Project No.

MAGNESIUM DEFICIENCY IN RADIATA PINE: RESULTS OF TWO FERTILISER TRIALS AFTER THREE YEARS

by

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TABLE OF CONTENTS

MANAGEMENT SUMMARY

1. Magnesium deficiency symptoms are widespread in Radiata pine plantations throughout New Zealand. They have been seen in Northland, in Nelson, on the West Coast of the South Island and are most severe on the Central Pumice Plateau.

2. Severe deficiency areas occur sporadically . We cannot yet predict from soil analyses where they will appear.

3. In the only trial we had until recently, Dolomite fertiliser led to a slow but lasting improvement in growth. After 5 years trees were 60% bigger in both height and diameter.

4. We started another series of trials in 1984. The trials were at two sites :- one in 5 year old trees in Southern Kaingaroa with slight Mg deficiency symptoms, the other near Broadlands (Central North Island) in 5 year old trees planted over grass, where the trees were strongly Mg deficient.

5. The trial objectives were:
   - To determine the minimum rate of dolmite fertiliser.
   - To determine whether there is a more effective form of magnesium fertiliser.
   - To determine what effect pruning magnesium deficient stands has on tree growth
   - To determine whether pasture interferes with magnesium uptake

6. The results to date are:

- the Southern Kaingaroa site has behaved similarly to our initial experiment. Foliar magnesium has risen over the three years. There has been no growth increase after fertilising.

- the pasture site , at Broadlands, remained strongly deficient. Even rates of dolomite as high as 4 tonnes per hectare improved the magnesium status only slightly. However Epsom salts and fine ground calcined magnesite have improved foliar concentrations and growth slightly.

- height growth was sharply reduced following pruning. Pruning magnesium deficient trees is not advisable.

- boron concentrations in the foliage were reduced by increasing amounts of dolomite.

- at the Broadlands site the pasture took up nearly 25% of the applied fertiliser in a 3 month period. Foliar Mg in the trees improved less than in Waimihia . Clearly grass out-competes radiata pine for magnesium.

- magnesium deficiency places three restraints on management:- tree growth is slower, height growth is greatly reduced after pruning, and grazing opportunities are limited by radiata pines inability to compete for Mg.

- our existing recommended treatment of 1 tonne of dolomite is slow to take effect. It could be used as a pre-emptive treatment at time of planting on forest sites but Mg deficiency is not widespread enough to justify a general fertiliser application costing $200 per hectare. Morover we cannot yet predict on the basis of soil tests where deficiency will occur. We do not have a completely effective treatment for magnesium deficiency over grass. However it appears that the more soluble forms of fertiliser are more effective.

INTRODUCTION

Our initial trial, RO 1814, showed that substantial gains in tree growth could be achieved by correcting magnesium deficiency with 100 kg/ha of magnesium, mainly as dolomite. However dolomite was slow to react in the soil and slow to correct the deficiency.

The slow response to applied fertiliser and the high (expensive) rate that had been used prompted a search for a lower rate and alternative fertiliser sources. A chance observation of an apparently severe side effect of pruning magnesium deficient trees prompted the inclusion of pruning in new trial treatments.

Two sites were chosen. There was marginal or strong magnesium deficiency existing at both sites :- one was in Cpt. 615 Waimihia Forest (RO2002/2) in a normal Southern Kaingaroa site and the other in a stand of trees near Broadlands (RO2002/1).The Broadlands site was over good pasture grass. The trials were established in November 1984.

METHODS.

The experiments consisted of a randomised block design with four rates of dolomite. The rates have been designed to be linear on a log scale and are as follows:-

Tmt No.	Treatment.	
1	Mg 0	- no fertiliser
2	Mg 20	- 20 kg/ha (200 kg dolomite)
3	Mg 55	- 55 kg/ha (550 kg dolomite)
4	Mg 150	- 150 kg/ha (1500 kg dolomite)
5	Mg 400	- 400 kg/ha (4000 kg dolomite)

In addition, at each site, a further 5 plots to which different formulations of Mg (coarse ground calcined magnesite, fine ground calcined magnesite, serpentine, Keiserite, and Epsom salts) were applied at the rate of 55 kg/ha Mg rate.

Tmt No.	Treatment
6	Keiserite - 55 kg/ha (elemental)
7	Epsom salts _ 55 kg/ha (elemental)
8	Calc. mag (coarse) - 55 kg/ha (elemental)
9	Caus. mag. (fine) _ 55 kg/ha (elemental)
10	Serpentine - 55 kg/ha (elemental)

R02002/1 BROADLANDS - Planted 1979.

Two replications of each of the above treatments i.e. 20 plots plus a further 4 plots (2 each of Mg 0 and Mg 55) with total grass control were established.

Half of each mainplot received pruning up to 2.0 metres, so that the effects of pruning on tree growth could be monitored.

Plot size = 50 x 30 metres with each subplot 18 x 20 metres.

Sheep grazed through the site on several occasions. They were left in the fenced off trial area for a few days at a time.

In each of 6 plots (2 of Mg 0, 2 of Mg 55, and 2 of Mg 400 - non-grass control), three grazing exclusion frames were placed in the pruned subplot. The purpose of these frames was to exclude sheep grazing. They were left for 3 months, from November 1985 to February 1986 after which a pasture biomass and chemical analysis was performed.

Grass was completely sprayed out of 4 plots (2 each of Mg 0 and Mg 55) using Round-Up.

R02002/2 WAIMIHIA FOREST - Planted 1979.

Two replications of each of the 10 treatments were established.

Pruning of the subplots was to about 1.6 metres (as the trees were smaller than Broadlands).

Each subplot was 0.0144 hectares.

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RESULTS.

1. A Genstat analysis was performed on basal area and mean height. The responses to the pruned and unpruned treatments are shown in Tables 1 and 2.

TABLE 1. R02002/1 BROADLANDS.

BASAL AREA (m2/ha)
(adjusted for covariate)

Trmt	1984	1985 Unpruned	1985 Pruned	1986 Unpr	1986 Pruned	1987 Unpr	1987 Pruned
Control		5.32	4.97	9.72	8.86	14.81	12.92
Dolomite rates							
200 kg dolomite		5.15	4.78	9.31	8.44	14.11	12.36
550 kg dolomite		5.27	4.58	9.76	7.91	15.03	11.69
1500 kg dolomite		5.14	4.88	9.25	8.48	14.14	12.31
4000 kg dolomite		5.30	4.75	9.63	8.35	15.19	12.34
Magnesium types @ 55 kg of Mg							
Keiserite		5.32	5.39	9.53	9.70	14.67	14.46
Epsom salts		5.29	5.39	9.63	9.79	15.02	14.82
Coarse calmag		5.86	4.88	10.94	8.26	17.06	12.06
Fine calmag		5.40	4.87	9.89	8.41	15.31	12.37
Serpentine		5.43	4.88	9.78	8.34	14.72	12.10
Grand mean	2.60	5.46	5.08	9.96	8.90	15.04	12.74
Difference		0.38		1.06		2.30	
Reduction in growth due to pruning alone as % of growth from 1984		13.2		14.4		18.4	

TABLE 1 Continued.

HEIGHT (m)
(adjusted for covariate)

Trmt	1985 Unpruned	1985 Pruned	1986 Unpr	1986 Pruned	1987 Unpr	1987 Pruned
Control	5.63	5.19	7.27	6.81	9.33	8.85
Dolomite rates						
200kg	5.37	5.09	7.07	6.52	8.97	8.16
550kg	5.51	5.15	7.20	6.63	9.13	8.68
1500kg	5.41	5.10	6.85	6.48	8.88	8.29
4000kg	5.40	5.16	7.08	6.35	9.13	8.32
Magnesium types @ 55 kg Mg						
Keiserite	5.66	5.29	7.31	6.87	9.16	8.77
Epsom salts	5.51	5.22	7.18	6.81	9.33	8.68
Crse Calmag	5.60	5.37	7.12	6.81	8.96	8.61
Fine Calmag	5.68	5.32	7.55	6.78	9.40	8.68
Serpentine	5.30	5.25	7.12	6.94	8.86	8.69
1984 Grand mean 4.17	5.55	5.29	7.26	6.83	9.11	8.58
Difference	0.26		0.43		0.53	

Reduction in growth due to pruning as % of growth since 1984

	1985	1986	1987
	18.8	13.9	10.7

TABLE 2. R02002/2 WAIMIHIA FOREST.

BASAL AREA (m2/ha)
(adjusted for covariate)

Trmt	1985 Unpruned	1985 Pruned	1986 Unpr	1986 Pruned	1987 Unpr	1987 Pruned
Control	8.81	8.39	14.53	13.21	20.43	17.78
Dolomite rates						
200 kg	8.49	8.43	13.66	13.35	19.17	18.49
550 kg	9.05	8.47	14.97	13.43	20.71	18.46
1500 kg	8.83	8.52	14.51	13.50	20.23	18.88
4000 kg	8.57	8.07	14.08	12.76	19.74	17.63
Magnesium types @ 55 kg of Mg						
Keiserite	9.24	8.92	14.74	13.66	20.56	18.73
Epsom salts	9.38	9.08	15.15	13.71	21.33	18.88
Crse Calmag	8.97	8.52	14.74	13.61	20.96	18.30
Fine Calmag	9.62	8.95	16.02	14.37	22.50	19.89
Serpentine	9.11	8.85	14.78	13.93	20.30	19.17
1984 Grand mean 5.33	8.75	8.38	14.35	13.25	20.59	18.86
Difference	0.37		1.10		1.72	
Reduction as % of growth	10.8		12.1		11.3	

TABLE 2 continued

HEIGHT (m)
(adjusted for covariate)

Trmt No.	1985 Unpruned	1985 Pruned	1986 Unpr	1986 Pruned	1987 Unpr	1987 Pruned
Control	4.63	4.50	5.91	5.84	7.50	7.32
Rates of dolomite						
200 kg/ha	4.71	4.60	6.04	5.89	7.60	7.27
550 kg/ha	4.69	4.50	6.21	5.85	7.58	7.36
1500 kg/ha	4.59	4.57	6.07	5.99	7.54	7.32
4000 kg/ha	4.68	4.43	6.03	5.67	7.42	7.18
Types of magnesium @ 55 kg/ha						
Keiserite	4.68	4.52	6.12	5.86	7.52	7.33
Epsom salts	4.72	4.59	6.22	5.90	7.63	7.38
Crse Calmag	4.68	4.56	6.20	6.00	7.58	7.35
Fine Calmag	4.62	4.57	6.22	5.97	7.72	7.52
Serpentine	4.62	4.44	6.20	5.95	7.67	7.30
1984 Grand mean 3.68	4.66	4.52	6.05	5.85	7.58	7.34
Difference	0.14		0.20		0.24	
Reduction as % of growth	14.3		14.4		6.2	

There was no effect of dolomite rates or fertiliser type on either height growth or basal area growth at Waimihia. However at Broadlands the most soluble magnesium fertilisers , Epsom salts Keiserite and fine ground magnesite are having a small , significant positive effect on growth.

2.

TABLE 3. Pasture dry matter weights and magnesium concentration in R02002/1.

Treatment	g/m2		mg%	
Mg 0	1013)	) 1192	0.205)	) 0.194
	1371)		0.183)	
Mg 55	1257)	) 1268	0.275)	) 0.287
	1279)		0.298)	
Mg 400	1310)	) 1344	0.306)	) 0.298
	1377)		0.290)	

From Table 3 it can be concluded that there was little effect on the pasture dry matter production with increased applications of magnesium fertiliser but the tissue analyses show a 50% increase in pasture magnesium concentration between the unfertilised and fertilised plots.

3. A genstat analysis shows that the grass is taking up appreciable and significant amounts of magnesium - see Table 4.

TABLE 4. Magnesium content in kg/ha.

Control 0 kg/ha	Mg 55	Mg 400
22.93	36.34	40.01

The uptake, by difference, is equivalent to just under 25% of the applied fertiliser at the lower rate.

4. A Genstat analysis was performed on foliar concentrations of N, P, K, Ca, and Mg.

Results are as follows;-

Nitrogen, phosphorus, potassium and calcium no effect of treatment.

Mean values for each site are given in Table 5.

Table 5. Mean values of foliar N,P,K,Ca

Site	N	P	K	Ca
Waimihia	1.38	0.15	0.74	0.15
Broadlands	1.59	0.20	1.08	0.16

The higher N.P.K status at Broadlands is expected on a farmland site and would normally be associated with increased growth.

The results of the treatments on foliar magnesium are shown in Table 6 for R02002/1 and Table 7 for R02002/2.

TABLE 6. Foliar magnesium - R02002/1, Broadlands.

Treatment		1986 Unpruned	1986 Pruned	1987 Unpruned	1987 Pruned
1	Mg 0	0.062	0.064	0.67	0.56
2	Mg 20	0.057	0.067	0.65	0.63
3	Mg 55	0.066	0.064	0.65	0.72
4	Mg 150	0.066	0.064	0.63	0.61
5	Mg 400	0.070	0.065	0.75	0.67
6	Keiserite	0.067	0.080	0.66	0.66
7	Epsom salts	0.074	0.081	0.81	0.71
8	Calc. mag.	0.059	0.065	0.64	0.57
9	Caus. mag.	0.067	0.077	0.72	0.65
10	Serpentine	0.077	0.070	0.71	0.58

By 1987 pruning had had a strong depressing effect on foliar Mg averaging 0.005% Mg. There is a significant effect of fertiliser treatment, with a weak positive effect of dolomite rates and a strong effect from the more soluble Mg types such as Epsom salts, Keiserite and fine ground Causmag. The growth effects from the soluble fertilisers are already showing through and we can expect some growth effect from the dolomite rates to occur soon.

TABLE 7. Foliar magnesium - R02002/2, Waimihia.

		1986		1987	
Treatment		Unpruned	Pruned	Unpruned	Pruned
1	Mg 0	0.086	0.098	0.094	0.074
2	Mg 20	0.107	0.106	0.083	0.085
3	Mg 55	0.094	0.097	0.095	0.087
4	Mg 150	0.097	0.104	0.097	0.097
5	Mg 400	0.100	0.098	0.115	0.102
6	Keiserite	0.097	0.099	0.097	0.088
7	Epsom salts	0.097	0.105	0.093	0.090
8	Calc. mag.	0.100	0.095	0.090	0.088
9	Caus. mag.	0.088	0.094	0.097	0.089
10	Serpentine	0.085	0.096	0.091	0.078

Dolomite in increasing amounts has increased foliar Mg from 0.084 to 0.11%. In 1987 pruning significantly depressed foliar Mg by 0.008%. More soluble forms of Mg improved foliar Mg.

Boron concentrations were also significantly affected by treatment. Increasing amounts of dolomite had a depressing effect (Table 8). This effect has been noticed in agriculture and is due to the "liming" effect of dolomite. Boron is less available when pH is increased. At both trials the reduction was 3 ppm however at Waimihia it was from a marginal to a deficient level and therefore more worrying.

Table 8. Effect of dolomite rates on foliar B

Foliar B ppm

Site	Dolomite rate				
	0	200	550	1500	4000
Waimihia	8.3	7.3	7.5	6.0	5.5
Broadlands	10.8	10.0	9.3	8.3	8.3

The other sources of Mg seem to have had a less pronounced effect on foliar B than the dolomite.

Table 9. Effect of different sources of Mg on foliar B

Foliar boron ppm

Site	Keiser.	Epsom.	Coarse Calm.	Fine Calm.	Serp.
Waimihia	7.3	7.3	8.3	8.5	8.5
Broadlands	10.0	9.8	8.8	9.0	12.3

CONCLUSIONS

Overall, Broadlands is more strongly Mg deficient than Waimihia. Pruning had a marked effect on the basal area and height response in both trials, with Broadlands having the greater reduction.

In 1986 the application of fertiliser had had no significant effect on the tree foliar magnesium content, at R02002/1 (Broadlands) but in 1987 a weak effect of dolomite rates and a stronger effect from some of the more soluble fertilisers was beginning to emerge.

In 1986 R02002/2 (Southern Kaingaroa) showed a slight foliar effect to the application of magnesium fertiliser. In 1987 the effect was stronger and clearly related to amount of dolomite applied.

A tree growth response has begun to emerge at the Broadlands site in response to the more soluble magnesium fertiliser types.

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