

Growth to age 15 in the long-term  
rock-phosphate/superphosphate  
comparison trial: AK734

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# FRI/INDUSTRY RESEARCH CO-OPERATIVES

## EXECUTIVE SUMMARY

### ABSTRACT

This report outlines the results obtained from the Winter 1989 re-measurement of the AK 734 trial series. In this series of three trials ( at Riverhead, Waipoua and Tairua ) superphosphate is compared against three types of rock phosphate. The trials were established in 1978 when the trees were 4/5 and these results are from a measurement 11 years later. The trials were thinned in 1985 and this is the first re-measurement since that thinning. Unfortunately the Waipoua trial was very badly damaged by Cyclone Bola.

The main conclusions are:-

1. At both remaining sites the controls ( unfertilised plots ) are now significantly and markedly behind the fertilised plots. Growth in the fertilised plots has on average been 31 -34% better over the last four years than in the control.
2. Two rate of fertiliser were used, 75 and 150 kg/ha of P. There is no difference between these two rates indicating that the lower rate is useful.
3. Three types of rock P were used, ranging from extremely insoluble C-grade rock, through slightly more soluble Citraphos to A-grade rock. All these types are regarded as too insoluble for agriculture, however. At both sites A-grade rock and Citraphos have given as good a result as Superphosphate. C-grade gave a good result at Tairua but a very poor result at Riverhead.

Provided the granulation question can be solved, we, as an industry, can move with confidence to low-solubility rock phosphates for our P fertiliser requirements.

# Introduction

In 1978 three trials were established in 4/5 year old radiata pine. The trials compared four types of phosphorus fertiliser:-

1. Superphosphate
2. A grade rock phosphate from Christmas Island
3. C grade rock phosphate from Christmas Island
4. Citraphos; a calcined C grade rock.

There was a control, or unfertilised plot, in each replication.

The fertiliser was applied at two rates of P:-

1. 75 kg/ha
2. 150 kg/ha

The actual amounts of fertiliser applied per plot therefore varied because the elemental concentration of the fertilisers varied from 10% to 14.6% P.

There were three complete replications of this design at each site.

The trials were deliberately located on soils that had varying P retention. One trial was at Tairua (93% P retention); one at Riverhead ( 48% ) and the other at Waipoua ( 0% ). The P retention figures refer to the amount of phosphorus retained by a soil sample. The practical implications of this test are that soils like Tairua are expected to grab the orthophosphate molecule released by solubilising superphosphate and to turn it into insoluble aluminium- or iron-phosphate before the trees can get it. Soils like Waipoua are expected to be unable to retain P at all and to allow it to leach away.

There have been three Co-op reports and one published paper about the trial series to date. In the paper<sup>1</sup> the results up to three years after fertilising are given. At that time there was a significant response to P fertiliser at Riverhead with the more soil-soluble sources of fertiliser ( superphosphate and A-grade ) giving the biggest responses. At Waipoua the control was significantly poorer than the fertilised plots with no differences between the fertiliser types. At Tairua there were no fertiliser effects. By 1985, seven years after fertilising, Jeannette King showed<sup>2</sup> that the more soluble fertilisers had increased growth by 50% at Riverhead; by 20% at

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<sup>1</sup> Hunter I.R. and Graham J.D. 1983: Three year response of Pinus radiata to several types and rates of phosphorus fertiliser on soils of contrasting phosphorus retention. N.Z. J. Forest Science 13(2): 229-83.

<sup>2</sup> King J.M. 1988: Basal area and volume response of Pinus radiata to application of phosphorus fertilisers of varying solubility on sites displaying different degrees of phosphorus retention: 7 years after application. National Forest Fertiliser Co-operative Report No 33.

Waipoua and by 12% at Tairua. Seven years after fertilising, a biomass study<sup>3</sup> showed that approximately 10-15% of the applied P appeared to have been taken up by the trees. Malcolm Skinner has taken soils from the sites and has shown that an organic fraction of P seems to build up under the trees<sup>4</sup> and that fraction may be important in the continued nutrient supply from the soil.

In 1985 the three trial sites were thinned from establishment stocking down to approximately 375 s/ha. The Waipoua site was subsequently severely wind-blown in Cyclone Bola. Riverhead and Tairua were intensively re-measured in 1989 as part of the Co-op program. The site at Waipoua was visited to see if any useful measurements could be salvaged.

## Results of the 1989 winter remeasurement

### 1. Tairua

The results of measurements taken in 1985 both before and after thinning are given in Table 1. These results show that no treatment differences were significant at that time although a small difference between the controls and the fertilised plots appeared to be emerging. There was no difference between the types of fertilisers or amongst the two rates. By 1989 however a significant difference between the controls and the fertilised plots had occurred. Since thinning, the fertilised plots had on average grown 34% faster than the unfertilised plots. This means that there are some soils on which radiata pine grows well for up to 10 years without fertiliser only becoming P deficient in its teens. A similar result was observed in the AK286 series in the trial at Whangapoua<sup>5</sup>. There the trees grew very well for the first 8 - 10 years before the control began to fall progressively further behind. The Tairua and Whangapoua soils have some broad similarities, being derived from the weathering of old ash. This decline in growth after the time of maximum nutrient demand on the site, and after our biomass determination showed that the controls had been successful in acquiring satisfactory amounts of P, must imply an inefficiency or interruption to the cycling of P.

There was no difference between the fertiliser types. This too is most interesting. C-grade rock P is regarded as almost useless and inert by agriculturalists. There was no difference between the two fertiliser rates (75 & 150 kg/ha of P).

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<sup>3</sup> Hunter I.R., Hunter J.A.C., Graham J.D., Prince J.M., Nicholson G., and Robertson E 1987: Phosphorus Uptake of Radiata Pine on soils of different phosphorus retention, fertilised with superphosphate and A-grade rock. National Forest Fertiliser Co-operative Report No 16.

<sup>4</sup> Skinner M.F. and Nicholson G: 1988; Soil phosphates and the growth of radiata pine in Auckland and Northland. A report on the AK734 Series of trials in established stands. National Forest Fertiliser Co-operative Report No 23.

<sup>5</sup> Hunter I.R. and Graham J.D. 1982: Growth response of phosphorus-deficient Pinus radiata to various rates of superphosphate fertiliser. N.Z. J. Forest Science 12(1): 49-61

Table 1: AK 734 TAIRUA: Basal area in 1985

1. Between the control and all the fertilised plots

	Control	All fertilised plots	
	m2/ha		
Before thin	39.44	41.67	Significance
In thin	23.75	24.23	
After thin	15.69	17.44	
			17% NS

2. Amongst the fertiliser types

	Superphosphate	A-grade	C-grade	Citraphos	Significance
Before thin	41.68	43.62	40.87	40.49	19% NS
In thin	24.32	25.66	23.06	23.86	
After thin	17.36	17.96	17.81	16.63	

3. Between the fertiliser rates

	kg/ha of P		
	0	75	
Before thin	39.44	41.71	Significance of difference between 75 & 150
In thin	23.75	24.22	
After thin	15.69	17.39	
			93% NS

Table 2: AK 734 TAIRUA: Basal area in 1989

1. Between the control and all the fertilised plots

m2/ha		Significance
Control	All fertilised plots	
27.61	33.42	5% *

2. Amongst the fertiliser types

Superphosphate	A-grade	C-grade	Citraphos	Significance
33.23	35.73	32.5	32.21	51% NS

3. Between the fertiliser rates

kg/ha of P		Significance of difference between 75 & 150
0	75	
27.61	33.45	33.39 97% NS

## 2. Riverhead.

In 1985 there was a very strongly significant difference between the controls and the average of all the fertilised plots ( Table 3 ). There were also marked differences between the types of fertilisers. In contrast to Tairua, at Riverhead the fertilisers behaved as indicated by degrees of solubility. That is to say, the most soluble ( superphosphate ) did slightly better than A-grade, which in turn was better than Citraphos and the least soluble ( C-grade ) was the poorest and little better than the control. There was a weakly significant difference between the two rates of fertiliser with the higher rate being just 7% larger in basal area.

By 1989 the strong difference between the controls and the fertilised plots still remained. Since thinning the fertilised plots had grown 31% faster than the controls. Over the first 7 years Tairua trees grew much faster than those in Riverhead. Since thinning the controls have made very similar basal area increment at both sites. Three of the fertiliser types have now given similar growth ( superphosphate, A-grade and Citraphos ) with C-grade giving markedly poorer growth. So in one respect the two sites give a consistent answer: it is possible to fertilise radiata pine with poorly soluble rock phosphates such as A-grade rock and achieve good results. In another sense the two sites have given inconsistent answers: at one site the agriculturally-inert C-grade rock gave good results while at the other it gave almost no response. Why? It is also interesting that with time, at both sites, the less soluble fertiliser, A-grade, seems to be catching up and perhaps surpassing the most soluble fertiliser, superphosphate. It has been hypothesised that this would happen.

The difference between the rates now seems to be small.

Table 3: AK 734 RIVERHEAD: Basal area in 1985

### 1. Between the control and all the fertilised plots

	Control	m2/ha	All fertilised plots		Significance
Before thin	22.5		29.23		***
In thin	10.88		15.82		
After thin	11.62		13.41		4%

### 2. Amongst the fertiliser types

	Superphosphate	A-grade	C-grade	Citraphos	Significance
Before thin	31.98	29.72	25.91	29.32	0%
In thin	17.52	15.56	14.35	15.85	***
After thin	14.46	14.16	11.56	13.47	2%

### 3. Between the fertiliser rates

	kg/ha of P		Significance of difference between 75 & 150	
	0	75		
Before thin	22.5	28.25	30.22	4% *
In thin	10.88	15.16	16.48	
After thin	11.62	13.09	13.74	10% NS

NS



Table 4: AK 734 RIVERHEAD: Basal area in 1989

1. Between the control and all the fertilised plots

Control	m2/ha All fertilised plots	Significance
23.78	29.24	1% ***

2. Amongst the fertiliser types

Superphosphate	A-grade	C-grade	Citraphos	Significance
30.9	31.57	24.63	29.84	0% ***

3. Between the fertiliser rates

kg/ha of P		Significance of difference between 75 & 150	
0	75	150	
23.78	28.82	29.65	45% NS

### 3. Waipoua

The trial at Waipoua is a mess. Very few plots are completely without wind-throw. Many have only a few stems standing. In order to see if large differences had begun to emerge since

**Table 5:** Ratio of  $d^2$  in 1989 to  $d^2$  in 1985 for the Waipoua site of AK734

Treatment	Rate	Block		
		1	2	3
Control	0	1.99	2.18	2.02
A-grade	75	2.20	*	2.00
	150	*	*	1.96
Citraphos	75	2.21	2.00	2.32
	150	2.00	2.21	1.80
Superphosphate	75	*	2.24	1.80
	150	2.37	2.07	1.80

\* means no trees standing.

thinning the ratio of the diameter squared of trees standing in 1989 to their diameter squared in 1985 was calculated. The results are given in table 5. From these incomplete results, which cannot be statistically analyzed it is clear that no great changes have occurred in the trial since 1985. There is still, as there was then, very little difference between the treatments.