FUTURE FORESTS RESEARCH

RADIATA MANAGEMENT
TECHNICAL NOTE
Site Productivity

Number: RSPTN-008
Date: September 2011

Nitrogen and Phosphorous Responses in Mid-rotation Stands of *Pinus radiata*

Summary

Trials were designed to quantify responses of the mid-rotation radiata pine stands to nitrogen (N) and phosphorous (P) fertilisers on a range of sites, including those with contrasting rainfall.

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SITE LOCATION AND SOIL PROPERTIES

FR467/1-2 trials are located approximately 16 km and 30 km northwest of Dargaville, while FR467-5 is at the junction of Pekepeke and Kiorenui roads, in Kaingaroa Forest. FR467/3-4 trials are about 35 km and 45 km southwest of Richmond (South Island). The properties of surface soil (0-10 cm) are listed in Table 1.

EXPERIMENTAL DESIGN

Treatment: For all 5 trials (FR467/1-5), a 2×2 factorial design of the following treatments (with 3 replicates in blocks) is used:

- rates of N (added as urea) at 0 and 200 kg N/ha,
- rates of P (added as triple superphosphate) at 0 and 75 kg P/ha

Two additional treatments (without replication) were assigned to FR467-1 and FR467-4 only:
(1) No fertiliser + weed control;
(2) 200 kg N/ha + 75 kg P/ha + weed control

There were a total of 14 plots for FR467/1 and 4, 12 plots for FR467/2, 3 and 5. Blocking was based on the mean tree basal area increment during 2003-04.

Outer plot size: 40-50 × 40-50 m, **inner plot size:** 20-30 × 20-30 m.
Tree stocking rate: 400-600, 350-480, 200-320, 350-670 and 336-512 sph in FR467-1 to FR467-5, respectively.
Trial established: FR467/1-4 on Sep. 2003, FR467-5 on Oct. 2006.
Fertiliser applied: FR467/1-4 on Sept. 2004, FR467-5 on Nov 2007.

MEASUREMENT AND ANALYSIS

Tree growth (DBH and height) was measured annually from 2003 to 2008, and the mean annual increments of tree basal area (BA) and volume for each plot were calculated. Foliar samples were collected and analysed annually from 2004 to 2008. Due to storm damage, tree growth was not measured at FR467/4. The data were analysed using the GLM procedure in SAS for main effects of N and P fertilisers, and the interaction of N × P fertilisers on tree growth and foliar nutrient concentrations.

RESULTS

Foliar Nutrient Concentrations in 2008

At site FR467-1, the foliar P level was low, and N and Mg levels were marginal, while the other nutrients were satisfactory for the control plot (i.e., N_0P_0). N application (main effect) had no significant effect on foliar nutrient concentrations. P application (main effect) significantly (P<0.05) increased foliar P, but reduced foliar Ca and Mg concentrations. The interaction of N×P was not significant for all foliar nutrients (Table 2).

At site FR467-2, both foliar N and P levels were low, and both Cu and Zn levels were marginal while the other nutrients were satisfactory for the control plot (i.e.N_0P_0). N application (main effect) significantly (P<0.05) reduced foliar Ca concentration. P application (main effect) significantly (P<0.05) increased foliar P, but reduced foliar Mg concentration. There was no significant interaction of N×P for foliar nutrient concentrations (Table 2).

At site FR467-3, foliar N level was marginal while the other nutrients were satisfactory for the control plot (i.e. N_0P_0). Forty-two months after treatment (2008), N or P application (main effect) had no significant effect on foliar nutrient concentrations. There was no significant interaction of N×P on foliar nutrient concentrations (Table 3).

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Table 1. Selected soil properties (0-10 cm) of five trials

Site	Plant	Soil Type	pH	Total C %	Total N %	Bray P (mg/kg)
FR467-1 Whatoro	1987	Waimatenui clay	4.8	10.5	0.78	25.4
FR467-2 Mamaranui	1982	Tangitiki sandy loam/Te Kopuru sand	4.4	3.41	0.12	6.75
FR467-3 Kainui	1988	Spooner/Motupiko gravelly loam	5.2	6.47	0.51	52.8
FR467-4 Golden Downs	1989	Korere hill soil, silt loam	4.8	4.83	0.19	28.0
FR467-5 Kaingaroa	1992	Pekepeke sand/ Pekepeke hill soil	5.3	4.3	0-16	23.0

Table 2. Effect of N and P fertilisers on foliar nutrient concentrations in 2008 at trials FR467-1 and 2

Site	Year/ Treat	N %	P %	K %	Ca %	Mg %	Cu mg/kg	B mg/kg	Mn mg/kg	Zn mg/kg
FR467-1	2005	1.8	0.14	0.90	0.14	0.09	5.5	22	130	31
	2006	1.6	0.11	0.86	0.12	0.09	4.7	22	106	29
Control	2007	1.4	0.12	0.84	0.17	0.09	5.3	21	121	27
plot	2008	1.5	0.12	0.86	0.24	0.09	4.6	19	157	27
N or P	N0	1.5	0.12							
main	N200	1.5	0.12							
effect	P0	1.5	**0.11 b**		**0.22 a**	**0.09 a**				
	P75	1.5	**0.13 a**		**0.17 b**	**0.07 b**				
FR467-2	2005	1.6	0.16	0.73	0.21	0.17	3.5	26	195	20
	2006	1.1	0.13	0.77	0.20	0.16	2.3	26	135	17
Control	2007	1.0	0.12	0.83	0.27	0.18	4.0	27	162	11
plot	2008	1.0	0.11	0.64	0.41	0.16	3.0	26	279	11
N or P	N0	1.1	0.14		**0.41 a**					
main	N200	1.2	0.12		**0.30 b**					
effect	P0	1.1	**0.11 b**			**0.17 a**				
	P75	1.1	**0.15 a**			**0.15 b**				

At site FR467-5, foliar N was low, and Mg, Cu and B levels were marginal while the other nutrients were satisfactory for the control plot (i.e., N_0P_0). Four months after treatment (2008), N application (main effect) significantly (P<0.05) increased foliar N, but reduced foliar B concentrations. P application (main effect) had no significant effect on foliar nutrient concentrations. There was no significant interaction of N×P on foliar nutrient concentrations (Table 3).

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Table 3. Effect of N and P fertilisers on foliar nutrient concentrations in 2008 at trials FR467-3 and 5

Site	Year/ Treat	N %	P %	K %	Ca %	Mg %	Cu mg/kg	B mg/kg	Mn mg/kg	Zn mg/kg
FR467-3	2005	1.8	0.18	0.84	0.31	0.15	3.5	20	98	29
	2006	1.4	0.16	0.71	0.20	0.14	4.0	19	99	31
Control	2007	1.4	0.17	0.84	0.18	0.11	4.3	23	86	27
plot	2008	1.4	0.14	0.70	0.41	0.13	4.7	19	151	21
N or P	N0	1.4	0.15							
main	N200	1.4	0.13							
effect	P0	1.4	0.14							
	P75	1.4	0.14							
FR467-5										
Control	2007	1.3	0.17	1.00	0.13	0.09	5.4	13	215	30
plot	2008	1.1	0.16	0.91	0.13	0.09	3.8	11	210	34
N or P	N0	**1.2 b**	0.16					**12 a**		
main	N200	**1.4 a**	0.15					**10 b**		
effect	P0	1.3	0.16							
	P75	1.3	0.16							

Tree Growth in 2008

Across four sites, both N and P fertilisers had no significant effect on basal area (BA) increment (Fig. 1-2), despite a 22% increase with N application (Fig. 1). There were no significant weed control (WC) effects and WC by N or P interactions (Fig. 3). However, the P fertiliser main effect was significant (P<0.05) on tree volume (Fig. 4).

When data were analysed separately for each site, a significant (P<0.05) N fertiliser effect was only found at Kaingaroa (FR467-5) for BA increment (Fig. 5). There were no significant effects of P fertiliser (Fig. 6) or N by P interactions at each site.

CONCLUSIONS

- In mid-rotation forests, N and P fertilisation could increase foliar N and P concentrations dependent on site conditions.
- About four years after application, P fertiliser still improved foliar P nutrition of radiata pine at Whatoro and Mamaranui sites. However, the residual effect of N fertiliser didn't last so long.
- P fertilisation overall improved tree volume by 5% four years after fertilisation.
- The large growth response to N fertilisation at Kaingaroa site was related to the low foliar N level in the control plots.

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Fig 1. N fertiliser main effect on BA increment

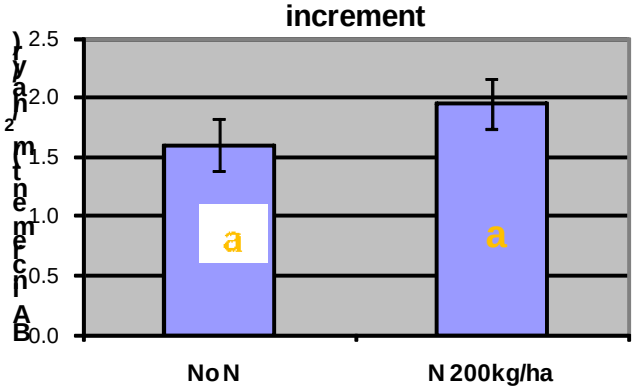


Fig 2. P fertiliser main effect on BA increment

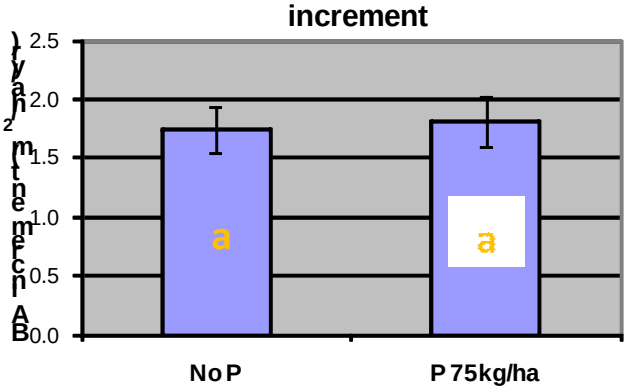


Fig 3. Treatment effect on BA increment

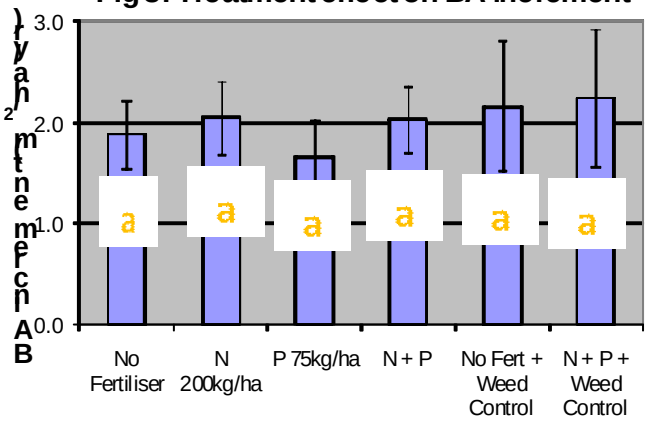
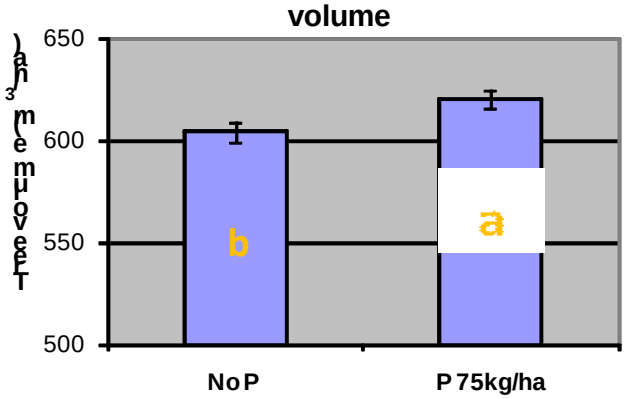


Fig 4. P fertiliser main effect on tree volume



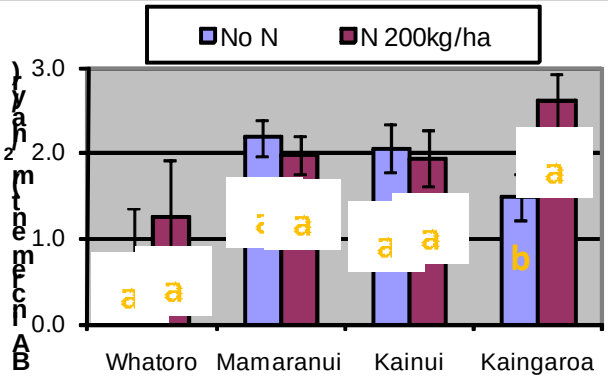


Fig 5. N fertiliser effect on BA increment at 4 sites

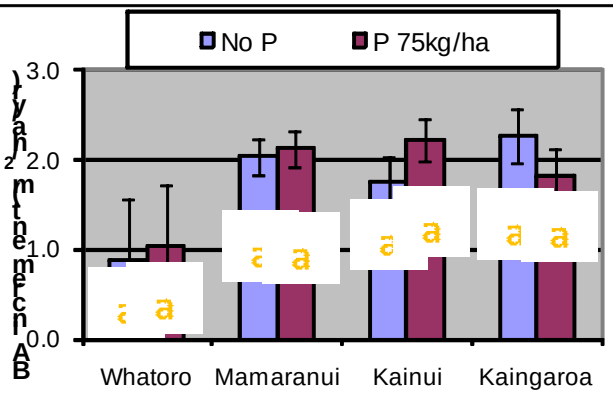


Fig 6. P fertiliser effect on BA increment at 4 sites

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