NORTHLAND NATURALLY
FIRST REGION OF NEW ZEALAND

Northland Pastoral Extension Research Stocktake

Fertiliser Research in Northland

Contents

1.0 Fertiliser Summary

Pasture Development

All soils in Northland in the undeveloped state are deficient in phosphate sulphur and some trace elements. While in the development phase capital inputs of fertiliser and lime are required to build up over time the reserves of nutrients both in the organic and inorganic forms. Eventually the stage is reached where further increases in soil nutrients will not result in more pasture production. At this stage the optimum soil nutrient status is achieved and the soil requirements are for a maintenance input of fertiliser. Maintenance levels of fertiliser are needed to make up for nutrients lost by leaching and by the removal of products.

The amount of fertiliser needed to develop a soil and in particular to build up the soil nutrient status is much greater than that needed to maintain the nutrient status once the optimum is obtained.

Many trials were carried out in Northland in the 1960s and 1970s to determine which nutrient and how much was needed to establish pasture on virgin soils. All of the major soil groups were involved in these trials. In general phosphorus, sulphur and lime were always needed. Potassium deficiency developed over time. Molybdenum was needed on most soils but not all and copper may be needed on the podzols.

Large capital inputs are needed on virgin soils to fill up all the soil reserves and get pasture production underway, and the results of a trial on a Yellow brown earth are typical of what happens.

Superphosphate Kg/ha	**Rate of P Kg/ha**	**Pasture production % of Control**	
		6 months	12 months
370	33	100	100
740	66	118	117
1100	100	123	132
1480	133	137	141

Trials such as this indicate that capital requirements of 160-200kg P per ha in the first one to two years of development are needed. The first application could include molybdenum as well. The use of a soluble form of phosphate is usually preferred to ensure the P status is increased rapidly.

Sulphur is required for pasture establishment on most Northland soils. As superphosphate contains about 10% sulphur then adequate sulphur is applied if the above rates of superphosphate are used. For other soluble forms of phosphate such as triple super which do not contain sulphur then elemental sulphur would needed to be added at a rate of 40-50kg of S per ha.

Potassium is not generally needed except for the Wharekohe and related soils where an initial application of potassium of 50kg K/ha is needed. After a number of years applications of potassium become necessary on most Northland soil types.

Lime is essential for pasture establishment and rates of 5.0 tonnes per hectare are usually sufficient. The best way to determine the initial lime requirement is the have a soil test and then uses sufficient lime to increase the pH level to a minimum of 5.4 with an upper limit of 5.8 to 6.0. On average allow one tonnes of lime per ha to lift the pH by one point. This formula applies to the mineral soils inclusive of the sands, volcanic and the clays.

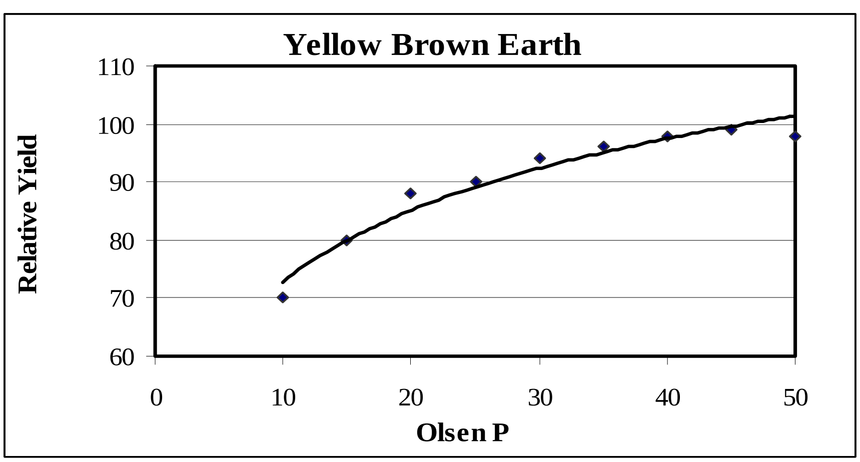
The main trace element deficiency in Northland for pasture establishment is molybdenum and should be used on virgin soils at 50gm per ha. At this rate pasture establishment can be enhanced with limited adverse affects on stock health associated with high Mo levels in the pasture.
Copper deficiency in pasture is rare but the more leached podzolised Wharekohe soils and some peat soils have shown some requirement for copper, which can be applied at 10kg/ha of copper sulphate. Where Molybdenum is used then copper can also be applied.

Pasture Maintenance

Once soil nutrients are at the optimum level then fertilisers are applied to replace the losses that occur by the sale of products such as milk, meat and wool, and by the losses of nutrients by leaching or the displacement of animal waste to areas not in pasture.

Phosphorus

The optimum levels for nutrient in the soil are determined from pasture production response curves. These curves for the major Northland soil groups are based on data from grazing trials carried out in the 1980s, and a typical example is as follows.



It is important to understand that in many farm situations it is not economical to farm at the optimum Olsen P level and it all depends on how efficient each property is operating at. The higher the financial returns are per ha the closer the economic optimum comes to the biological optimum. Each major soil group has its own response curve and from these the optimum P level can be given as follows.

Soil Group	Optimum Olsen P	Desired Range
YBE	25	20-25
RBL and BGC	30	25-30
YBS & Recent soils	25	20-25

Note: The optimum P level is that for 95% of maximum production.
Note: A desired range is given because soil test and field trials results are not precise measurements.

The RBL and the BGC have a higher optimum Olsen P test than the YBE and YB sands because they tend to fix more of the phosphate that is applied so the maintenance levels are higher as a result. If the Olsen P levels are less than above then pasture production is less than it could be and if the levels are higher than above then less fertiliser can be used and the surplus soil P reserves used and the Olsen P will decline.

Changing the P Status
The trial work carried out in Northland has given some good indicators to the amount of P that needs to be applied to increase the soil test levels. The rates needed are clearly related to the phosphate retention levels.

Soil Group	P (kg/ha) to lift Olsen P by one unit.	P Retention %
YBE and Podzol	11	20-40
YBS and Recent soils	20	30-40
RBL and BGC	30	50-70

Maintenance Rates
Trial work has looked at the effect on the Olsen P level at rates of P applied at 0, 10, 25, 50 and 100kg P per ha. These trials were conducted over a 5-6 year period. In most cases when P was applied consistently at 100kg/ ha there was a marked elevation in the Olsen P level in the soil. For most soil types the P status remained constant at rates of P from 25-50kg/ha. However the actual amount needed depends on the farm type like sheep & beef or dairy and the intensity of grazing management within each farm enterprise. The individual farmer can by regular soil testing can monitor their own situation and determine the rates and types of fertiliser needed.

There are some rules of thumb measurement based on per ha production. For example on dairy farms it has be suggested that a maintenance rate would be

100kg/ha of 20% potassic super for each 100kg of milksolids production per ha. Presently the average milksolids production per ha on the milking area is about 650kg milksolids so the rule of thumb would suggest 650kg/ha of 20% potassic super, which is equivalent to about 50kg/ha of P and 100kg/ha of K and 65kg/ha of S. Like wise for sheep and beef farms 100kg/ha of superphosphate for each 100kg per ha of net carcass meat and wool production per ha. The average production level on Northland sheep and beef farms is about 250kg net carcass meat and wool per ha so 250kg/ha of superphosphate would be a maintenance level.

Optimum Soil Sulphur Levels

Most of the trials looking at the relationship between S levels and pasture production have been done in other districts with limited work in Northland. It is assumed that these trials give an indication for Northland. Most of the S in the soil is in the organic form so soils that have been farmed intensively for a long time say 20-30 years would contain more S than soils more recently developed. Sulphur in the soil is very mobile and can be leached rapidly and the sulphate sulphur test can fluctuate widely depending on rainfall. For this reason when soil testing the organic sulphur test in addition to the sulphate sulphur test is desirable. Generally speaking the sulphate S levels need to be maintained at about 8-10. If a soil test result shows that the sulphate S levels are low and the organic S levels are also low then it is clear that extra S needs to be added to the fertiliser program. But if the sulphate S levels are marginal say 6-8, and the organic S levels good then extra S is probably not needed.

Field trials carried out in Northland looked at sulphur requirements and in particular to see if extra S was needed when superphosphate was used at rates suitable to maintain the P status. The results were that in most situations where superphosphate was used at 25-50kgP per ha then no extra S was required. There are however some soils where sulphate S leaches including the Wharekohe podzols, the peats, the peaty sands and some other YBE soils subject to high rainfall 1800-2000mm per year. If these soils receive fertiliser spring and autumn then extra S is not needed. If topdressed once a year then the addition of a slow release elemental S on an annual basis is needed.

Potassium

The response curve for K is similar across the soil groups largely because potassium is a mobile nutrient and not held as tightly by the soil as is P. The losses of K on dairy farms are much greater than on sheep and beef farms and the need for K is much higher.

For dairy farming the K soil test needs to be maintained at 8-10 and annual inputs of 70-100kg K per ha per year are needed. Potassium can be applied once a year spring or autumn, but if the rate of K to be applied is greater than

100kg/ha then split dressing are desirable. For most soil types 80kg of K will increase the K soil test by one unit and that would need to be applied in addition to the amount needed for maintenance.

On sheep and beef farms the soil K level can be as low as 3-4 and no K is needed. On the intensive beef unit with limited sheep grazing then the need for K is more acute and can be determined by regular soil testing to monitor the K status under such intensive management systems.

Trace Elements

Molybdenum is the main trace element required for pasture production. It is essential in the nitrogen fixation process in clover and hence deficiency symptoms will show in terms of reduced clover content and vigour. When the advantages of Mo were discovered in the 1960s there was an overuse of Mo on some soil types leading to stock health problems. The present recommendation is for Mo to be applied at 50gm/ha every four to five years depending on the soil type (in the 60's it was 375g/ha!). There are many properties that have not had any Mo application for about 20 years and there are some signs that Mo is needed and is an overlooked element in the improvement of pasture vigour.

Guidelines for Soil Testing and Plant Analysis
There are a number of laboratories that are able to test the soil for the level of nutrients that are available for pasture production. The important test would be for pH, P status either Olsen P or Resin P (in the case of RPR usage), P retention, magnesium, sulphate sulphur and organic sulphur. To be of practical use soil tests must be calibrated in field trials under New Zealand conditions, which had been done by Ministry Agriculture over many years. A soil-testing service offered by organisations with little or no field research backing under local conditions is of limited value. Soil test results are a valuable guide and can be used in when making fertiliser recommendations by people with some expertise in soil fertility and knowledge of the individual farmer's property.

The following guidelines can be used for Northland soils:

Test	Very low	Low	Medium	High
Olsen P				
YBE	<10	10-20	20-25	>25
RBL/BGC	<15	15-25	25-30	>30
YBS and Recent	<10	10-20	20-25	>25
P retention	0-30	30-60	60-90	>90
Quick test K				
Dairy	0-4	4-6	6-10	>10
Sheep & Beef		0-4	4-8	>8
Sulphate S				
Developed soils		5-8	8-10	.10
Virgin soils		0-10	10-15	.15
Soil pH	<5.0	5.0-5.6	5.6-6.0	>6.0

There can be errors with soil testing due to biological variation, operator error issues with transport and delivery of samples. So one test only at one time is of less value than the trend from samples consistently collected every second year from the same area over a number of years. Each sample should be from areas or paddocks of similar management, topography, soil type and fertiliser history.

Soil samples can be taken for trace elements like molybdenum, manganese, copper, and cobalt. However calibration of the tests is not good. It is better to do plant analyses for trace elements. These results can then be used for both plant health as well as for animal health purposes.

2.0 Comparative Effectiveness of Liquid and Solid Phosphatic Fertilisers on Grassland

G Goold, J Karlovsky, K Steele
New Zealand Journal of Experimental Agriculture 6 (1978): 227-232

Overview

The production of liquid fertilisers in New Zealand started in 1967.and were promoted as more efficient in supplying phosphate to pastures and crops than solid fertilisers such as superphosphate. The claim was that only 10-25% of the phosphate in superphosphate was utilised by pasture plants and that foliar applications would be 5-8 times more efficient. These claims were strongly challenged by Karlovsky and Elliot who deduced from field trials that 75-90% of P was effectively utilised by pasture plants. A series of trials was carried out in 1973-1975 in various parts of New Zealand to confirm this contention. Of the five trials carried out three were in Northland and the results of these trials only are given below. The Northland results were similar to the other two sites.

Previous Trial Evidence 1952

A trial was carried out in 1952 at Rukuhia Soil Research Station to investigate the extent to which pasture plants could use phosphate sprayed on to their leaves compared with phosphate applied to the soil, as follows. The trial was carried out on Horotiu sandy loam, a soil with high phosphate retention and low phosphate status. The products were sprayed on to the pasture in solutions of 4-8%P.

Treatments	**Yields-Foliar Application**	**Yields-Soil applications**
Control	100	100
Monocalcium phosphate	113	117
Di-ammonium phosphate	120	114
Di-potassium phosphate	118	119
Phosphoric acid + urea	105*	114
Glycerophosphoric acid	108	108
Average of all treatments	113	114

Note: The 105 suffered from scorching.*

<u>Results</u>

- The yields from the foliar-applied solutions were similar to those from solid fertilisers applied by topdressing to the soil.

Field Trials Carried Out 1973-1975

Several field trials were carried out to test commercially manufactured liquids as well as their alginate component, which it was claimed would prevent leaching, fixation, provide a sticker to prevent the fertiliser from washing off the foliage by rain.

Treatment 2 – Carried Out on Ohaeawai Silt Loam a High Phosphate-Retentive Soil

The aim was to compare a liquid product liquiphos with solid fertiliser on an equal-cost and equal-nutrient basis. Also to compare liquiphos containing 1% alginate, with a laboratory-prepared liquid fertiliser, containing N, P, and K but without the alginate. The trial was a mowing and clippings removal technique on a perennial ryegrass-paspalum white clover pasture. The soil test samples at the start of the trial indicated a likely response to phosphate only. However during the time of the trial the K levels dropped drastically no doubt due to the removal of clippings. Treatments were applied on 11 Oct 73, and reapplied on 19 Apr74 and 17 Oct74.

Results - Herbage DM relative to control (100)

Treatments	**Period of application**			
	Oct73-Apr74	**Apr74-Oct74**	**Oct74-Jan75**	**Total**
Control	100cA	100abA	100bcBC	100bcAB
Liquiphos (10/3/5) at 40kg per ha	114 abcA	95abA	95cBC	104abcAB
Solid fertilisers equal-cost basis	117abA	97abA	118bB	111abAB
Solid fertilisers equal-nutrient basis	103bcA	81bA	90cC	93cB
Superphosphate 200kg per ha*	115abcA	108aA	144aA	119aA
Super 200kg/ha + urea 50kg/ha**	120aA	102abA	107bcBC	112abAB
Liquid N-P-K (10/3/5) at 40kg/ha	116abcA	107aA	95cBC	109abAB
CV	10%	17%	12%	10%

*Note: *50kg K added for period 2 and 300kg K added for period 3 and P doubled for period 3.*
*Note: **P doubled for period 3.*

Results

- Because of the changes to some of the treatments for the second and third applications the results are given separately for each period.
- For the first period the only treatments that yielded significantly more than control were the super at 200kg/ha plus 50kg/ha urea and the solid fertiliser on an equal cost basis.
- After the second application of treatments there were no significant responses compared with control, probably due to low K levels of 3.
- For the third application a highly significant response was obtained on only the treatment with the high rate of potash.
- Both Liquiphos and the laboratory-prepared liquid fertiliser yielded similarly to control throughout the trial.

Summary

Given the K deficiency that developed during the trial and that when applied it was not to all treatments the results from this trial are of limited value.

Treatment 3 – Carried Out on Waikare Clay a Medium Phosphate-Retentive Soil

The trial was a mowing and clippings return technique on a perennial ryegrass-white clover dominant pasture with some paspalum. The soil test data indicated responses to K only with the P values well above the response range. All plots received a basal application of lime at 2tonnes/ha, copper sulphate 1.5kgCu/ha and sodium molybdate 70gmMo/ha and gypsum at 8.6kg s/ha.

Treatments: Herbage Dry Matter Compared With Control

Treatments	**Period Sep 73 to Jan 74**
Control	100a
Liquiphos (8/5/8) at 40kg/ha	97a
Solid fertiliser equal cost basis 500kg/ha 30% potassic super	100a
Solid fertilisers equal-nutrient basis.	95a

Results

- As expected from the high P levels there were no response to any of the treatments.
- Even though the K levels were low there was no response to the third treatment containing 75kg K/ha.

Treatment 4 – Carried Out on Harihari Sandy Loam a Low Phosphate-Retentive Soil

The trial was a mowing and clippings return technique on a perennial ryegrass-white clover dominant pasture with some Yorkshire fog. The soil test data indicated responses to P and K.

Treatments: Herbage Dry Matter Compared With Control

Treatments	**Jan 75 to Oct 75**
Control	100cC
Liquiphos (10/3/5) at 40kg/ha + S 5kg/ha	113bcBC
Solid fertilisers equal-nutrient basis to above.	105cBC
Solid fertiliser equal cost basis 345kg/ha 30% potassic super+7.3kg urea	119abAB
Liquiphos (10/3/5) at 1116kg/ha + S 210kg/ha	122aA

Results

- Neither Liquiphos applied at the recommended rate of 40kg/ha nor solid fertilisers on an equal nutrient basis yielded significantly more than control.
- Liquiphos applied at a very heavy rate yielded significantly more than Liquiphos at the recommended rate but not significantly more than solid fertiliser at an equivalent cost basis to the second treatment.

Treatment 1 – Carried Out on a Hamilton Clay-Loam at Ruakura

Treatments	**May 74 to Sep 75**	**Relative efficiency**
Control	100cB	
Liquiphos (10/3/5) at 60kg/ha.	106bcB	23
Solid fertiliser's equal-nutrient basis to above.	108bcAB	31
Urea 65kg/ha	114abAB	54
Solid fertiliser equal cost basis.	126abAB	100

<u>Results</u>

- Solid fertiliser was significantly better than Liquiphos when compared on an equal-cost basis, and no difference on an equal nutrient basis.

Treatment 5 – Carried Out on a Tisbury Silt Loam in Southland.

Treatments	**May 75 to May 76**
Control	100Babc
Liquiphos (0/7/14) at 28kg/ha.	99Bbc
Liquiphos (0/7/14) at 47kg/ha.	95bC
Liquiphos (0/7/14) at 360kg/ha, equal nutrient basis to 5 below.	116aAB
Solid fertiliser equal cost basis to treatment 2	119aA

<u>Results</u>

- Again solid fertiliser was significantly better than Liquiphos when compared on an equal-cost basis, and no difference on an equal nutrient basis.

Conclusions

- Solid fertilisers applied at equivalent cost to liquid fertilisers were always superior in pasture production.
- There was no evidence to show that alginate improved the performance of the liquid product.
- The liquid fertiliser "liquiphos" is no longer available.
- It is interesting to note that in some of these trials there was no response recorded due to the high base soil fertility level. This demonstrates the importance of testing new fertiliser products over a number of years on a number of sites. The benefit of any fertiliser product promoted on the basis of the results of a limited number of trials should be treated with caution.

3.0 Fertiliser Trials on the Pinaki Suite

G L B Cumberland, January 1969
MAF Research Report 20, Fertility Trials on the Pinaki Suite (Part II). NARL Ref 507

This report summarises all the trial work carried out by the Auckland Field Research Section project investigating fertiliser requirements of the Pinaki suite. These trials were carried out during the period 1965 to 1969 and the trials were carried out on soil types classified as follows.

Subgroup	Stage	Soil type
Yellow Earths	**Young to Immature**	**Pinaki Sand**
	Immature to early semi-mature	Houhora Sand
		Red Hill Sand
		Red Hill Sandy Loam
		Red Hill Sandy Clay Loam
Weakly & moderately	Semi-mature and sub mature	Tangitiki Sand
Podsolized yellow earths		
Strongly podsolized yellow	Mature	Te Kopuru sand
Earths and podzols		Te Kopuru complex

Project Design

The project was designed to determine firstly what fertilisers were needed and secondly in what amounts to maintain a high producing pasture. The first stage required sites with little or no previous topdressing and the second required sites with well-established pasture. The soil type at each site was confirmed by Soil Bureau personnel. Treatments were lime, phosphorus, potassium, molybdenum, sulphur and copper. A few trace element trials were carried out with, copper, molybdenum, boron, iron and zinc, with basal applications of lime, phosphorus and potassium.

Some trials had occasional dry matter cuts but in most cases were marked on a visual fertility index.

Pinaki Sand
Six trials were carried on and lime responses were recorded only were the pH level was less than 5.5 and levels higher than this did not have any effect on plant growth.

Applications of 500-1000kg per ha of superphosphate were needed for pasture development and to maintain a high producing pasture. If superphosphate is applied at these rates then sufficient sulphur is applied as well. There was no response to potassium and in these trials and the K levels were 3-6.

Regular application of molybdenum at 350gm per ha and copper at 10kg per ha were applied. If pasture growth is poor once adequate phosphorus, molybdenum, and copper has been applied then iron and boron can be needed.
Sulphur gave a response but only when phosphorus and molybdenum were also applied.

Molybdenum consistently showed a strong response and copper alone did not give a pasture response but did so if applied with molybdenum.

Houhora Sand
Only one trial was carried out on a site with soil test levels as follows:

pH	Calcium	Olsen P	Potassium
6.4	6	13	4

The trial responded to phosphate, no significant response to potassium or molybdenum and a depression to the application of lime.

Red Hill Sand
In total 9 trials were carried out and lime was required at pH levels below 5.5-5.6.

Rates of phosphate applied were at rates up to 160kg/ha but there was no extra response at rates above 40-50kg/ha of P even when the base Olsen P levels were as low as 4-7. Once Olsen P levels were at 26-30 annual applications of 50kg P per ha would maintain pasture production. In some of these trials 10kg of P per ha lifted the Olsen P level by 2 points.

Potassium was needed after a number of years of phosphate application and where the K levels had declined to less than10.

There appeared to be a beneficial interaction on pasture production between copper and molybdenum. In one trial copper increased the percentage of grasses and the molybdenum produced more clover and both elements together produced a better sward than either of these elements by themselves. In other trials where copper and molybdenum improved the sward it was by an improvement in the legume content only.

Tangitiki Sand
There were 16 trials and lime is needed to lift the pH level to 5.5 but little benefit to rates above this.

For pasture establishment rates of P up to 200kg per ha were beneficial but once the Olsen P levels were at 30-35 then maximum pasture production could be achieved. For most sites P at 100kg per ha was sufficient and if applied as superphosphate supplied enough sulphur as well. In one trial sulphur was applied at rates of 0, 25, 50, and 100kg/ha and despite the sulphur being applied in split applications there was no response to sulphur.

Responses to molybdenum and potassium were initially small and not significant until adequate phosphate had been applied. Potash responses on established pastures are more likely at K levels below 8.

Te Kopuru Sand

A survey of all previous trial work done on this soil type indicates that reliable results are rare, and that unusual and inexplicable results are quite common. The soil type naturally deficient in most plant nutrients has very little buffering capacity, a fast leaching ability and is renowned for producing confusing trial results.

Six trials that were carried out showed that pastures on this soil type responded to lime, phosphorus, potassium and molybdenum. To date trails to test molybdenum and copper interactions had not been carried out but trials results on other soil types in this suite suggest that copper responses in pasture are possible where molybdenum is adequate.

The confusing results that can be obtained from this soil type is evident in one trial where there was a depression in pasture production when the soil pH was increased to 6.0 and at Olsen P levels above 35.

4.0 The Effects on Production of Stopping or Reducing Fertiliser Inputs on Hill-Country Sheep and Beef Farms

P W Shannon and M B O'Conner
Proceedings New Zealand Grasslands Association 47 (1986): 217-222)

Overview

When product prices are low and farmers have sufficient returns to fund only a maintenance level of expenditure then there is little ability to fund development or improvement expenditure apart from borrowed money. However if spending on fertiliser was omitted for one or two years could fund this development work such as extra subdivision and access lanes, drainage, upgraded water supply, and building of yards or woolsheds. These are all items would enhance the efficiency of production. Before any such steps are taken some knowledge of the consequences in terms of a loss in production would be useful. Hence the purpose of these trials.

Methods

There were five trials laid down in Northland in May 1982 on a range of soil types as follows.

Soil Type	Soil Group	pH	Olsen P	P	Stocking Rate	
				Retention	Present	Potential
Hukerenui silt loam	N Podzol	6.0	15	17	13	16
Warkworth clay	YBE	5.9	19	21	12	16
Whangaripo clay	YBE	5.9	16	35	14	18
Awarua clay	BGC	5.5	15	60	12	18
Waimate clay loam	RL	5.6	10	66	11	16

Treatments were five rates of P applied in May as superphosphate 0, 12.5, 25, 50 and 100kgP/ha Basal applications of gypsum are applied to the 0 P plots at a rate equivalent to 125kg super per ha. Each site gets 50kg potassium in May and October/November each year.

Results

- On the no P plots there was no significant decline in pasture production for the first two years where the Olsen P was initially at 15 or above.
- Reducing fertiliser input from 25 to 12.5kg of P had little effect on pasture yield on all five sites.

- By year 3 the sites with initial Olsen P of 15+ the pasture production on the nil P plots were lower than the 25kgP/ha treatments, as below.

Relative pasture yields for the third year on the four sites with Olsen P greater than 15.

Site	**Hukerenui**	**Warkworth**	**Whangaripo**	**Awarua**
Treatment				
0	82	92	92	96
12.5	106	106	105	105
25	100	100	100	100

On the Waimate clay site with an Olsen P of 10 withholding P resulted in a decline in pasture production in the first year as follows.

Year	**1982/83**	**1983/84**	**1984/85**
Treatment kg P/ha			
0	85	94	104
12.5	97	99	101
25	100	100	100

Decline Olsen P levels; soil sample taken in Mar/Apr each year.

	Hukerenui		**Warkworth**		**Whangaripo**		**Awarua**		**Waimate**	
	Nil	25	Nil	25	Nil	25	Nil	25	Nil	25
1982	15	15	19	19	16	16	15	15	10	10
1983	22	23	12	18	16	19	11	11	10	12
1984	16	19	11	18	17	24	13	14	11	14
1985		14	13	22	13	16	17	20	11	14

- Soil Olsen P levels showed little decline on the nil P plots until the end of the third year of the trial, while 25kgP/ha/yr either maintained or slightly increased Olsen P levels.
- The lack of a decline in Olsen P levels until the third year means that the Olsen P teat may not in the short term accurately monitor a decline in soil P-status.

Conclusions

The results from these trials suggest that where Olsen P levels are 15 or greater, and the farm is stocked at below the maximum possible rate then there are “capital” reserves of P in the soil to prevent losses of production for up to two years if no fertiliser is applied.

5.0 RPR Recommendation for Farmers

Superphosphate is prepared by treating phosphate rock with an acid, which changes the insoluble dicalcic phosphate into a soluble Monocalcium phosphate. The amount of phosphorus in super, which is available to plants, is assumed to be the amount, which can be dissolved by a 2% citric acid solution. When super is applied to the soil this is the phosphate which dissolves out of the granules within a few days of the product being applied to the soil.

Reactive phosphate rock used in agriculture as fertilisers are those which without any treatment with acid are able to dissolve at least 30% of the total phosphate content with 2% citric acid. When RPRs are applied to the soil the phosphate dissolves more slowly. The main agronomic differences between RPR and superphosphate are the rates at which they release phosphate and the fact that superphosphate also contain about 10-11% sulphur while the RPR seldom contain more than 1% sulphur. The four main RPR used in New Zealand are Arad, Egypt, North Carolina, and Sechura. They appear to be equally effective sources of phosphate but Sechura contains molybdenum as well.

While phosphate dissolves rapidly from superphosphate it is not lost from the soil but remains held and is available over a number of years to the pasture plants. There are some losses due to phosphate fixation, which applied to all forms of phosphatic fertiliser applied to a high fixing soil. On some of the more mature podzols soil there is some leaching of the phosphate, which may be more acute as compared with the RPRs.

The rate at which RPR dissolve depends on soil conditions especially the acidity and soil moisture levels and on the particle size of the RPR material. During the late 1970s and 1980s there were a National series of trials, which compared the effectiveness of superphosphate and the RPRs over a period of 12 years. There were 19 sites and most trials lasted six years and five of these sites were in Northland. Most trials compared Sechura and North Carolina with triple super. Superphosphate. Sulphur was applied to eliminate any possible deficiencies of that element. The trial results were put into two groups; those were adequate molybdenum was present and those, which may have been Mo deficient.

Results

The results would suggest the following:

- For the RPR between 30-40% of the RPR dissolved in the first year of application.
- By the third or fourth year the amount of phosphorus dissolved from the 3 or 4 years of application was equal to that of triple superphosphate.
- The RPRs dissolved more slowly on sites that were dry (less than 600mm rain) or had pH levels above 6.0 but few sites were in the grouping.

- Pasture production yields varied considerably from year to year and this variation often exceed the differences in the response of the fertilisers used.

Recommendations

The recommendations that can be made are:

- RPR should not be used if pH greater than 6.0 or there is les than 800mm of rain.
- For capital applications of phosphate to lift the P level use a soluble phosphate.
- To maintain soil P levels either RPRs or soluble forms of phosphate can be used.
- If the Olsen P levels are high then a change to RPR products will show little decline in production and is likely to be less than the normal variation from year to year.

If an economic analysis is carried out on RPRs compared with soluble forms of phosphate then the benefit of previous applications of the soluble form of phosphate should be taken into account. This is necessary where previous applications of the phosphate have resulted in a satisfactory to high P status.

6.0 Alternative P-Fertilisers for Northland Soils

PW Shannon
Proceedings New Zealand Grasslands Association 47 (1986): 229-232)

Overview

The purpose of this study was to compare a range of RPR and readily soluble P-sources under Northland conditions. The objectives were three fold.

1. Compare responses to increasing rates of Sechura phosphate rock and triple superphosphate.
2. Compare the efficiencies of different P-fertilisers at a common rate on pasture production.
3. To evaluate the potential of phosphate rock fertilisers for infrequent application.

Method

There were five trial sites in Northland selected to cover the range of soil types that are generally present. All trials were laid down in May 1983 on sheep and beef farms. The pastures were mostly ryegrass and clover with some paspalum during the summer on the Whangaripo & Awarua clays. All sites had received annual applications of 375kg/kg/ha of 15% potassic superphosphate for the two years prior to the start of the trials.

Site Number	**1**	**2**	**3**	**4**	**5**
Soil Type	**Hukerenui Silt loam**	**Warkworth clay**	**Whangaripo clay**	**Red Hill sand**	**Awarua clay**
Soil group	N podzol	YBE	YBE	YBS	BGC
P-retention	15	22	34	37	52
Olsen-P	23	14	14	21	15
pH	6.0	5.9	5.9	6.0	5.5
Maintenance P kg per ha*	33	33	33	31	36

Note: the maintenance P requirement was estimated for each site using the MAF fertiliser recommendation scheme assuming that each site was been farmed at 90% of maximum carrying capacity.

Basal applications of sulphur as gypsum and potassium were applied to all treatments .The actual treatments were as follows:

TSP-triple superphosphate at 0.5, 0.75, 1.0 & 2.0 times maintenance
SPR-sechura phosphate rock at the same rates above

The comparison between the phosphate rocks included:

TSP & SPR plus
NCPR-north carolina phosphate rock
CRP-chatham rise phosphorite

In addition TSP and SPR were applied triennially at .2.5 times the maintenance rate.

Results

Very few responses occurred in year one, but during year two most sites became responsive to soluble P-fertilisers. On the highest PR site there were however increasing responses to increasing rates of SPR. This would suggest that on the lower PR sites there were soil chemical processes limiting the maximum rate of dissolution of the reactive phosphate rocks. This site also had the lowest pH status 5.5 compared with 5.9-6.0 and acid conditions tend to increase the rate of dissolution of RPR materials.

Pasture yields relative to control=100 for the second year 1984/85:

Soil Type	**Hukerenui**		**Warkworth**		**Whangaripo**		**Red Hill**		**Awarua**	
	TSP	SPR	TSP	SPR	TSP	SPR	TSP	SPR	TSP	SPR
0.5M	95	114	104	104	104	100	104	109	111	107
0.75M	105	105	100	104	109	109	105	103	120	109
1.0M	107	108	109	102	105	105	105	104	119	111
2.0M	120	105	116	111	103	103	114	111	123	119
SED	8		5		3		12		10	
DM/ha*	7530		10900		11390		6600		5630	

Note: DM per ha was for the control plots.

Pasture yields reactive to control at 100 from the different forms of phosphatic fertilisers at 0.75 maintenance for the 1984/85 trial year:

Soil type	**Hukerenui**	**Warkworth**	**Whangaripo**	**Red Hill**	**Awarua**	
Control DM/ha	7180	10310	11370	5760	5770	
Fertiliser	Forms comparison all at 0.75 M					Mean
a CRP	91	110	101	105	109	103
b NCPR	98	103	104	122	120	109
c SPR	102	111	102	125	120	112
Mean a-c	97	108	102	117	116	108
	Forms X frequency					
SPR 2.25 M	102	113	104	127	126	
TSP 2.25M	97	110	109	116	128	
SED	7	5	5	15		

- Of the different reactive rocks the finely-ground granulated Chatham Rise rock appeared to be slightly less effective than the ungrounded and ungranulated North Carolina and Sechura phosphate rocks. Possibly the granulation process has reduced the rate of dissolution of the Chatham Rise material.
- On average the RPR rocks at 0.75M produced less pasture than the soluble phosphate fertilisers applied at the same rate.
- In the rates x frequency trial few consistent trends have emerged, except for the Awarura site, where annual applications of triple super at 0.75m are in year 2 already out producing the triennial application at 2.25M.

Conclusions

- The gradual development of responses to RPR is in keeping with the high pH levels on four of the five sites.
- The soil with the highest response had the lowest pH and highest phosphate retention levels, both factors would increase the rate of dissolution.
- Infrequent applications of P-fertilisers at high rates do not generally appear to be less effective than annual applications.

7.0 Review of Field Research Fertiliser x Stocking Rate Grazing Trials

A D H Joblin, G L B Cumberland, et al
Proceedings New Zealand Society of Animal Production 32 (1972): 64-76

Overview

Eight trials were reviewed where ewes and lambs, hoggets or dairy cows were used for the estimation of responses from fertiliser applications to pasture. One of these sites was in Northland at Otakanini near Helensville and hoggets were the indicator animals that were used.

This site consisted of red hill sandy clay on rolling hill country.

Method

The hoggets are carried at three stocking rates and at three rates of superphosphate, 125kg/ha every second years and 500 & 1000kg/ha every year.
Hoggets are added in spring, and again in summer as pasture surpluses develop.
Statistical analysis is only on the hoggets that remain for the whole year.

Results

Three years data has been analysed and:

- There have been significant responses to higher levels of fertiliser used.
- The responses have been in both liveweight gain and wool growth.
- The responses have been linear over the three fertiliser rates.
- While wool weights have been a sensitive measure of fertiliser responses they have not always been as sensitive as liveweight.

Conclusion

- It was noted that at the higher stocking rates the relationship between pasture dry matter response and livestock performance were satisfactory.
- The trials therefore increase the confidence with which data from mowing trials can be used to indicate probable level of animal response.

8.0 Sulphur Fertiliser of a Well-Established Pasture on a Northern Yellow-Brown Earth

G J Piggot
New Zealand Journal of Experimental Agriculture. 1984, Vol 12;65-68

Overview

The Northern YBE soils of Northland formed from sedimentary materials comprise 60% of the soils north of Auckland and the predominant land use is for pastoral farming. Observational trials have clearly demonstrated a need for sulphur in the establishment phase of pastoral farming. That work by Cumberland, Goold and During, provided a basis for the current sulphur recommendations on well developed pasture, that standard applications of superphosphate also provided sufficient sulphur as well as the phosphate. However very little trial work has been carried out on well developed pasture to test this recommendation.

Method

The work consisted of a field trial and a subsidiary glasshouse trial starting September 1976 to February 1981. The site was south of Helensville on a Mahurangi clay located about 10km from the west coast and subject to the prevailing westerly winds. The trial area was northern sloping and the pasture was primarily composed of ryegrass with lesser amounts of paspalum, cocksfoot, and Yorkshire fog, the Agrostis spp and white clover. It had been topdressed for 20 years with superphosphate at annual rates of 200-400kg per ha.

The field trial was of the continuously-mown small plots with about 80% of the clippings returned. All cuttings were by rotary mower cut to 3cm and 50 production cuts were taken, generally when the pastures were 10-20cm tall. There were nine treatments and six replications, and the soil test levels in June 1976 were as follows.

	pH	Ca	P	K	S	Mg	P retention	S retention
1976	6.5	15	23	5	12	15	20%	8%

There was a basal application of 50kg/ha of P as mono-calcium phosphate or superphosphate depending on the treatment. Potassium was applied in the spring and autumn at a total of 130kg/ha per year. Copper and boron were applied each year and molybdenum once. The sulphur used was collected after sieving normal agricultural sulphur through a 16-mesh sieve (1000u).

1	Control D	Depletion treatment all clippings removed +10kgN per cut.
2	Control	
3	S10	As superphosphate applied in the spring.
4	S10+S40 S	As for 3 plus 40kg elemental S applied in the spring.
5	S10+S40 A	As for 4 but the S was applied in the autumn.
6	S10+S80	As for 3 with 40kg elemental S applied in both autumn & spring.
7	S50	As superphosphate applied in the spring.
8	S50+S40S	As for 7 plus 40kg elemental S applied in the spring
9	S50+s40A	As for 8 but the sulphur was applied in the autumn.

Results

The table below shows the means of the pasture dry matter production for the entire trial period. These results are grouped into three seasonal periods to determine the effectiveness of spring compared with autumn applications of sulphur.

Table 1: Pasture dry matter production

Treatment	Spring-early summer	Summer-autumn	Winter
2 Control	4920	1780	2800
3 S10	5130	1760	2650
4 S10+S40 S	5140	1760	2910
5 S10+S40 A	5150	1760	2660
6 S10+S80	5190	1750	2760
7 S50	5240	1800	2810
8 S50+S40S	5310	1810	2870
9 S50+s40A	5530	1820	2920
SE	380	170	220
MSD	300	150	200

- Significant responses to sulphur occurred only in the spring and early summer period, and were a response to the basal rate of sulphur in superphosphate rather than to the extra elemental sulphur applied. There was no significant difference between the spring and autumn applied sulphur.

- Apart from fertiliser, sulphur was derived from the atmosphere at an average rate of 15kg/ha per year. It is assumed this source of atmospheric sulphur was from the sea given the close location of the trial site to the coast and the prevailing westerly winds.

Table 2: Soil sulphur levels pre treatment and post treatment

Soil Sulphur levels	**Depth (cm)**		
Pre Treatment Sep 1976	0-8cm	8-15cm	15-30cm
Total S	528	338	278
Available S	9	6	20
Post Treatment May 1981			
1 Depletion	11	13	16
2 Control	12	10	18
3 S10	17	12	11
4 S10+S40 S	18	10	13
5 S10+S40 A	15	17	15
6 S10+S80	18	11	19
7 S50	10	12	17
8 S50+S40S	19	15	18
9 S50+s40A	18	17	12

- Sulphur deficiency (less than 0.2%) as determined by herbage analysis did not occur in the depletion plots.
- The sulphur removed from the depletion plots averaged 25kg/ha per year.
- Final soil testing of available S showed little change in the control and depletion plots indicating either the ability of mineralisation to maintain S over long periods in this case up to 5years, or the addition of S from the atmosphere.

Summary

The sulphur requirements of grazed pastures in a “maintenance” state are likely to be fully meet from a single application of superphosphate applied at maintenance rate on the YBE soils of Northland.

The rate at which sulphur is applied from the atmosphere may be a major determinant of any sulphur requirements.

9.0 Laboratory Studies on Losses of Phosphorus, Sulphur, and Potassium from Te Kopuru Sand

D E Hogg and M Cooper
New Zealand Journal AgriResearch 7 (1963): 364-374

Overview

Previous studies on sandy soil have indicated that large losses of sulphur and phosphorus can occur. In addition Farm Advisory Officers have reported that low fertility conditions persist on these sandy soils despite applications of lime, superphosphate and potassium.

Method

Sample 0-75cm deep were collected from several sites as below and forwarded to the laboratory for analysis.

	Location	Dept pan	Description
Farm A	Mamaranui	15 cm	Sheep farm annually 500-600kg/ha 30% K Super
Farm B	Aoroa	30 cm	Dairy farm with fair pastures.
Farm C	Tataraiki	60 cm	Dairy farm with fair to good pasture.
Farm D	Mahuta		Sheep farm untopdressed danthonia pasture.
Farm E	Dargaville	20-30cm	Dairy farm with split applications spring & autumn total 750kg/ha K Super
Farm F	Te Kopuru	15-30cm	Dairy farm low fertiliser inputs and poor pastures.

Farm	pH	CEC	TEC	Ca	Mg	Na	K	% saturatn	Truog P	Avail S ppm
A	6.3	10.3	14.2	13.1	0.70	0.20	0.20	100*	22	4
B	5.1	14.3	5.3	4.0	0.85	0.18	0.24	37	4	8
C	5.2	13.6	6.7	5.4	0.83	0.28	0.19	49	5	6
D	5.7	8.3	3.9	3.1	0.48	0.19	0.15	47	3	1
E	5.3	26.7	12.2	10.7	0.90	0.23	0.42	46	11	15
F	5.8	17.8	5.8	5.1	0.48	0.16	0.12	32	11	4

Note: In sample A there was free lime present hence the 100% saturation.
Note: The K is below the accepted response level of 0.5me.
Note: The available P is below optimum (10) on B C and D.
Note: The response level for S is about 10 so all sites apart from E are low in sulphur.

Treatments: Phosphorus

Control
Superphosphate at equivalent to 500kg/ha
Basic slag at 585kg/ha with total p equal to the 500kg/ha of super

The amount of P that was leached was measured over 4 weeks on a weekly basis, as follows:

Farm	Fertiliser	% applied P leached
A	Super	36
	Basic slag	2
B	Super	1
C	Super	4
D	Super	1
E	Super	22
F	Super	2

Results

- The only appreciable losses of P were from A and E and both samples were from properties with a history of good rates of fertiliser.
- The leaching of P from the basic slag was low compared with the superphosphate.

Treatments: Potassium

Control
Potassium chloride (KCL) at a rate equivalent to 250kg/ha
Potassium bicarbonate (KHCO) equal to the K above
Potassium chloride + superphosphate at 375kg/ha

Farm	Fertiliser	% applied K leached
A	KCL	25
	KHCO	12
	KCL + Super	41
B	KCL	29
	KHCO	8
C	KCL	17
	KHCO	12
D	KCL	20
	KHCO	7
E	KCL	17
	KHCO	0
F	KCL	24
	KHCO	9

Results

- in all cases less K was leached where the K was applied as potassium bicarbonate
- the addition of superphosphate to the sample from farm A increased the amount of K leached.

Relationships Between P Loss and Phosphate Fixation

Farm	% P leached	% P fixation
A	36	Nil
B	22	12
C	4	29
D	2	22
E	1	32
F	1	47

Results

- The two samples with the lowest P fixation had the highest amount of phosphate leached.

Effect of Fertiliser Type on the Leaching of K, Mg, and S

Method

Farm B was considered typical Te Kopuru sand and so more samples were taken and the following treatments applied in the laboratory.

1. Control.
2. Potassium chloride (KCL) at a rate equivalent to 250kg/ha.
3. Potassium chloride (KCL) at 250kg/ha +superphosphate at 500kg/ha.
4. Potassium bicarbonate (KHCO) equal to the K above.
5. Potassium bicarbonate (KHCO) + superphosphate at 500kg/ha.
6. Potassium bicarbonate (KHCO) + 250kg/ha gypsum.
7. Potassium bicarbonate (KHCO) + 30kg elemental sulphur/ha.
8. Potassium bicarbonate (KHCO) + 30kg sulphur/ha +basic slag at 580kg/ha.
9. Potassium phosphate (KHPO) at a rate equal to 8.
10. Potassium phosphate (KHPO) +30kg sulphur/ha.
11. Potassium phosphate (KHPO) +30kg sulphur/ha+ basic slag at 580kg/ha +lime at 2.5 t/ha.

Results

Treatment	Fertiliser	% applied K leached
1	Control	
2	KCL	27
3	KCL + Super.	61
4	KHCO	5
5	KHCO + Super.	53
6	KHCO + Sulphur as gypsum.	25
7	KHCO + Sulphur at 28kg/ha	9
8	KHCO + Sulphur at 28kg/ha + Basic slag.	13
9	KHPO.	7
10	KHPO + Sulphur at 28kg/ha	11
11	KHCO +S +Basic slag + Lime.	16

- The addition of super markedly increased the leaching of K 3 compared with 2.
- Very little K was leached when supplied in the bicarbonate and phosphate form.
- The addition of super to KHCO negated the ability of this product to withstand leaching.
- K losses were only slightly increased by the addition of elemental sulphur.
- The addition of basic slag decreased the leaching losses of K.

<u>The effects of treatments 1-11 on the leached losses of Mg and S was measured as well</u>

- There was large initial displacement of Mg where KCL and KCL+Super were used.
- For the applications of KHCO the losses of Mg were much lower.
- Where superphosphate or gypsum was used the leaching losses of S were high up to 80% mostly in the first week.
- Where S was applied as elemental S leaching losses as the sulphur was oxidised increased each week but the total loss were smaller.

<u>The effect of alternative phosphate fertilisers on leaching of K</u>
As basic slag had little effect in accelerating losses of K from KHCO it was tested with KCL as well. Further samples were collected from farm E and other forms of phosphate tested as follows:

<u>Treatments</u>

1. Control
2. KCL at 250kg/ha
3. KCL at 250kg/ha + super at 500kg/ha.
4. KCL at 250250kg/ha + basic slag at 580kg/ha.
5. KCL at 250kg/ha + serpentine super at 670kg/ha.
6. KCL at 250kh/ha + Gafsa at 450kg/ha.

Note: the amount of P applied was the same for the super, basic slag, serpentine and Gafsa.

Results

Treatments	**% applied K leached**	**% applied P leached**
Control		
KCL	17	
KCL + super	45	15
KCL + Basic slag.	17	6
KCL + serpentine super	38	5
KCL + Gafsa	15	0

- Basic slag and Gafsa had no effect in increasing K losses.
- Serpentine super did accelerate K losses but to a lesser extent than superphosphate.
- P losses from basic slag and serpentine super were one third that of super with negligible losses from Gafsa.

Summary

- The laboratory technique used will exaggerate leaching losses, as there are no plants to counter the losses.
- It is assumed that if there were considerable leaching losses in the laboratory then some losses would occur in the field.
- The preference for basic slag by farmers may be due possible reduced losses of P and K as well as basic slag's liming value and molybdenum content.
- On Farm A with the greatest loss of P the pan is only 15cm from the surface, and is likely to suffer from water logging during the winter. This water logging may be a factor in the loss of P from some Northland soils.
- Leaching losses could be reduced by applying fertiliser in split dressings autumn and spring.
- The use of potassium phosphate as a fertiliser is a possibility.
- P loss may not be confined to sandy soils as a sample of Wharekohe silt loam has also shown large losses of P and S when leached in the laboratory.