FRI Project Record No 2472

RESULTS FROM SEVERAL LONG-TERM FIELD TRIALS

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Report Number 47 July 1990

Note: Confidential to Participants in the National Forest Fertiliser Co-operative program.

EXECUTIVE SUMMARY

This report contains the results from several trial series maintained by the Co-op. The main points are as follows:-

1. The long-term P trial at Whangapoua:

   22 years after fertilising P deficient radiata pine with various amounts of Superphosphate fertiliser the volume gain is in excess of 350 m3/ha.

2. The nitrogen and potassium factorial in Waipoua:

   In a trial where N and K were applied to ten year old radiata pine shortly after thinning to 375 s/ha, there was a small response to N and no response to K. N concentrations varied between 1.2 and 1.7%. K concentrations varied between 0.5 and 0.6%. This trial confirms that K deficiency occurs below 0.6% in the foliage.

3. Rock phosphate at time of planting:

   Rock phosphate and Rock/super mix applied at time of planting have maintained adequate P concentrations in radiata pine foliage and good growth for 9 years. The rock/super mix was superior.

4. Whole tree thinning trials.

   Nitrogen fertiliser responses of a magnitude to be expected from foliar N concentrations have occurred. There has been no effect on residual stand growth from the varying levels of green material removal.

5. Interception of Fertiliser by weeds.

   The phosphorus contents of manuka, gorse and native grass/broadleaf weed associations have been doubled by P fertiliser applied to benefit the trees. The amounts taken up by the weeds are of the same magnitude as those taken up by the trees. The potential for competition clearly exists. Potassium concentrations in weed species were not so greatly affected by K fertiliser.

GROWTH OF RADIATA PINE IN THE LONG-TERM PHOSPHORUS FERTILISER TRIAL AT WHANGAPOUA

Introduction

A very detailed report on this trial to age 25 was distributed as National Forest Fertilising Co-operative report no 17. The management summary in this report said:-

1. Phosphorus fertilised trees produced, at age 25, the very satisfactory volume of 700 m3/ha. This shows that with appropriate management, good crops of radiata pine can be grown on P deficient soils.

2. The unfertilised plots lagged 270 m3/ha behind the fertilised plots.

3. The economic rate of return to fertilising exceeds 20% and is maximised by applying frequent light rates of fertiliser.

4. The best way to do this is to regularly foliage sample stands and apply fertiliser when growth falls :-

below 0.11% P for young crops up to age 16;

below 0.10% P for older crops.

The trial was re-measured in 1989 and the results of that measurement are presented here.

Methods

The trial is laid out in Compartment 13 of Whangapoua Forest. It was established in 1967 when the trees were 6 years old. Blocks 1 and 2 were fertilised in 1967. Block 3 was not fertilised until 1969. By 1989 the trees were 28 years old and had 22 years of fertiliser response.

There were 7 fertiliser treatments:-

1. No fertiliser
2. 625 kg/ha of superphosphate at trial establishment.
3. 1250 kg/ha of superphosphate at trial establishment.
4. 625 kg/ha at establishment and again after 10 years (625*2).
5. 625 kg/ha at establishment and again after 5,10,15 years (625*4) .
6. 625 kg/ha delayed for 5 years after trial establishment.
7. 625 kg/ha applied every time foliar P fell below 0.13% (625 foliar P).

Treatment 6 is only present in blocks 1 & 2. Treatment 7 is only present in blocks 2 & 3.

Results

1. Volume

Table I Volume at age 28

Treatment	Volume m3/ha Rep 1	2	3	Average	Stdev	GAIN
Control	337	614	351	434	156	
625	637	666	870	724	127	290
1250	876	710	920	835	111	401
625*2	806	828	789	808	20	374
625*4	871	845	831	849	20	415
625 delayed	713	796		755	59	321
625 fol P		936	721	829	152	395

Table 1 shows volume at age 28. The gain to fertiliser (as calculated from the PSP volumes) from the more successful treatments has now increased to between 370 and 415 m3/ha. The actual gain is probably higher than this since not all of the volume in the control plots is useable due to malformation. The gain from applying a light dose (625 at age 6) only once is only 290 m3/ha; while the gain from the delayed application of a light dose (625 at age 10) is only 321 m3/ha.

It is interesting to note that the three control plots have the greatest variability of all the treatments. The control in rep 2 has had the highest foliar P of all the reps, starting at 0.12% and declining to 0.09% recently. The controls in the other two reps have been at 0.08 or less since trial establishment. It is also interesting to note that repeated doses seem to cause greater uniformity (lower standard deviation) than single doses. The implication for forest management is that a more even stand results from repeated doses than from single larger applications.

Table 2 shows predominant mean height at age 28. The gain in height from the more successful treatments is 7 or 8 metres.

Table II Predominant mean height at age 28.

	PM	Height		metres	
Treatment		Rep			
	1	2	3	Average	GAIN
Control	27.3	38.0	32.3	33	
625	33.8	37.9	39.2	37	4
1250	40.6	39.5	39.4	40	7
625*2	41.4	38.1	37.8	39	7
625*4	41.9	38.6	40.4	40	8
625 delayed	35.6	38.8		37	5
625 fol P		41.4	38.1	40	7

SIX YEAR RESPONSE OF RADIATA PINE TO NITROGEN AND POTASSIUM FERTILISER IN WAIPOUA FOREST.

Introduction.

In 1980 staff of the Forest Service in Kaikohe said they wanted to establish an N-rates trial in an established stand in Waipoua. I said that we already had a network of such trials; that the answers they were giving were relatively consistent. I said, however, that we would be interested in collaborating in a potassium * nitrogen factorial trial.

Methods

The trial was established in 1981 in Cpt 8 Waipoua on a podzolised sand soil. The plots are adjacent to the rock phosphate trial AK734 which blew down in cyclone Bola. The trees were 10 years old and had just been thinned to a nominal 375 s/ha.

A basal dressing of 100 kg/ha of phosphorus was applied to all plots. The following treatments were then applied to the four replicates:-

1. No extra fertiliser
2. N as Urea at 200 kg/ha of N.
3. K as Muriate of Potash at 200 kg/ha of K.
4. K & N at above rate.

Soils were collected and analyzed before fertilising. Foliage was collected and analyzed in 1982 and 1983. The trial was re-measured in 1982, 1983 and 1986.

Results

1. Soil analysis

Table III Soil Physical and Chemical Analysis

Ph	Physical		%	Total N	BrayP	P retn	Bray cations meq		
	Sand	Silt	Clay				Ca	Mg	K
4.5	90	8	2	0.1	1 ppm	4%	0.02	0.43	0.08

Results of soil analysis are given in table III. These results show the soil to be: acid, sandy, very low in available P, low in available N and low in available cations. With the benefit of hind-sight and utilising information from other trials we would expect the trial to be N responsive, (any soil N below 0.15% is expected to carry N responsive trees). We would not now expect the trial to be K responsive (Soil K needs to be below 0.02 meq).

2. Foliage analysis.

The background application of phosphorus raised foliar P levels to well above the deficiency level. Results of the chemical analysis of foliage for nitrogen and potassium are given in Table IV. Nitrogen fertiliser increased foliar N markedly. By the second year trees in unfertilised plots had become N deficient. Potassium fertiliser increased foliar K levels strongly. The levels were raised more by K alone than N&K together. Foliar K levels in the control were marginal only.

3. Basal area response.

The gain to fertiliser is shown in Table V. There was a strongly significant nitrogen response, which appeared to be slightly greater in the absence of K. There was no statistically significant K response although the means differ slightly in favour of the K fertiliser. There appeared to be a slight negative interaction between the two fertilisers; when both were applied together there was no gain in growth over N alone.

Table IV Analysis of foliage for potassium and nitrogen: results from 1982 and 1983.

Element	Treatment	Rep 1	Rep 2	Rep 3	Rep 4	Mean
1982			% d.w.			
Nitrogen						
	Control	1.7	1.5	1.6	1.6	1.58
	N alone	2.2	2.2	1.9	2.2	2.14
	K alone	1.7	1.7	1.6	1.8	1.68
	N & K	2.4	2.6	2.0	2.5	2.38
Potassium						
	Control	0.50	0.39	0.61	0.44	0.49
	N alone	0.44	0.49	0.61	0.48	0.50
	K alone	1.06	0.96	0.86	0.93	0.95
	N & K	0.68	0.89	0.76	0.62	0.73
1983						
Nitrogen						
	Control	1.2	1.2	1.2	1.2	1.19
	N alone	1.4	1.4	1.5	1.4	1.45
	K alone	1.2	1.1	1.2	1.4	1.20
	N & K	1.3	1.6	1.6	1.5	1.50
Potassium						
	Control	0.59	0.62	0.87	0.58	0.66
	N alone	0.79	0.45	0.47	0.54	0.56
	K alone	1.02	1.14	1.19	1.24	1.15
	N & K	0.93	1.16	1.25	0.89	1.06

Table V Effect of nitrogen and potassium fertiliser on basal area.

	1982			1983			1986		
	No N	+ N	Sign.	No N	+ N	Sign.	No N	+ N	Sign.
N Fert	7.98	8.65	***	9.67	11.16	***	16.5	18.8	***
	No K	+ K	Sign.	No K	+ K	Sign.	No K	+ K	Sign.
K Fert	8.21	8.42	NS	10.34	10.49	NS	17.4	17.9	NS
N*K Fert	No K	+ K	Sign.	No K	+ K	Sign.	No K	+ K	Sign.
No N	7.77	8.19	NS	9.36	9.98	NS	15.8	17.2	NS
Plus N	8.64	8.65		11.32	10.99		19.1	18.5	

Conclusions

1. As expected from the soil analyses and from the 1983 foliage analyses, this stand responded strongly to N fertiliser.

2. Again, as expected from the soil and foliage analyses, this stand did not respond strongly to K fertiliser.

3. There was no interaction between N and K which was perhaps unexpected since the K concentrations in the foliage were close enough to marginal to be diluted by N application.

ROCK PHOSPHATE AND SUPERPHOSPHATE BROADCAST AT TIME OF PLANTING: RESULTS TO AGE 9 AT MAROMAKU

Introduction

AK 850/2 started life at time of planting as a series of 10 tree rows superimposed on plots with no basal fertiliser dressing and basal dressings of rock and rock/superphosphate mixture. At age 3 the main-plots were subdivided and half were re-fertilised with NPK. The trial was left completely unthinned and unpruned from its establishment stocking of approximately 1500 s/ha.

The treatments used on the main plots were:-

1. Control; no basal dressing of fertiliser
2. Rock phosphate at 1 tonne per hectare (approximately 125 kg of P)
3. Rock phosphate and superphosphate (0.5 tonne of each giving approximately 110 kg/ha of P).

Inside each main plot there were 16 ten tree rows - two repeats of 8 treatments of N, P and K starter doses at 5g active each. At age three one half of each main plot received 0.5 tonnes/ha of DAP.

Thus the trial shows the effect of basal dressings of rock phosphate over 9 years from time of planting, in conjunction with other fertiliser treatments.

Results

Results for both basal area and height growth are contained in table VI. There are three main conclusions:

1. Three treatments have given the same growth. They are the rock/super mix, with and without refertilising at age three and the rock alone with refertilising.
2. The rock alone treatment has basal area growth 19% poorer than those three. Height growth is only 6% poorer.
3. The completely unfertilised control has a basal area 68% poorer than the best three and height growth 31% poorer. Refertilising the control improved growth by nearly 100% but the basal area at age 9 in the refertilised control is still 39% poorer than the best three treatments.

Foliage analysis in 1988 revealed that the control was at 0.08% P; the rock treatment (not refertilised) was at 0.114%P and the rock/super (not refertilised) was at 0.12%.

Conclusions

The rock/super mix had a composition similar to modern PAPR fertilisers. These results show that it should be possible to broadcast PAPR fertilisers at planting and do away with refertilising at age 4. Less soluble forms of rock phosphate are also useful, but not as effective as the more soluble mix.

Table VI: Basal area and height growth in a rock phosphate/superphosphate trial from Tree-age 4 to tree-age 9 years.

Initial Treatment	Refert-ilising	Year	BA m2/ha REP 1	BA m2/ha REP 2	BA m2/ha Avge	Mean Ht REP 1	Mean Ht REP 2	Mean Ht Avge
Control	No	1984	2.14	2.60	2.37	3.3	3.5	3.40
		1985	3.89	6.32	5.11	4.3	5.1	4.70
		1986	5.24	9.51	7.38	5.4	6.5	5.95
		1987	6.82	12.7	9.80	6.4	8.1	7.25
		1989	11.7	20.0	15.87			
Control	yes	1984	3.00	3.24	3.12	3.7	3.7	3.70
		1985	8.03	8.06	8.05	6.2	6.1	6.15
		1986	13.2	12.7	12.9	8.1	8.3	8.20
		1987	19.0	17.4	18.2	9.7	10.5	10.1
		1989	30.1	30.2	30.22			
Rock	No	1984	7.12	5.44	6.28	5.2	4.4	4.80
		1985	16.6	12.0	14.3	7.9	7.0	7.45
		1986	24.8	17.2	21.0	10.0	8.9	9.45
		1987	31.9	22.2	27.1	12.0	11.0	11.50
		1989	47.5	34.0	40.75			
Rock	Yes	1984	9.53	6.48	8.01	5.3	4.5	4.90
		1985	20.7	15.1	17.9	8.0	7.4	7.70
		1986	30.3	22.6	26.5	9.8	9.3	9.55
		1987	39.0	29.6	34.3	12.2	11.4	11.80
		1989	56.3	46.0	51.23			
Rock/Super	No	1984	8.90	6.32	7.61	5.2	4.6	4.90
		1985	19.9	16.5	18.2	8.0	7.3	7.65
		1986	29.5	24.9	27.2	10.0	9.3	9.65
		1987	36.9	31.9	34.4	12.2	11.2	11.70
		1989	51.6	46.8	49.24			
Rock/super	Yes	1984	7.27	8.12	7.70	4.8	5.0	4.90
		1985	17.1	19.0	18.1	7.7	8.1	7.90
		1986	25.8	28.5	27.2	10.0	10.5	10.25
		1987	32.5	36.2	34.3	12.0	12.5	12.25
		1989	46.8	51.2	49.07			

The Whole Tree Thinning Trials: Results to 1990

Introduction

The three Whole Tree Thinning trials were established in 1986 (Woodhill) and 1987 (Tarawera and Crohane). At Woodhill and at Tarawera, three thinning removal intensities are present; total removal of stems and branches (whole tree), removal of stems only and waste thinning. At Crohane only whole tree and stem removal is present. Nitrogen fertiliser was applied in a factorial arrangement.

Results

1. Woodhill

Foliage samples were collected in 1987, 1988 and 1989 and analyzed for nitrogen content.
The nitrogen fertiliser treatment was strongly significant in 1987 only, raising nitrogen content from 0.955% by 0.5%. Thinning appeared to have an effect; the whole-tree treatment had a lower foliar N when fertilised. In 1988 and 1989 there were no significant effects on foliar N. The trial averaged 1.1% N in 188 and 1.0% in 1989. Thus it is strongly N deficient but the treatment appears to have had little effect on the degree of N deficiency.

Table VII Volume response to N fertiliser m3/ha.

		Year	
Treatment	1987	1988	1989
Without N	127.4	150.3	176.0
With N Fertiliser	132.4	165.9	213.0
GAIN	5.0	15.6	37

Volume growth has been strongly and significantly affected by N fertiliser (Table VII).
There has been no effect at all from thinning treatment on subsequent volume growth.

Tarawera

Nitrogen fertiliser had a significant effect on foliar N in 1988 at Tarawera raising the N concentration from 1.39% by 0.27%. The N fertiliser had a significant effect on growth by 1989 increasing volume by 8.1 m3/ha. There appears to be a weakly significant difference between thinning treatments (probability 0.06). The stem-only treatment appears (after covariance analysis) to give a higher volume than the other two treatments. However there is a relatively large covariance adjustment due to the fact that the stem-only harvest removed slightly more stems than planned, and the waste treatment left slightly more.

Crohane

Nitrogen fertiliser had a significant effect on foliar N in 1988 raising it from 1.55% by 0.1% only. Nitrogen fertiliser has had a weakly significant effect on volume growth, increasing volume by 6.1 m3/ha after 2 years. There was no growth difference between the two thinning treatments.

Conclusions

This suite of trials is behaving much as we would expect from our previous experience with N fertiliser. There is a large and useful N response at the most N deficient site (Woodhill), and progressively smaller N responses at the other two (less deficient) sites. Given that Woodhill is so N deficient it is perhaps surprising that the large N removal implicit in whole-tree thinning has not yet impacted growth. However we know from other work that the N release from both naturally falling and cut foliage is slow. Perhaps we should not expect an immediate impact from whole-tree thinning on growth.

Interception of Fertiliser by Weeds

Part of the Co-op program for 1989/90 was to assess the interception of applied fertiliser by plants in the understorey (weeds). Four trials were assessed. They were the special P uptake trials at Harakeke, and at Tairua; and parts of the K rates trials at Ngatahine and Rotu.

The weight of the weeds was assessed by cutting randomly located quadrats within the plots, drying the total mass and weighing it. A subsample was then analyzed for N,P,K,Ca, Mg and B. The weight was multiplied by the concentration and the interception determined by difference between fertilised and unfertilised plots.

Results

There was no significant difference in weed weight between fertilised and unfertilised plots. Therefore the nutrient concentration differences were multiplied by the average weight for each site.

Tairua

The weed weight at Tairua was 25.8 tonnes per hectare. The weeds were mainly tall grasses, manuka and native broadleaves. The treatments compared were a control, PAPR, and Superphosphate. There was a clear difference in P concentrations with P fertilised plots having weed P concentrations almost twice those of control plots. Calcium concentrations in weeds were also increased by P fertilising. N concentrations increased slightly. As a result P fertilising increased the N content of the weeds by 6%; the P content by 92% and the Ca content by 43%. The actual uptake of P averaged 7 kg/ha. This is a small percentage of the total applied but very close in magnitude to that probably taken up by the trees.

Harakeke

The weed weight at Harakeke averaged 38.8 tonnes per hectare of mostly gorse. The treatments compared were plus and minus P. Again P fertiliser more than doubled the P concentration in the weeds. Other nutrient concentrations were relatively unaffected. P uptake was increased by 13 kg/ha (147% increase).

Ngatahine

The weed weight at Ngatahine averaged 24.9 tonnes/ha of mainly manuka. The treatments compared were potassium fertiliser and potassium plus DAP. Concentrations of K in the weeds were increased slightly by K fertiliser. K fertiliser caused a slight increase in N and Ca concentrations. DAP fertiliser raised P concentrations to more than double and further increased both N and K concentrations. As a result 3 kg/ha of K was taken up following K fertilising alone but 17 kg/ha when DAP was applied in conjunction with K. No extra P was taken up following K fertilising but 9 kg/ha was taken up from DAP (an increase of 240%). N uptake increased by between 9 and 14%.

Rotu

At Rotu there was only 3.8 tonnes/ha of grass. The grass had been grazed so the uptake figures are affected by removals in stock. The treatments compared were potassium fertiliser and a control. There was almost no impact of fertiliser on nutrient concentrations. K fertiliser appeared to raise K concentrations in the grass by 5%.

Overall

Table VII Average nutrient concentrations in unfertilised weeds

	Nutrient concentration %d.w.					
	N	P	K	Ca	Mg	B(ppm)
Weed Type						
Tairua (grasses)	0.56	0.03	0.79	0.27	0.09	4.5
Harakeke (gorse)	0.90	0.02	0.37	0.21	0.14	15
Ngatahine (manuka)	0.33	0.03	0.33	0.50	0.10	10
Rotu (grass)	1.14	0.14	0.56	0.29	0.14	4.3

The different vegetation types had very different average nutrient concentrations (Table VII). The concentrations are not directly comparable with radiata pine foliage because woody material was also included from the weeds. Nevertheless, gorse and manuka seem to grow with very low nutrient concentrations of N and P by comparison with radiata pine.

The weed nutrient most affected by fertilising was P. Although the total amounts taken up by the weeds are small in relation to the amount applied, so is the amount taken up by the trees. It is not clear from these results whether any direct competition exists. However the potential clearly exists.