as superphosphate, and including too much elemental sulphur, can make the aluminium more available, which discourages ryegrass root penetration, which is a major cause of ryegrass pulling. Lime and RP reduce aluminium effects and ryegrass pulling. Fine elemental sulphur must be mixed with RP to make it more available, and to gradually provide the amount of S required based on a pasture analysis. Course sulphur or the Ravensdown pebbled sulphur are not good because they don't make contact with RP and take too long to become available.

Reactive phosphate and Ca in lime reduce Al toxicity, so high-aluminium soils need more of one or both, but for the best results they have to be cultivated in, or taken down by earthworms or given time. A pasture analysis should include Al, which should preferably be below 100 ppm.

For many reasons, most farmers don't apply sufficient P to pastures and forage crops. One reason in New Zealand is that the old 6 cwt/acre in NZ was wrongly translated to 600 kg/ha, whereas it should be 753 kg/ha, which is 153 kg/ha or 25% more.

Another is the confusion over what the soil levels should be. The ideal level is a contentious issue, and varies depending on rainfall, type of soil, farming (dairy, beef, sheep, cropping) etc. A cynic would say the sellers of P recommend high levels while non-sellers of P recommend low levels. A major independent laboratory suggests a level of 20 as ample. Many will disagree.

See P-Retention & P-Fixation for more on Al and the rest of this Chapter and Elements > Aluminium.

Recycling

Dairy cows recycle the majority (approximately 65%) of P they consume from pasture via their manure. Ellinbank dairy cows have been calculated to return 18 to 40 kg P/ha in dung annually. The phosphorus in animal manure is available for use by pasture plants, and has significant impact on soil chemical properties. The P recycled by decaying and un-utilised pasture was 15 to 28 kg P/ha pa.

Recycling of phosphorus from sewage sludge is very costly, but if it has to be done to reduce water pollution, then so be it.

Wash, waste & pollution

This has been mentioned above. Wash should be avoided at all costs because the world's P reserves won't last forever. Nauru Island's has finished and left the country poor, and New Zealand has to pay more from other sources further away. Some quote about 500 more years for those without too many contaminants such as cadmium, however, the increase in demand in 2008 caused a 30% increase in prices. The increase came mostly from developing countries, which are on the increase.

Wash into waterways is also a form of pollution, because it increases algal bloom and plant growth in waterways, reducing some species of fish and vegetation by clouding the surface of the water, and decreasing oxygen levels.

See Nitrates book - Trials on a UK lake divided in half by plastic sheeting showed that added nitrogen and phosphate grew a lot more algae than nitrogen only.

We've used and recommended slow release fertilisers since 1980s. RP is not water soluble so doesn't wash at all, unless with soil in erosion. It is also cheaper per kg of P and the best can include some salt and other elements. Sulphur usually has to be added to most fertiliser mixes, which should be done with pure elemental 100% sulphur which also doesn't wash or leach. These two won't work in other than acid soils. How acid, depends on the health of the soil. This is subjective. Healthy soils have at least 5% organic matter, at least 20 earthworms per 20 by 20 by 20 cm when the soils are moist, are free-draining with adequate air (not compacted), a pH somewhere around 6, with moisture, moist-soil organisms and close to an optimum mineral balance of Ca, N, P, K, S and trace minerals. Obviously levels won't all be perfect or fertiliser would not be required. A deficiency of one important element can cause a dead soil. Pasture tissue analyses diagnose deficiencies - and excesses that can be as bad. Soil analyses don't measure all 17 elements.

World fertiliser consumption has increased tenfold since 1930. The annual global production of phosphate is around 40 million tonnes of P2O5, derived from roughly 140 million tons of powder concentrate. Approximately 80% of the P used worldwide is in agriculture, with the balance divided between detergents (12%), animal feeds (5%) and speciality applications (3%).

Retention & Fixation

Research tells us that phosphate efficiency is relatively low in any agricultural system and that during the first year after application, only 15 to 25% of the phosphate is taken up by crops, as most of it is fixed in the soil and thus not available to plants. Much of the residue remains in the soil to increase phosphate reserves, but only a small proportion of each residual increment is available to subsequent crops.

These terms are misnomers because the P is not retained or fixed and not lost forever. I suggested to our AgResearch people several times over decades that they were confusing farmers and that "Initial P Requirement" which is a capital dressing, would be a better term because it indicates how much phosphorus is necessary for the soil microbes and to suppress aluminium, and leave some for optimum plant growth.

They changed the term to "High P Storage Capacity". However, this is still not exact and doesn't tell the farmers what they need to know, i.e., how much is needed as a capital (first) dressing to correct the soil deficiency.

They don't say what the levels of calcium are in pasture tissue. They might mention pH, but it is an old fashioned and horribly incorrect measuring system, with no relationship to accurate calcium levels. A beef farmer client, Barry Brunton, just south of Hamilton had relied on fertiliser companies for recommendations so had not applied lime for 40 years to a clay loam soil that NZ Department of Agriculture recommended three tonnes per hectare every three years (about one ton per acre every three years). This meant that it was 40,000 kg of lime per hectare behind. I got him to apply 3,000, then 2,500 then 3,000 kg per hectare in one and a half years.

So-called "P retention" is a problem in some acid soils and those with high aluminium levels. Aluminium reduces the availability of P. This would not be a problem if only farmers would apply simple soil science that I learned at agricultural college in South Africa in 1946 and has been written about in many books for 60 years, i.e., lime before fertilisers. Lime at the mine is worth only about $21 per tonne so lime companies can't sponsor researchers like fertiliser companies do, and can't have travelling sales people galore promoting it, so farmers have to sniff out information about lime.

Heavy clays and ash soils are usually worse than high organic, sandy, and pumices about retaining P.

After soluble P fertiliser (DAP, MAP, superphosphates) is applied and cultivated or washed in, most is immediately available to plant roots. With time (days to months depending on soils and growing conditions) the soluble P not used enters soil particles, and becomes attached, mostly to aluminium ions and to iron and excess calcium ions. It then become slowly available to plants. This occurs in most mineral soils, but less in high organic soils. P requirements in soils can be very high, but decreases as more P is applied to balance the **excess** aluminium (See Elements > Aluminium), iron or excess calcium ions that reduce the availability of P. Both low pH (under 5.5) and high pH (over 7) increase fixation.

Regular applications of even small amounts of soluble phosphate, or the steady release of powder phosphates, reduce the ill effects of soils storing P, but only after levels have been built up with an initial capital application - if needed. Half rates don't help grow much pasture because soil microbes use it. Once the microbes have enough and increased in numbers they start improving the soil, which then grows more pasture, and often more DM than nitrogen grows, and for a longer period. However it takes time. Steady continuous P supply, as is achieved with RP, as long as there is a bit of acidity (pH not above 6.3) and moisture, is, I believe, good for everything in the soil, i.e., microbes, earthworms, aluminium suppression, pasture rooting, pasture growth, as well as animal health, and is the cheapest form of P. It releases faster when mixed with elemental sulphur and chisel ploughed into the soil and when the soil has adequate organic matter.

Once P levels are optimum, annual P fertilising can decrease, based on how much pasture is leaving the paddock and not returning in animal manure. Once fertility levels increase, the only certain way to find out how much to apply to various soils under different rainfalls and stocking rates is by doing comparative trials on your farm. It was doing these trials that got me using up to three times more lime and fertiliser than recommended back in the 50's, and achieving highly profitable pasture production within a year, rather than not for several years, as happens with inadequate applications. Forty years later New Zealand AgResearch recommendations caught up.

The benefit of capital applications of P is not new. LJ Wild in 1945 explained it in his excellent book Soils & Manures in New Zealand (out of print), but it took about 40 years before most fertiliser researchers and advisers recommended the practice. Some consultants still don't.

Reasons for capital applications include -

- Soil microbes use most of the first P applied.
- P storage requirements decrease as the amount applied increases.
- High fertility grasses such as perennial ryegrass and white clover need optimum P levels to thrive.
- Clovers then make more nitrogen.
- Perennial ryegrass plants pulling out of the soil, which is accentuated by aluminium toxicity, reduces when P levels are adequate. Trials I did on several farms showed that it reduces more so when good RPs are used, rather than single superphosphate or any other water-soluble P.
- Insect damage of perennial ryegrass by Argentine stem weevil, grass grub, etc., is less devastating when it is growing well. The same applies to white clovers attacked by Clover Flea and Clover Root Weevil.
- A profitable return that is essential from high value land justifies capital applications of P (and other fertilisers).
- If applied in the best form which is the best RP in high rainfall areas and below pH 6.4 soils, it is like money in the bank, except that, as well as earning interest, it increases the value of your farm (because of its higher production level), giving capital gain.

P & Calcium

It was shown in USA before 1940 that in soils with low pH and low P levels, plants responded to P without lime, but not to lime when P is low; however, lime is still the first essential after drainage, but must be followed by adequate P soon after. They should not be applied together, because Ca slows the availability of P, but, if lime is chisel ploughed in deeply down to the subsoil or to at least 25 cm into deep and/or organic soils, as it should be, P can be applied immediately afterwards and cultivated in. If fertiliser is not cultivated in, and a fast growing crop is grown, yields on low fertility soils can be 25% lower than when cultivated in to at least 20 cm (8”) because the roots go down faster than the fertiliser moves down, especially if little rain falls. Where fertilisers have been applied and not cultivated in, and crops sown, followed by little rain, as is typical in late spring and early summer, crops have been poor, but not where soils were fertile. Excessive amounts of aluminium reduce the plant’s ability to access phosphorus. P and lime, especially when chisel ploughed in deeply, help overcome this.

More land almost free

P is such a powerful growth element that, if needed, it can provide more pasture and animal production for very little extra cost, above the fixed costs (including that of owning the land), and the soils, rainfall and pasture are appropriate, and the extra pasture grown is used.

On high producing land with good clover based temperate pastures, extra P can produce the equivalent of having 25% more land, worth $300/ha/year more, after a capital application at an initial cost of about $200/ha for about 100 kg/ha of P, plus any other elements needed such as cobalt, selenium, magnesium, etc. Annual applications are then necessary, costing about $100/ha for about 50 kg of P per year thereafter, until levels are adequate. All are tax deductible. No capital outlay is needed to buy more land, fence it, drain it, reticulate water and improve the pastures.

Fertiliser trials - Te Kuiti by MAF

These increases again show Sechura well ahead of other RPs. Pasture responses from the Te Kuiti trials, based on equal amounts of P and equal costs, were -

	/P	/$
Single superphosphate - control	24%	24%
Sechura	16%	24%
Egyptian	9%	14%
Nauru	8%	13%
Arad	6%	10%

Cost per kg DM grown - Te Kuiti 1995

	c/kg DM
Sechura	3.8
Gafsa estimate - about	4.3
North Carolina	4.4
Arad	5.6
Egyptian	7.5

I recommend that you do trials on your farm, but, if you use superphosphate or DAP comparisons on paddocks that have already had RP in the previous year, the results will favour the fast release fertiliser, because the RP will also continue to become available.

A VJ template adds up the amount of P applied minus production-based losses over the years. Many farms have been losing fertility since the late 80’s, encouraged by AgResearch’s low recommendations and farms’ low financial returns. Northland, NZ was a classic example. Northland farmers invited and showed the scientists that they were wrong. They then invited me to come and explain my natural practises with RP on pastures that I had used since 1952. Lime, serpentine and RP improve soils, increase earthworm numbers and microbes, while urea and superphosphate reduce them.

Taranaki NZ AgResearch

They are to be commended for the following and the many useful and practical trials they’ve done. The DM figures in kg/ha are from adjusted Taranaki AgResearch trials on mineral soils and show the increases from increasing fertiliser P.

To show the profit/ha, I added the dollar figures using $2/kg of P spread, $6.00/kg of milksolids payout including cull and calf values, land value of $35,000/ha, rates at $100/ha pa, cow value $1,500, annual costs to keep and milk a cow $634, and an interest rate of 9%. Costs were adjusted to start from the Control. The above figures are about double, but the proportions are about the same so still show the benefits of P.

Fertiliser P Returns

kg P/ha applied	0	12.5	25	50	100
DM yields in kg/ha	13,170	14,200	14,330	14,700	15,630
Net profit/ha	Control	$304	$321	$385	$579

Soluble in 2% citric acid

The NZ fertiliser industry standard for measuring phosphate fertilisers is by using 2% citric acid to measure the percentage of P that becomes available. In 1994 they were Sechura 37%, Quinphos 30% and Arad 30%. Unfortunately Gafsa the second best RP was not tested. North Carolina has been discontinued in New Zealand because of its high cadmium levels.

Get the figures from suppliers before buying. See Elements > Phosphorus.

Phosphate field experiment in North Taranaki by WMH Saunders

This showed that in spring pastures made effective use of P coming available in warming soils, irrespective of when fertiliser had been applied, and in autumn the pasture responded much more quickly to the immediately applied fertiliser. Further trials to try to discover why this occurred showed that phosphate was at its maximum in early spring, and minimum in summer. The high demand for P during spring growth can be met from mineralisation (being made available) of organic P over winter, when the low temperatures reduced plant growth and so the uptake of P. Fertilising to increase spring growth, rather than autumn growth, is negative because it grows surpluses of pasture, which have to be harvested to feed in late autumn. This does not apply in snow-covered areas, where winter feed has to be obtained from harvesting pastures in spring, and autumn fertilising is not done.

Animal Deficiencies of P

P is the second most abundant mineral element in bodies after calcium, accounting for more than 20 percent of the body's minerals. It is essential to all known life forms because it is a key element in many physiological and biochemical processes. A lack of phosphorus not only affects bone structure, but also appetite, growth and fertility. When pasture P is very low, animal health suffers. P is involved in energy metabolism and many other metabolic functions in the body. A phosphorus deficiency can impair energy utilisation, reduce breeding efficiency, result in decreased or depraved appetite (pica, which is the chewing of wood, bones, or hair), stiff joints, three day sickness also called stiff-sickness in South Africa, fragile bones, reduced milk production, and delayed rising again after curing a metabolic illness, Some say is caused by insect stings, which could be a double whammy syndrome.

P is a major constituent of bones, so plenty is required for growing animals. About 80% of the P in an animal is in the bones and teeth.

Vitamin D is necessary for optimum absorption and utilisation of P and calcium. Confinement farmers should give animals access to direct sunlight or vitamin D in some form. Calves deprived of vitamin D can develop rickets unless fed sun-cured forages. Some feed fish oils, but all now have high levels of heavy metals.

Where pasture P levels are low, and it is not economic to fertilise with it, P should be supplemented as a mineral, however, fertilising with P is important, especially for legume growth. As with many elements, P is better absorbed from forage than from mineral supplements. Also, animals prefer plants with adequate P, and will select pasture with optimum P and eat more of it. A main aim in pasture farming to get high animal production, is to grow highly palatable pastures to encourage high animal consumption.

Feeding excessive amounts of magnesium (50 grams/cow/day) lowers the P levels in the blood, so should be avoided.

Low P symptoms include -

- Slow growth of young animals.
- Poor and irregular cycling, poor conception because ovaries become hard and inactive.
- Stiff joints, lameness and even downer cows.
- Cows failing to get up after calving. Low zinc and/or low boron can also cause this. Dystocia difficult calving can be from an excess of phosphorus fed before calving. P is a major pasture growth element, so most farmers apply too much P fertiliser.

- Decreased appetite. Cattle will chew wood and eat dirt and other materials to try to obtain phosphorus.
- Poor health and unthriftiness, rough hair, slow growth.
- Milk yields can be low, and, if combined with high K, the possibility of nitrate toxicity increases.
- Low (< 3.5 mg/dl) phosphorus in blood plasma didn't reduce milk levels.

Deficiency symptoms can occur quickly. Deficiency is most common in cattle grazing pasture or fed crops grown on soils low in phosphorus, or in animals fed mature pasture or crop residues with low phosphorus content (less than 0.25%, dry basis). Non-specific chronic signs of deficiency can occur if protein is low.

Feeding 0.42 percent phosphorus in TMR to high yielding cows during the first 8 weeks of lactation maximised milk production and resulted in normal concentrations in blood serum (Wu et al., 2000). Milk yield of cows was highest with 0.40 to 0.42 percent dietary phosphorus. 0.50 to 0.52 percent didn't change milk yield in this trial, but lowered it in another. See Excesses of P below.

While low P can cause any of the problems above, feeding an excess will not improve these problems if caused by other deficiencies or excesses. Get all elements at optimum levels. The P to Ca ratio should be 0.6 to 1, although some say 1 to 2, however, ratios are not as important as correct optimum levels. If the N to P level is up around 12 to 1 then P is much too low.

A book has been written in USA on the benefits of feeding P to ruminants grazing pastures, but USA P fertilising of pastures are much lower than in New Zealand where higher animal production is obtained from pasture alone, i.e., no grains.

Animal Excesses of P

Water soluble P in DAP, MAP and superphosphate in that order can cause toxic P levels in pasture very quickly to adversely affect animals.

Symptoms of excess P levels include -

- Low magnesium uptake, increasing the likelihood of milk fever.
- Milk yield may not be affected by high phosphorus levels in the diet during the first month after calving, but from week 5 to 12, production was 8% higher on pasture with 0.4% P than 0.5% P (Carstairs et al., 1981).
- Hill Laboratory recommends between 0.4 and 0.5%, when it should say very close to 0.4%.
- Dystocia (difficult birth) can be from an excess of phosphorus fed before calving.
- Very high P levels reduce copper uptake. Water soluble P such as superphosphate, and more so DAP and MAP, can increase pasture levels to above 0.6% for short periods which is very toxic which can cause calves to suffer, scour and even die. The optimum in ryegrass and clover is 0.4%.

Some seasonal dairy farmers seek my help a few months after calving after cow health suffers, I've traced to soluble P applications in early Spring. Cows on Bill Chynoweth's farm that never got artificial N (except for new pastures after crops which deplete N), would not eat pasture on a paddock that he had given some left over DAP from growing maize.

Boron reduces the ill effects of high P, but no scientist* recommends boron because no fertiliser company has sponsored research on it. A Walton, Waikato, boron trial by Ruakura was a disaster. See Elements > Boron. There have been many fertiliser company sponsorships on P, but almost none on Ca.

* Most of today's so called scientists do no useful original or corrective research, but write articles galore based on having a swag of references to quote, many of which have been superseded, or found incorrect by practical people, for example 'not applying lime to peat soils', which was incorrect in 1955 when I proved it wrong, and is wrong now.

Blind faith is an unpardonable sin. When what you see happenings on your farm that are different to what science says, believe the evidence, not the so-called science, which is seldom 100% right for long.

Soil & Pasture Deficiencies of P

There are many soil test systems available for phosphorus such as Olsen P, Bray I and Bray II, Mehlich I and Mehlich III, Morgan, Saturated Paste, and Resin. Over the years some of us and soil scientists have been unhappy with soil tests so new ones have been developed. Pasture tissue tests are more accurate than soil tests, more reliable and easier to use when calculating amounts of P to apply as fertiliser. With pasture analysing, there is only one system and one standard. There can be variations between laboratories, but if the same one is used, users will set their standards, based on pasture and animal results.

P deficiencies can cause -

- Low pasture production.
- An excess of Mg, Mn and/or Fe lowers the absorption of P. Feeding excessive amounts of magnesium (50 grams/cow/day) lowers the P levels in the blood, so should be avoided.
- Soils under high rainfall and/or irrigation where pasture yields are high, and where artificial N is applied and mechanical harvesting is done, run out of P more quickly than lower rainfall areas, and/or where grazing is done.
- In vast extensive low rainfall areas fertilising with P can be uneconomic, so, if necessary for animal health, it may have to be fed. See Minerals - Feeding.
- Seed germination of many plants, especially clovers and the higher fertility requirement species such as the temperate grasses, is decreased when P is low.
- Nature is wonderful in that there is no sense in plants germinating and then competing for deficient nutrients to the extent that they die. To overcome this it is better to apply less seed and more P. One kg of white clover per hectare is 150 seeds/m2, so why apply three kg/ha? 10 kg/ha of perennial ryegrass is 500 seeds/m2. Spending less on seeds and more P and/or lime as needed, gives better returns.

Pasture growth can be severely restricted when P levels are low. It is a major cause of the death of high fertility plants in droughts, partly because root growth is less and not as deep when P is lacking. Aluminium in soil can stop ryegrass roots going down. Adequate Ca and P reduce this problem. Most of animals' unabsorbed P is excreted in the dung. I've seen perennial ryegrasses in dry weather thriving around gateways, camping areas and water troughs, where extra dung has been dropped, whilst in the same paddock dry weather killed perennial ryegrass because of low fertility levels. It is now recognised that adequate P gives increased growth in dry weather. Correcting levels can give highly profitable returns, especially when sulphur, boron and calcium levels are correct.

When P is deficient, pastures are sometimes darker green and ryegrass leaves become a brown/maroon as shown, and clover leaves have black spots going right through them as shown. Spots under clover leaves and not going through, indicate low potassium. Low temperature increases the ryegrass brown/maroon P deficiency symptoms and slows pasture growth. When phosphorus is low, the response to potassium is reduced, so increasing K can achieve little response. Low P with high K increases the nitrate toxicity effects on susceptible animals.

Excessive amounts of fluorine reduce plant's ability to absorb phosphorus.

Fertilising with reactive phosphates (Gafsa and Sechura) is best done before wet periods, and must be with very fine elemental sulphur to make P more available more quickly.

Lowering the organic matter content of some soils by cropping, especially with maize, can lower P levels, to the severe detriment of subsequent pastures, unless 100 kg or more of actual P is applied at sowing the new pasture, and again every six months until the pasture tissue levels increase again. See Forage Crops > Maize.

Humus (decomposed organic matter) reduces P fixation in soils and makes P more available, so is important. LimeMagPlus helps achieve this by increasing humus partly through increasing earthworm numbers. Maize growers should apply poultry or animal manure, **especially** before growing ryegrass after maize, because ryegrass has to have humus to reduce pulling out and dying. Read Calcium in Elements.

Soil & pasture excesses

An excess of P lowers pasture production and Al, Ca, Cu, Fe, K, Mg, Mo, Zn. Calves scour and some have died. Cu reduces the bad effects. The percentages of P are higher in the growing parts of pasture (leaf tips) and in late autumn and in winter in winter rainfall areas.

Excesses can lower animal uptake of copper, calcium, zinc, magnesium, and, with high nitrogen and high potassium, can accentuate nitrate toxicity. P toxicity is more likely to occur where iron is low. High phosphorus and/or low calcium and selenium can encourage grass staggers.

Fast growing conditions and too much phosphate or nitrogen, keep leaves in an immature (lush) state with a poor nutritional balance, which is not what is required for animal health and production, hence the increase in metabolic problems when these conditions prevail.

High rates of soluble phosphates make iron less available to plants (and so to grazing animals). This can happen in both acid and alkaline soils. It is more common in sandy soils, because clay soils fix more of the excess soluble phosphates within weeks.

Plants have varying levels of the various elements in different parts of the leaves, stems and seeds. For example leaf tips have more P, but less Ca, so if only the tips of leaves were collected, P could be inaccurately high and Ca inaccurately low. Sampling very short pasture where only leaf tips can be collected would do the same, so, if done, allow for it when reading the figures. At seeding, many leaf P levels drop as the elements move to the seed, because the leaves have finished their job and are ready to die. The percentage of P is also higher in autumn and winter.

Excessively high P levels in soils lowers calcium, zinc, magnesium and copper levels in pasture.

Sources

There are many forms of P fertiliser with levels of from 1 to 30%. Only the worthwhile ones will be mentioned.

Reactive phosphate (RP) also known as reactive phosphate rock, but it is a powder mined and imported to New Zealand, and has between 11 and 14% P, depending on its source.

Nearly 90% of the world's estimated phosphorus reserves are in five countries: Morocco, China, South Africa (slow release), Jordan, and the United States (North Carolina RP was discontinued in New Zealand because of its very high cadmium levels.

I first learned that RP grew grass well when I used Langfos RP on Ronpha grass near Greytown, South Africa, in 1952 and was astounded at the long lasting growth achieved. The trial was an accident when staff applied all the Langfos to half the area, so half got what I thought was too much and half got none. At the time hardly any grasses in South Africa were fertilised, so the mistake ended up a useful comparison. The area had previously been cropped so had received fertiliser. The extra RP paid for itself many times over. When calculating fertiliser requirements and costs, use the cost figure after tax, because fertiliser is tax deductible.

Many things are learned by mistake, so when mistakes occur look at them to see if they can be turned into an advantage. If you have a positive outlook you will do so automatically, without having to say to yourself “When I get time I had better think if I can benefit from this.”

Reactive phosphate (RP) fertilisers

These are sold as a powder from phosphate deposits. Some are ground and some are washed. All can have other elements added to give a balanced fertiliser. Fineness of the RP varies. Use only fine ones which should look like pepper, not sand. The coarse parts of some can take up to 40 years to become available (MAF figures). As well as being fine they should be soft and available.

Sechura RP is from a mine in Peru, where it was apparently once under the sea so is a marine product with a high salt content. It contains molybdenum so can help where this is low, but should not be used for too many years in succession where it is too high.

The important thing is to have a complete analysis of the RP to compare it with your pasture analyses to avoid excesses, and to use the RP containing the elements you need.

Don’t use RP on its own where soils are dead, i.e., lack earthworm and microbe life, have a thatch layer on top and are packed tightly so not ‘living’. A spade will show what I’m referring to. Get pasture growth going with half RP with S, and half single superphosphate or DAP if nitrogen (N) is needed. Dead soils usually need calcium to help decompose the thatch, encourage soil life and get everything going. They also need sulphur. Single superphosphate has calcium sulphate (gypsum) and sulphur, both in water-soluble forms that leach down through soils, whereas reactive phosphates and elemental sulphur don’t. They have to be acidified by the soil, taken down by earthworms, or cultivated in, if soils are dead, usually caused by insufficient lime, too much urea, too much chemical spraying, repeated harvesting mechanically and feeding elsewhere with no animal manure being returned, and other bad farming practises, such as pugging, mouldboard ploughing, shallow cultivation instead of chisel ploughing.

Dead soils are likely to need earthworms, but these won’t thrive before the LimeMagPlus has had time to work, which it can do in a month of rain or irrigation.

Some hard and/or coarse mined powder phosphates are not reactive, sometimes even if advertised as reactive. These need treatment with sulphuric or phosphoric acid to make them into superphosphate.

One North Island fertiliser co-operative stated in their autumn 2005 newsletter that RP’s didn’t work in peat. When I questioned them they acknowledged that elemental sulphur (S) had not been included with the RP use - it was not a trial, but a search for propaganda to attack it. How pathetic! They must know that P and S are synergistic and that the S makes the RP more available, but slowly, which is the best way. I repeat, that they were obviously discouraging the use of reactive phosphate, because they wanted to keep their superphosphate factories going. Pastures can’t use all the water soluble P available in single superphosphates (Sulphuric acid treated) before it is leached, taking other elements with it. The almost 100% national lack of calcium in New Zealand soils, partly because of relying on soil testing, accentuates soils’ low organic matter and leaching.

Some might be cautious about using reactive phosphate because of the poor results some had with “Longlife” fertilisers. The fertiliser companies that used soft fine RP’s, Longlife was reasonably successful, but where they used hard, coarse, phosphates that were not even reactive, Longlife proved a disaster. Some so called RP’s are not as reactive as the best.

AgResearch trials and figures show that coarse granules as in Quinphos can take up to 40 years to become available. Fine, pepper-size grains, if applied with fine (not Ravensdown granuled) elemental sulphur can be used by soil microbes and plants within weeks. Pasture growth responses even on peat farms prooved this.

The mix was -

	kg/ha
Gafsa reactive phosphate (0-13-0-1)	1,079
Fine elemental sulphur (100% S)	15
Muriate of Potash (0-0-50-0)	50
Ulexite (now slow release OrganiBor) (10% boron)	10
Copper Hydroxide lump free 24% Cu	5
Salt (coarse agricultural)	30 (plus the 1.6% in Sechura or 1.2% in Gafsa)
Selcote Ultra slow release selenium (1% Se)	1
Total	**1,200**

The first point to remember is that RP’s can be as different as different waters - rain water, sea water, peat water, etc. As recently as 1992 a Ruakura “scientist?” wrote in a farming publication that all RP’s are equal.This was despite MAF research and field trials having shown that Sechura RP is twice as reactive and effective as Arad, which AgResearch have listed as an RP. This is ignorance, especially seeing there is little difference in prices between the best and the worst of the reactive ones. Coarse nonreactive ones are cheaper. Use the best RP, which trials and farmer results show is equal to single superphosphate (0-9-0-11) if spread at correct rates with elemental sulphur in optimum conditions, while the worst RP (coarse and/or hard and slow release) can mean a 40 year wait for all the coarse particles to become available to plants.

If, say, when 700 kg/ha is needed on a farm, but only 200 kg is to be spread for financial or other reasons, then triple phosphate is better, but, with today's land costs, limiting fertilisers is unprofitable.

Dozens of comparative fertiliser trials have been done in New Zealand and overseas. All I know of have been on an equal P basis, which favours single superphosphate that is 30% to 40% more expensive per kilogram of P. I believe that they should have been done on an equal cost basis to give a useful result to farmers. The National Trials New Zealand wide, Nelson, and Winchmore Irrigation Research Station ones, if corrected to a cost basis, all showed that Sechura outperforms single superphosphate in the first and subsequent years. I don't know of a single trial with acid soils (pH not above 6.5) and adequate rainfall that shows otherwise - on a cost basis. Summaries of many trials, but not Winchmore's, are often biased, to say the least, and don't reflect the facts. Many start on very low P soils, so favour water soluble fertilisers. If your soil is very low in P, start with a mix half water soluble and half the best reactive phosphate. If chisel ploughing after applying the RP, the thorough mixing will help make it more available sooner. For evidence of this look at the photos of maize in this chapter and the fact that in one year the three best crops I saw in the Waikato all did it with RP.

Good RP's work best in 'live', slightly acid soils where the pH is 6.3 or lower (the lower the better for acidifying RP, but not for earthworms and maintaining selenium levels), and rainfall is 800 mm or more. RP's don't work in dry dead soils, even if acid. A dead peat is one that has not been correctly drained, limed, fertilised and cultivated, so is compact lacking earthworms and soil bacteria and not growing much.

A major cause of K leaching in NZ is the use of single superphosphate with its 11% sulphur which leaches and takes K with it. Thank goodness single superphosphate and its mixes (15% potassic super and 30% potassic super) sales in NZ have dropped from 90% of all fertilisers to 30% and reactive phosphate sales have increased substantially. Even the 800 ha (2,000 acre) Whatawhata Hill Country Research Station has used RP since about 1995. Top farmers have since the 1980s.

Analyses of the two best RP's available in New Zealand in 2006

Sechura from Peru (Not always available.)

%	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	pm	ppm
P	K	S	Mg	CaCO3	Ca	As	Al	Cd	Co	Cu	F	Fe	Mn	Mo	Na	U	Zn
13.1	0.01	1.60	0.32	33.4	13.6	5	0.36	11	3	6	3.4	0.32	91	30	1.6	72	178

Gafsa from Tunisia

P	K	S	Mg	CaCO3	Ca	As	Al	Cd	Co	Cu	F	Fe	Mn	Mo	Na	U	Zn
13.4	0.18	0.80	0.25	35.3	14.3	4	0.24	23	3	15	4.1	0.18	7	<5	1.2	88	393

The following are the international abbreviations for minerals.

As	Arsenic
Al	Aluminium
B	Boron
Ca	Calcium
Cd	Cadmium
Cl	Chlorine
Cr	Chromium
Co	Cobalt
Cu	Copper
F	Fluoride
Fe	Iron
Hg	Mercury
I	Iodine
K	Potassium
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
Na	Sodium

Ni	Nickel
N	Nitrogen
O	Oxygen
P	Phosphorus
Pb	Lead
S	Sulphur
Se	Selenium
Si	Silver
Zn	Zinc

Soil Phosphate Trends

Superphosphate use since the 1980s has increased by about 100% and DAP use has increased by 550% over the same period. Other phosphate fertilisers annual application of close to 200,000 tonne/year adds up to a grand total of more than 1.5 million tonnes of phosphate fertiliser applied to NZ farms per year.

With the recent huge price increases in phosphate fertiliser cost, it is appropriate to review some statistics to see how sustainable the recent application rates of phosphate fertiliser have been. There is ongoing concern over the environmental effect of excessive fertiliser application, and now there will be real economic concern about the affordability of phosphate fertiliser at high application rates.

A reality check on attitudes to phosphate fertiliser –

If your soil P test result is high (substantially above the target Olsen P 20 to 30 for most soil types), is your advisor prepared to recommend no fertiliser P application?

If your soil pH is adequate (around 6.0) does your advisor recommend no lime application?

The normal answer to ‘1’ is very different to the answer to ‘2’ for the vast majority of fertiliser advisors/reps, when there is a compelling reason to apply both phosphate and lime to achieve and maintain appropriate (but not excessive) soil P and pH levels. It sounds as though you are saying that if an Olsen P is above 30, P and lime should both still go on??

OK, so the fertiliser industry has a very strong focus on P fertiliser – where has this got NZ farmers to?

The best information available has been published by Environment Waikato, who make the statement based on comparing data from 1988-1996 to data from 1997-2001:

“Phosphorus fertility on dairy farms is near the maximum for a high producing farm – many soil samples from volcanic and sedimentary material show excessive phosphorus fertility.”

OK, so what were the numbers?

	High or excessive P	**Optimum P**	**Low P**
1988 to 1996	49%	20%	31%
1997 to 2001	75%	15%	10%

There is no data reported for 2002 to 2007 yet, but statistics record that annual fertiliser P applications during these 5 years have been at an all time high. Therefore the proportion of samples that will be rated as ‘high or excessive’ is most likely to have increased.

Based on the Waikato information (this is likely to apply to other pastoral farming regions also), a large proportion of farms have excessive soil P levels. Spels indicates that the sudden increase in fertiliser P cost may not be all bad if it makes farmers re-assess their fertiliser advise and how their budget is spent. There may even be environmental benefits from a change in P fertiliser use.

Quotes from Statistics NZ ‘Agricultural Production Census’, Environment Waikato ‘Fertiliser use on Farms’.

23 Reactive phosphorus (RP) questions & answers

RP is short for reactive phosphate powder, and PP for phosphate powder which is not reactive in normal soils. Reactive means that it is soft and fine, and will react with the acid in the soil, and become available to plants under favourable acid and moisture conditions within a reasonable time of a few years. RP's vary from the consistency of pepper to that of coarse sand. Obviously the finer it is the faster it will become available to plants. Trials have proved this and that the RP has to be soft to be reactive. Hard Nauru PP ground fine didn't respond as well as the softer RP's.

The following are my answers to questions and statements made about RP's.

Q1. We are told that only a third of RP's are available in the first year. Does this mean that pasture growth will be only a third of that from say single superphosphate?

A1. No. There will be residual P from whatever P was previously used, because none, not even superphosphate or Diammonium Phosphate (DAP) is all used in the first year, and some will be circulating in the pasture and animal cycle (dung). It also depends on which RP is used (fine soft ones such as Sechura and Gafsa are more quickly available), the amount of rain, the soil pH (acid soils break it down faster), and the amount of soil life - earthworm casts covering the RP will give it closer contact with the soil. Dead, poorly drained, pugged, inert soils take longer to make the P become available, because these soils have little soil life. Until fixed they will need water soluble P.

Averages of many equal P trials across the country show that pasture growth from Sechura RP is only 5% lower than that from single superphosphate in the first year at a 20% less cost. Sechura first year growth is about equal to that from serpentine single superphosphate and/or reverted single superphosphate. Reporoa pumice soils and Northland clay soils achieved a $26/ha/year saving by using Sechura for about the same pasture growth. In the dozens of trial figures I have seen, Sechura was best on a value for money basis. If not available, Asura is the next best available in New Zealand.

Q2. Is it true that RP's take 5 or 6 years for all to become available to the plant?

A2. It depends on which RP, but nor is superphosphate all used in the year of application, and some superphosphate could still be in the soil and/or system (recycling) after six years, depending on the soil type, rainfall, amount applied, pasture grown and phosphate fixation. This question comes about from statements made by those with vested interests, including some researchers who are not prepared to even read all the New Zealand and overseas research results of RP trials. Their loyalty to superphosphate manufacturers causes some of them to bundle all RP's together, which reveals their bias. There have been so many RP trials in New Zealand now that most researchers are having to acknowledge its benefits, but in October 2005 a fertilisers co-op publicised a trial set out to try to prove that RP didn't work on peat. I phoned them and they agreed that RP had been applied on its own without S - how deceptive.

The P in Super can't all be taken up by pasture as water soluble P in the time it is available as such. The surplus is fixed to become available at about the same rate as the best reactive phosphate. If all superphosphate were taken up by pastures (or washed or leached) in the first year the Olsen P level would not increase.

If 50% of P in 900 kg/ha (7 cwt) of superphosphate is used in the first year, it will provide half of 78 which is 39 kg of P per hectare. If only 33% of Sechura P is used in the first year it will provide a third of 117 which is 39 kg of P or about the same as Super. There will then be 78 Sechura P left, but only 39 P from the Super.

Some researchers have claimed that the water-soluble phosphate, as in superphosphate and DAP, can become totally fixed and lost forever, however I find this difficult to accept. Scientists from several countries have claimed that 50% of water soluble P, as in Super, can be bound in some soils within 10 days of applying, and then, like RP, become available over years - depending on the soil condition.

DAP, MAP and superphosphate are highly available (in the order listed) at the time of applying, but all P can’t be used instantly by pasture, so, being water soluble, some is washed down slopes or into cracks, drains and waterways, a little is leached, and some is fixed in the soil. It is just as well that some water soluble P is fixed, otherwise more of would be lost forever by washing and leaching. What is fixed becomes available over subsequent years at rates that depend on the soil type, P level, aluminium level, and other activities such as lime applications. It is the fixing that builds up the P levels in soil. How else does it build up?

Because RP’s cost less per unit of P, about 40% more P can be applied for the same cost, depending on how much sulphur (S) is required. Even with added elemental S, RP’s can provide 30% more P for the same cost. This higher P in RP’s (13% compared to 8.7% in single superphosphate) is one reason why Sechura has given virtually the same growth rates in the first year on many soils when calculated or applied on an equal cost basis (farm trials). It subsequently gives better growth and vastly improved soil and animal health.

Single superphosphate includes 11% sulphate S which is frequently more than is needed and is water soluble, so washes, leaches, and lowers copper and selenium levels for a period, after applying at rates of 500 kg/ha or more. Elemental S is usually the type mixed with RP’s. It is much better value in that it doesn’t create excesses or depress other elements, and doesn’t wash or leach.

One dogmatic retired farmer criticised Sechura to me because he had tried it and got no response. He did not apply sulphur with it and his soils were poor and partly dead. Hungry, poor pastures on dead soils need some quick release P together with the best RP. Poor pastures also need N so DAP is usually the best to apply with the RP. For 'live' soils see Soils > Calcium, Earthworms, Draining, Cultivating and other parts of GrazingInfo.

Q3. My soil pH is above 6. Does this mean that RP’s will be no good for my soil type?

A3. The claim that RP should not be used in soils with a pH above 6.1 (previously 5.9) is questionable and is promoted by fertiliser companies, not farmer users who have succeeded with it. . Trials on pumice (pH 6) and yellow-brown loam (pH 6.3) before 1982 (Dr Bill Saunders & Dr Sunder Rajan, NZ Journal of Agriculture, March 1982) showed that mixing Sechura with elemental sulphur gave equal or slightly superior results to single superphosphate in the first year. AgResearch trials in Puketona in Northland (pH 6) gave annual savings per hectare of $18. Dr Rajan also pointed out that by using reactive phosphate with elemental sulphur NZ-wide savings on many soil types with pH below 6.3 could total between $15 and $50 million a year, compared with using single superphosphate.

Some farmers have achieved good yields from using Sechura or Gafsa on soils with a pH of 6.5 and Massey University soil science department quoted under 6.5 (pH 7 is neutral) in 1996 as being suitable for good RP. There is more than pH that determines whether RP will be available to plants. It won’t work in pH 5 if on a dead soil, but will on pH 6.5 in a live soil teaming with earthworms.

A 1965 AgResearch trial on a farm with pH 6.3 and 1,300 mm (52”) rainfall gave 95% dissolution in the first year.

Keep calcium and selenium levels at optimum. Selenium is more available at soil optimum pH levels of 6.2 or above. The days of pH 5.8 through a lack of lime have gone, and anyone not recognising this is not doing as well as they could and the soils, earthworms and animals are suffering unnecessarily, and it is a disgraceful shame. Reactive phosphate still works well at pH 6.3 in live soils containing active earthworms and soil bacteria, but doesn't work on dead soils at pH 5. See Elements > Phosphorus.

The figure of pH 6 is used as a conservative, cautious guide, but it doesn’t mean that at 6.4 no RP will be available for plant growth. However, release could be a bit slower, depending on factors in A1. Healthy active soils (high earthworm and soil microbe numbers), even if the pH is higher, will break down RP’s faster than low pH soils that are dead, which show as hard compact lifeless soils rather than soft friable ones.

Most plant roots emit an acid from their leading tips. This is how some plants can move through soft rocks and concrete. This acid can also make P available.

The decision depends on existing P levels, rainfall, earthworm activity and soil life, and your requirements, i.e., immediate pasture growth or long-term animal health and eventual higher production per dollar spent. If rapid growth is required as soon as possible and the long-term benefits of RP are also required, then in the first year apply half triple superphosphate and half the best RP with between 10 and 20 kg/ha of elemental sulphur.

Q4. I have pumice soils and have heard that RP's are needed at rates of 3 to 5 times that of single superphosphate. Should I continue using single superphosphate?

A4. No. For every one person selling RP's there are dozens selling superphosphate, DAP and now MAP. Most of these attack RP's with all sorts of wrong and biased statements. Remember in life to always identify the source of statements you are considering. Brand Y sales people will exaggerate the bad points of brand Z, and vice versa.

Trials comparing Sechura RP with single superphosphate on pumice soils at Waikiti Valley, near Reporoa, showed that $28 was saved annually while achieving the same pasture growth. Many pumice and other farms are benefiting from using the best RP.

Q5. I am told that RP's are no good if you want a quick response on soils with a low phosphate status. My soil tests show an Olsen P of between 7 and 10. Am I better to use Super or DAP?

A5. DAP has highly available P and nitrogen, but no Ca, and has to be applied several times a year because it washes, leaches and fixes. Most soils require sulphur so DAP on its own can cause a drop in sulphur levels. Adequate rates of the best RP with elemental sulphur on live soils have increased pasture growth substantially within six weeks. David Webb (Wardville loam) had his Olsen P rise from 8 to 18 after 4 years of using Sechura (the most available RP, but not always obtainable) reactive phosphate. Gafsa is the second best and is cheaper so better value.

Q6. My soil has a high phosphate retention. Are RP's any good on these soil types?

A6. High P retention indicates high aluminium and/or high iron, so more P (capital application) of whatever type of P must be applied before adequate amounts are available to plants. Correct liming also reduces the problem slightly. RP's give more P per dollar and have about 33% calcium carbonate which is 57% more than in superphosphate. Some Ca with all phosphates is essential. Cows have died where DAP has been applied (especially with K) without Ca or where Ca was low.

Q7. I was told that RP's are difficult to spread and don't spread as evenly as single superphosphate.

A7. Again this is sales talk. Pilots have been pleased with the aerial spread of RP's, and any good spreader will do a good job of spreading both fine and coarse RP's. In most cases superphosphate spreaders travel too far apart, resulting in the fines dropping in close and the granules giving the appearance of a wide coverage. If trace elements have been mixed with superphosphate after granulating and the spreader travels too far apart, they will not be spread evenly. The sodium in Sechura attracts moisture, more so if coarse agricultural salt is added and most soils need salt, unless on the coast. The extra milk production achieved from supplying salt to cows on pumice also applies to peat (DRC trial) and low sodium soils. The best RP sticks to the salt, and when slightly damp it spreads better.

Q8. I was talked into using Longlife superphosphate and it was a disaster. How is Sechura better?

A8. Longlife superphosphate took off with a hiss and a roar, promoted by the manufacturers and by AgResearch. Many farmers after using it for a number of years stopped, showing that it had a problem. Some companies stopped producing it.

Longlife Super was a mixture of 70% single superphosphate and 30% RP, with the aim of overcoming the sudden high availability of phosphate and sulphur from straight single superphosphate, and aiming for a longer more steady release of phosphorus.

The failure of some Longlifes in the field led to investigations. One thought was that the sulphuric acid used in the manufacture of single superphosphate took the line of least resistance, so worked on the softer RP and left the harder one used in manufacturing superphosphate un-acidified, so unavailable for up to 30 years. This length of time depended on the qualities of the phosphate rocks used, which is usually the cheapest. Another comment was that the RP used was not a true RP, but a slow release one like Arad. It must be mentioned, however, that Longlife fertilisers from some companies worked well.

Many farmers have found that the best RP and elemental S have given far better results than Longlife, sometimes because one can’t guarantee which RP was used in Longlife. Mixing elemental sulphur with the best RP is making your own superphosphate which works almost as well as superphosphate, but without its problems of the sulphuric acid also making mercury, cadmium, manganese and aluminium available, which then gets into the plants, animals and the eventual consumers, causing bad health problems.

Q9. If the Olsen P test can’t measure RP levels accurately, what can?

A9. The Olsen P test is not even accurate in measuring soil P when superphosphate is used, especially on high organic soils, and soil tests can’t measure sulphur, potassium and trace elements accurately. The Resin soil test is slightly more useful, but on one peat farm one paddock measured 21 while another, fertilised identically for about ten years, was 30. Also some completely unrealistic Resin P figures have occurred, such as 90 on dry raw peat drain diggings growing only weeds because pasture would not grow there (Retired LIC consultant‘s findings). Analyse the pasture tissue (leaves) and use a specialist who recommends and knows pasture testing, not one who has no experience in it. The Winchmore soil and pasture comparisons from the same paddocks show how variable soil testing is, and how consistent pasture tissue analysing is.

Q10. Can RP be used for forage crops?

A10. It depends on the conditions and the quantity of RP to be applied. Small amounts, No. Correct amounts, Yes. On peat and pumice, Yes. On high P soils, Yes, on low P soils with high pH, No.

For crops, chisel ploughing RP to at least 30 cm on mineral soils and deeper on peat is essential. Don’t broadcast it on top and leave it there. When summer crops are sown, rainfall is usually low and decreasing in Winter rainfall areas, and the crop roots penetrate the soil rapidly. All fertilisers give much better crops if chisel ploughed in.

In 1992/93 three of the best maize crops in the Waikato were all grown by my my clients (Craig Clausen on peat near Gordonton, Colin Marshall on clay near Te Awamutu and Bill Chynoweth on loam at Pukeroro near Cambridge) with Sechura and trace element mixes at 1,000 to 1,200 kg/ha chisel ploughed in. Bill Chynoweth grew maize crops of 33,000 kg/ha using Sechura mixes and 100 kg/ha of DAP as a starter (See Forage Crops > Maize for full information). Wintering and/or feeding out on the paddock, or spreading effluent or poultry manure can save needing DAP.

After I resigned from consulting in 1995 because of suffering from gluten for seven years without knowing the reason, Bill used an establishment type consultant and yields dropped to 24,000 kg in a better rainfall year after he went back to a single superphosphate mix, losing over $800/ha.

Some summer forage crop failures have been because of not chisel ploughing the fertiliser in. See Forage Crops > Maize and Cultivation.

Q11 Are RP’s liming in action? How do they compare with single superphosphate in this respect?

A11. They are not liming when compared with agricultural lime which has up to 97% calcium carbonate, but they are when compared with single superphosphate, because RP’s have about 33% calcium and carbonate, single superphosphate has less calcium and no carbonate, which is the item that raises the pH. In trials over six years the pH in the RP areas didn’t drop, while it did drop in the single superphosphate areas. The true liming effect of a good RP can be up to 50% of its weight, thanks to the dissolution of the apatite mineral. Elemental S that is usually needed with RP has a slightly acidifying effect on the RP and the soil.

Fertilisers like single superphosphate and DAP were developed in the northern hemisphere for their generally higher pH soils. New Zealand soils are almost all acid. It has been estimated that 1.8 million tonnes of lime is required each year, just to maintain New Zealand soils' pH levels. Nowhere near this is applied. The use of RP's reduces this figure slightly and saves farmers money, and improves soil and animal health.

Q12 What is a P responsive site compared with a non P responsive site?

A12. If the P levels are low, pasture growth is usually low, and will respond to the application of fertiliser P. If the P levels are high, or soil is dead, little response can be expected, so the soil can be called “Non responsive”.

Q13 I have heard that the better response from Sechura is due more to the molybdenum it contains than from the phosphate.

A13. This statement was included in the National fertiliser trials report at the insistence of one person who would not accept the fact that Sechura, when compared with superphosphate, gave only 4% less growth in the first year, and at 20% less cost than Super. In the second year yields were equal. This went against all previous RP statements - not against RP trials, because there hadn’t been any. So he insisted that it must be the molybdenum in Sechura that helped.

I questioned two scientists involved in the trials, and asked if pasture molybdenum measurements were taken before the trials started. They confirmed that they were, and that the levels were adequate, or were corrected, so the molybdenum benefit claim either shows that the AgResearch optimum molybdenum figures are too low, or that it was not the molybdenum, but the simple superiority of Sechura that is incidentally a marine fertiliser with many elements from the sea.

If all the trials, soil types, molybdenum levels and evidence of Sechura producing more pasture even on high molybdenum soils, are studied, it is obvious that Sechura gave good yields and has something extra that most fertilisers don’t have. The salt in Sechura is obviously beneficial, as many farmers now fertilise with a little salt, which helps with lime to reduce the leaching of K and S (Indian, Australian and Massey trials). Calcium and salt help soften ryegrasses, which makes them less prone to pulling and more palatable, so animals eat more.

Q14. Why is RP so frequently recommended for hill country?

A14. Water-soluble fertilisers “wash” off hillsides. RP’s don’t, except under soil erosion, which is not common in well-farmed pastures. Wash can be seen on many hills by the fact that the flatter areas on hills sometimes grow more pasture than is grown on totally flat paddocks, while the steeper slopes around the flat areas grow little. Livestock camping on flat areas further increases the gain in fertility on flats on hill farms. This can happen to the extent where pasture on flat areas can become unpalatable. For these reasons, flats, around gateways, and around water troughs, should not be fertilised. However, they should be limed, or chickweed can take over.

Knobs on flat peat paddocks can be less productive because soluble fertilisers have been washed to lower areas, and similar fertiliser losses can occur if heavy rain falls after it is applied to paddocks with cracks.

Also hill country farmers have lower incomes per hectare, so are more thorough at saving costs.

Q15. Why was Sechura used for most fertiliser trials?

A15. It is recognised in New Zealand (when available) as the best RP in that it is the finest and the most plant available and has very little cadmium and arsenic. Sechura also has the most magnesium, the most sodium and the most sulphur. Applied with fine elemental sulphur it is as fast as equal cost superphosphate in most NZ soils even with pH 6.3. The currently available Gafsa reactive phosphate is almost as fast. I and dozens of farmers have achieved much higher yields of maize with lime chisel ploughed in, than those using superphosphate.

Q16. Can it poison stock as is done by some fertilisers?

A16. As with all fertilisers and limes, it should be well washed off leaves before grazing. To my knowledge, and that of Asura, the importer distributor, there have been no cases of livestock poisoning reported from grazing Sechura fertilised paddocks, whereas every year animals are killed from grazing superphosphate and some other fertilised pastures. However, if elements are added to the reactive phosphate then anything could happen, for example salt would make it more attractive to eat, especially if the animals were salt deficient, as is the case in a high percentage of New Zealand animals. Excess consumption could then affect them. Stock deficient in minerals can gorge any fertiliser. Too much of anything can kill, even salt. Most poisonings of animals are caused by fluoride in some phosphates, so some companies remove some of it.

Q17. Are there cost benefits in using the best RP's?

A17. Yes. Major fertiliser cost savings can be achieved - $20,000 a year in the case of the 1992 King Country NZ Fieldays Beef Farmer of the Year. It has been calculated that using the best RP instead of superphosphate for all suitable soils could save New Zealand farmers $50 million every year. The amount of fertiliser necessary is less, because RP's have about 13% phosphorus which becomes available, instead of under 9% in single superphosphates, some of which is lost through wash off hills, dry peat knobs and into cracks, leaching and fixation (DSIR Kaikohe, Massey and Australian research).

Moreover, it is easy to add only the required amount of elemental sulphur to RP's, whereas single superphosphate already contains 11% sulphate sulphur. This is all water soluble, so washes and leaches, taking other elements with it (Two Massey trials).

Q18. Should I apply straight Sechura?

A18. No. Before deciding, get a pasture tissue test, then add only the elements required, not a shotgun brew with minute amounts of almost everything. The lack of one element can adversely affect pasture production and animal production and health. Cobalt is an example that has been found to be too low in some peat soils. Low cobalt causes low nitrogen fixation by clovers and low vitamin B12 in ruminants. Sechura has no potassium (K) in it, and peats need a lot in the beginning then less, as long as calcium and sodium levels are kept right, as they reduce K leaching, and provided sulphate sulphur, as in single superphosphate at 11%, is not used because it increases the leaching of K.

Q19. Which RP should I use?

A19. All RP's are NOT the same. While their levels of phosphorus vary only from 12.7 to 14.1, the availability varies considerably, and the level of other useful and toxic minerals, while small in total quantity, vary quite significantly when applied at a 1,000 kg/ha. Sechura has more magnesium than others and is low in dangerous elements such as cadmium and lead, but higher in molybdenum (30 ppm), so if your peat is also high in molybdenum, it could pay to use Gafsa, which in acid soils gives growth results close to Sechura, but has only 5 ppm of molybdenum.

Phosphate availability is measured as the percentage of P available in 2% citric acid. Sechura's figure is 39%, Gafsa 32% and most others are about 30% or lower. With RP's it has been found that this test is not as accurate relative to pasture growth as formic acid. Soluble P in formic acid figures are Sechura 65%, Gafsa no figure available, North Carolina 56%, Quinphos Egyptian 41%.

Some scientists have recommended a change to using formic acid.

RP comparative trials (Dr S. Rajan, 1982 NZFMRA Research Symposium) showed that Sechura was superior, even out-yielding Super in the first year when used with fine elemental sulphur, so when headlines, articles and advertisements make similar claims for other RP's, they may not be strictly correct. Giving Sechura a figure of 100, Gafsa about 80, North Carolina about 66, Arad about 50, Quinphos Egyptian about 40, and Nauru (which has to be treated with sulphuric acid to be of any use) about 15. One company ground their RP to a very fine powder before doing trials, so beware of company trial figures.

Winchmore long-term trials (15 years) comparing Sechura with single superphosphate on an equal P basis, found that Sechura gives higher pasture yields, denser pastures, fewer weeds and more clovers. This backs up what farmers even in eastern Waikato's soils with a pH of 6 and higher have found.

Q20. Is particle size important?

A20. Yes. For RP's to work on their own (without artificial acid treatment) they must be fine, so that particles come in contact with the soil and break down and become available within a reasonable time. In this respect Sechura excels - it is the finest, followed by Gafsa.

Q21. Could Sechura and Gafsa be termed organic?

A21. Yes. They are both approved by the New Zealand Biodynamic organic group. This question is important because our organic vegetable growers and exporters can't meet the demand for organic foods, and in USA organic dairy farmers can't keep up with demand for their produce, despite being twice as much for it. A further point worth mentioning is that of "wash", which is the washing of elements into drains, streams, rivers and lakes by heavy rainfall. The effects of this are water pollution and increased algae and water weed growth. Whatawhata Hill Country Research Station west of Hamilton reported that after fertilising with single superphosphate P levels rose much higher in their streams than after RP.

The state of Florida is spending NZ$1,000 million on a clean water programme with their sugar cane and vegetable farmers to reduce P runoff to the extent that only one eighth of what is applied is allowed to leave farms. They are creating 16,000 hectares of wetlands to reduce pollution into their Everglades natural swamps region, and required farmers to reduce P runoff by 25% within two years. NZ is likely to have problems too, unless more farmers change to using RP's rather than using superphosphate, DAP, MAP, etc.

Q22. How does animal health compare when using RP's?

A22. A major benefit of RPs is that elemental S is added to them, whereas single superphosphate contains water soluble sulphate sulphur which is all immediately available so leaches. Plants, being greedy feeders of some elements, take up too much sulphur at the expense of selenium, even if the farmer has applied selenium. This results in the chronic selenium deficiencies seen each autumn and winter on many farms, requiring supplementing with selenium. See Elements > Selenium.

Findings in NZ and Australia show that when water soluble phosphate is applied to pasture, the highly available phosphate depresses the plant's ability to take up calcium, magnesium, zinc and copper and leaches Se. After applying single superphosphate in autumn, pasture levels of these and some other elements decrease, resulting in animals not being as healthy, and the necessity for supplementing them with the deficient elements. In one case, a vet recommended twenty times the normal selenium rate, and many have recommended twice the normal rate, and had improvements in dairy cow health and the milk protein percentage, as a result.

Client Phil Ryall of Clevedon, a long time and large beef farmer, after three years of Sechura and trace element fertilising, told me that his cattle had never looked better.

Clients Robin and Louise Hodges of Otorohanga, who were unsure of my recommendation, fertilised half the farm with equal cost Fertiliser Company recommendations (mostly DAP) and half with an RP and elemental S, both with trace elements in March/April 1992, and then divided and grazed the dries on each. They noticed improved animal health and condition in the RP mob by June. It is shown here after the spring cows were joined. The one on the right and at the back were on my fertiliser area. The low copper (brown hair), hair on neck (low cobalt) and low head (low selenium) were on the DAP which is a highly unpalatable fertiliser with no calcium, while RP contains calcium, an essential element which 99% of the 500 farms I have measured were deficient.

Steve Osborne of Ngarua, who had used Sechura for two years, observed that a month after applying 400 kg/ha of 30% Potassic Super on a few paddocks, his cows became "scratchy and unsettled". Few people notice things like this, and of course it only happens if the farm has previously had a balanced fertilising program. Steve told me that the 30% fertilised area grew no more pasture.

Robin and Louise Hodges noticed the same after using some potassic Super, and, worse still, their milk dropped when on those paddocks.

MAP and DAP are the worst fertilisers for producing high nitrate unpalatable pasture. Bill Chynoweth's (Pukeroro, south of Hamilton) farm manager phoned me and said that the cows walked all over a paddock and then came back out. He asked why they'd done this. I asked what fertiliser he'd applied. "The same as the rest, which was reactive phosphate and trace elements," he answered. I suggested he check with Bill and meanwhile give them another paddock. Bill had applied DAP that was left over from sowing with the maize crop. The cows ate in the other paddock. I suggested that he let the pasture get quite a bit longer, cut in the afternoon and make it into silage or hay.

Malcolm Clark of Patetonga noticed that his cows became 'scratchy' after grazing pastures previously sprayed with DAP slurry by helicopter. This application of about 2 kg of P per hectare results in a short-term pasture boost. Applications have to be repeated several times a year to maintain growth, which is very costly and puts more money into spreading than into fertiliser.

Another farmer had his cows walk around good-looking pasture in a paddock without eating. He had applied MAP on the paddock.

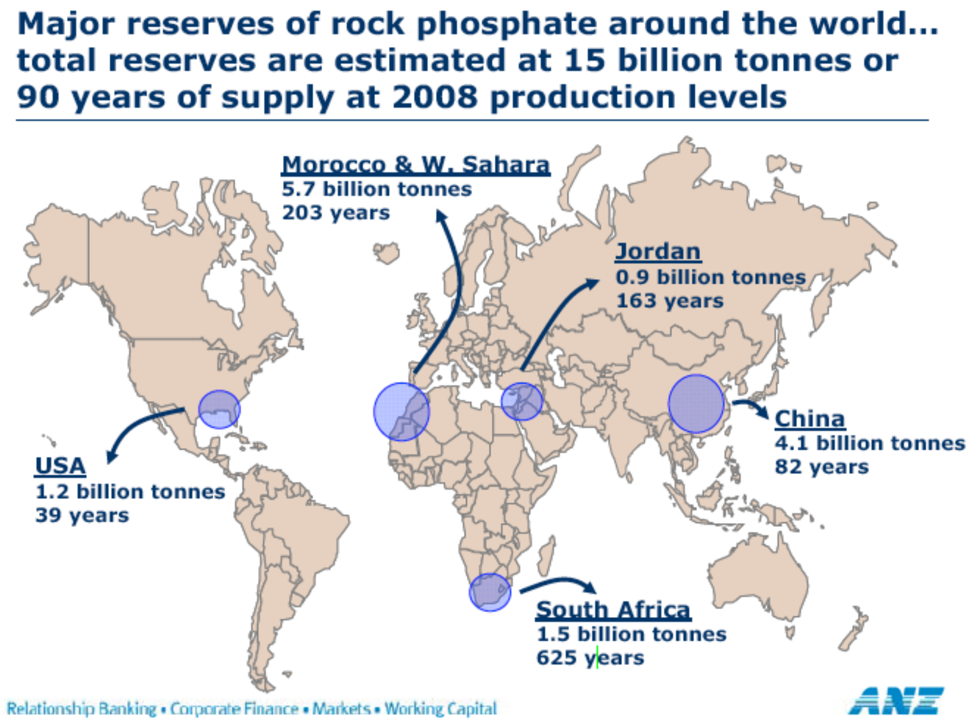
Q23. How can I be sure that Sechura is the best fertiliser for my farm, especially if rainfall is below 800 mm and the pH is higher than recommended?

A23. Divide your farm, or an area, into two equal parts and fertilise half with Sechura and the necessary trace elements, guided by a pasture tissue mineral analyses, and fertilise the other half as usual, but with the same trace elements. When calculating the rates of fertiliser to apply, do it to the spread cost, not to the same kg/ha. Then divide your herd in two, conserve the hay and silage for each mob from their own side, and there is every likelihood that the herd grazing on the Sechura area will be healthier, have less bloat and a better conception rate, and produce slightly more than the herd on conventional fertilising. Client Colin Marshall near Te Awamutu did comparative trials on pasture and maize, and, as with others who I changed to Sechura, found that their Sechura soils were more moist in dry weather and had more earthworms and soil life. Pasture roots grew deeper, perennial ryegrass pulling decreased, clover nodulation increased, and pastures became more dense and more even. See Winchmore above.

Some NZ farmers got improved animal health and empties decreasing from over 10% to about 2%. Gary Wilson in 1994 had only one empty out of 110 cows. Bad bloat disappeared on his and the farms of Tony Ashford, Richard Orr, David Webb, Bryce Wilson and many others.

So take all things into account when comparing the differences.

Phosphate reserves



The best reactive phosphate I know of is Sechura from Peru, but is not shown. Gafsa is second best and cheaper.

Superphosphate

Superphosphates vary depending on the processes, the reactive phosphate used and the acid used to acidify the P to make it available. Manufacture is usually a continuous process over three weeks whereby low cost raw phosphate is mixed with sulphuric acid for single superphosphate (0-9-0-11) or phosphoric acid for triple superphosphate (0-20-0-2). About 85% of the total phosphorus becomes water soluble, and over 90% is soluble in 2% citric acid (the official measuring method). New (fresh, immature) single superphosphate (less than three weeks old) is usually still hot and is not as available to plants.

Single superphosphate with 9% P (20% P205) contains calcium, mainly as calcium sulphate (gypsum), most of which is regarded as available to plants, provided the soil is not too acid. It is water-soluble and leaches quickly, taking some other elements with it. It doesn’t have the acid correcting qualities of the same amount in lime or reactive phosphate.

In some processes some of the fluorine in the powder phosphate is drawn off. The poisoning of animals grazing recently phosphate topdressed pasture is mainly due to the fluorine, so it needs to be removed.

All phosphates and fertilisers should be treated as toxic, so stored where animals can’t get to them, and grazing should not be allowed until all traces are washed off leaves which can take 50 mm (2 inches) of rain. Every year, when insufficient rain falls we read about animals being adversely affected by superphosphate, even when grazed weeks after application. Symptoms are similar to milk fever, the kidneys and abomassum are damaged, and some animals can die.

The acid from the sulphuric acid in single superphosphate doesn't lower the soil pH much, but the calcium removed by pasture lowers the Ca levels, and, if the superphosphate grows more pasture, resulting in an increase in growth and soil organic matter, the soil pH will drop over time. Triple superphosphate (0-20-0-2) has lowered soil pH levels.

Most superphosphates are granulated for better spreading, but if trace elements are added to the mix, the granules are of no benefit, because spreaders must travel closer for even spreading of the finer materials. Drivers usually forget this and drive too far apart because they see the granules going way out, so the granules can be a disadvantage.

Longlife Super

This is made of 70% single superphosphate and 30% RP. Some of the RPs were very slow release ones so results were disappointing. The poor results from Longlife Super in some areas gave them, Partly Acidulated Phosphate powders (PAPRs) and RPs a bad name, but only in some areas.

Serpentine Superphosphate 0 N, 6.8 P, 0 K, 8.4 S and 5 Magnesium.

This is made up of three parts of single superphosphate with one part of ground serpentine (hydrated magnesium silicate), a grey powder containing about 20% water-insoluble magnesium. The mixing with single superphosphate helps make the Mg water-soluble and the acid in soil helps make it available to plants. If the single superphosphate is still raw when the serpentine is added, some of the acid works on the serpentine and leaves some of the phosphate to become slowly available in the soil which is better than all immediately available to wash off hills and leach, and some become fixed.

Serpentine superphosphate is not recommended where magnesium levels are high, but can be used where -

1. A slower release P is required, and for acid soils.
2. To mix with seeds for broadcast sowing. Mature serpentine superphosphate has no acid, so doesn’t burn seeds as long as the mix is spread on the day of mixing in the seeds.
3. Magnesium is required. See Magnesium.

We never used superphosphate on our acid peat farms, but used serpentine superphosphate, as did many others where Mg was needed, which includes many dairy farms. Once reactive phosphate became available, we used it and got the magnesium by buying LimeMag which saved paying to transport serpentine to the fertiliser processing factory and back.

In the 1950s and 60s farmers who applied serpentine superphosphate and LimeMag, and did other things right, had almost no metabolic problems. A vet report to a farmer doing this without feeding Mg, stated, "Your cow blood levels are excellent so continue your Mg supplementing program."

Provided not overdone, Reactive Phosphates are 99% non polluting.

Diammonium Phosphate (DAP)

DAP has 18N, 20P, 0K, 2S, The P is highly available. The same amount of P applied in DAP as in single superphosphate (9% P) raised the soil Olsen P level much faster, but DAP is toxic to animals because it has no Ca in it. Some have even died. Superphosphate contains Ca and RP's have more, so problems of no Ca are less likely.

Dicalcic Super

Why pay to acidify a low grade phosphate to make it faster release, and then alkalise it with lime to make it slower release ending up with Dicalcic with 4.5% P, 4.7% water soluble S that leaches and 30% Ca costing $235.00 in November 2011. Gafsa is about $433 for 13% P. To get that much P in Dicalcic would cost $936.

To include that much elemental S to Gafsa would add $20 = $453 per tonne which is a lot less than $936. Please check the current figures from your suppliers.

Elemental Sulphur

Pastures are best fertilised with elemental sulphur rather than sulphate S because elemental releases S gradually, and doesn't leach and take other elements with it. In some cases deficiencies in pastures (yellowing of clovers) can be seen six months after applying superphosphate (0-9-0-11) because sulphate S leaches. Elemental S will not be needed if superphosphate has been applied recently because at usual rates it already gives much more S than is necessary.

1991 information from the Massey University Fertiliser and Lime research showed the loss of calcium, chlorine, magnesium, nitrogen, potassium, sodium and sulphur after applying 450 kg per hectare of superphosphate that had 50 kg per hectare of sulphate sulphur. The nutrients were measured in field tiles.

Leaching of Nutrients by Sulphate S in kg/ha

	1988		**1989**	
Element	**Sulphate S Paddock A**	**Elemental S Paddock B**	**Sulphate S Paddock A**	**Elemental S Paddock B**
Chlorine	117.8	92.8	76.3	71.9
Sulphur	17.0	3.4	9.4	3.5
Nitrogen	12.6	8.6	19.1	14.9
Calcium	52.5	35.2	40.8	30.7
Potassium	10.8	5.7	7.1	3.3
Magnesium	15.0	10.8	11.3	9.1
Sodium	64.5	50.8	31.9	31.1

Selenium was not measured, but leaches extensively with S. I am sure that if the results suggested the opposite to the above (that sulphate sulphur reduced leaching) we would have read about it many times.

Animal feed

P should be supplied through the pasture because it is a plant growth element and feed tissue levels should not exceed 0.43%. Over 0.45% can (not will) affect animal health. 0.46% has killed cattle, so feeding any form of P can be dangerous. Some use dicalcium phosphate or monoammonium phosphate. Consult the supplier about purity and possible toxins, and your feed specialist for local problems. They are expensive, so use them sparingly, and preferably increase pasture P levels because this way is cheaper, grows more pasture and improves soil's and animal's overall health.

Free choice

Coppock et al. (1972, 1975) studied the practice of free-choice feeding of phosphorus-containing supplements to dairy heifers and lactating cows to meet requirements when diets were low or marginally deficient in phosphorus or calcium. With heifers there was little relationship between need for the mineral elements and free-choice consumption of dicalcium phosphate or defluorinated phosphate. For lactating cows offered basal diets providing phosphorus and calcium below requirements for 9 and 12 weeks, there was no evidence that cows consumed dicalcium phosphate to correct the deficiency or that appetite for phosphorus and calcium supplements coincided with the animals' nutritional requirements.

Many free-choice trials with other minerals have shown the same. Salt is an exception, however adding salt will encourage most animals eat most minerals.

Beware

Impurities and toxins are in some fertilisers, especially 'silver bullet' ones using cheap junk minerals and in some feeds. Organic and silver bullet fertilisers and feeds are not always free of toxins, some with fatal results. Obtain assurances, get analyses of new types of products, get them tested for all minerals, toxic ones such as mercury, cadmium, manganese, lead, arsenic and/or try some on pastures grazed by low value animals and ask your vet and consultant who should have heard of problems in your area. Even weed seeds can be in some. This was beautiful, perfect pasture 100% clean and weed-free before Humate was applied in the Waikato a year before this photo below.