FR257 Douglas-fir Nutrition Trial: Foliar Nutrient Levels and Growth Effects Four Years After Fertilising

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NZ Douglas-fir Cooperative

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NEW ZEALAND DOUGLAS-FIR COOPERATIVE

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ABSTRACT

A fertiliser trial was established in 10-year-old Douglas-fir standing at 1310 stems/ha.

Treatments were:

(1) control
(2) phosphorus
(3) P + nitrogen
(4) P + N + magnesium
(5) P + N + Mg + boron

Foliar nutrient levels fluctuated from year to year but there was an overall trend for added nutrients to increase concentration.

There were no significant growth responses, over the four years, to any fertiliser treatment.

FR257 DOUGLAS-FIR NUTRITION TRIAL: FOLIAR NUTRIENT LEVELS AND GROWTH EFFECTS FOUR YEARS AFTER FERTILISING (AGE 14)

INTRODUCTION

A paucity of information on the likely response of Douglas-fir (*Pseudotsuga menziesii*) to added nutrients on typical central North Island pumice soils lead to the establishment of this trial in 1995 (Payn and Graham 1996). Decisions on the fertiliser treatments were based on recorded deficiencies of nitrogen, phosphorus, magnesium and boron in various stands of *Pinus radiata* in the region.

At that time little was known about interpreting critical nutrient levels in Douglas-fir foliage. Using the values published by Reuter and Robinson (1997) it now appears that the site should have been adequate for N, P, Ca, Cu, Zn and Mn and marginal for K, Mg and B. Our sampling strategy at the time was to collect foliage in late summer/early autumn. The now recommended mid-winter sampling (Graham and Kimberley 2003) may have given slightly different results.

The main thrust of this report is to analyse responses in foliar nutrition and growth from the pre-treatment assessment in 1995 through to 1999. In addition, the results of a 2004 foliage collection are presented.

THE TRIAL SITE

Location:	Cpt 657.01 of Kaingaroa Forest. NZMG 2795400mE 6252800mN.
Altitude:	800m
Rainfall:	About 1700mm p.a., fairly well distributed.
Soil type:	Oruanui sand, comprising Kaharoa and Taupo ashes, over lapilli on a greywacke basement.
Topography:	Slopes are in the range of 5 - 10 degrees but the landform would best be described as "lumpy". The aspect is northwest.
Current crop:	Planted in 1985 as 2/0 Cambridge stock (seedlot 4/2/82/002, origin Fort Bragg) at 4.0m x 1.8m (1389 s/ha). At trial establishment (1995) stocking of individual trial plots varied between 925s/ha and 1725s/ha with a mean of 1310s/ha.
Understorey:	Very little, grasses where there is sufficient light.

TRIAL DESIGN

Design is a randomised complete block consisting of four replications of the following five treatments:
1- No added fertiliser.
2- Phosphorus (P) at 75kg/ha as North Carolina rock phosphate.
3- P+ nitrogen (N) at 200kg/ha as urea.
4- P+N+ magnesium (Mg) at 200kg/ha (100 as calcined magnesite,100 as epsom salts).
5- P+N+Mg+ boron (B) at 6kg/ha as ulexite.

Plot size is 40x40m containing a measurement plot of 20x20m.
Blocking was done on mean tree b.a. after initial measurement.

Surveying and initial measurement of the plots were carried out over June - August 1995 (age 10).
Fertiliser materials were applied by hand in late September.

METHODS

(a) Foliage Sampling

Foliage was taken from second order branches in the well-lit upper portion of the crown.
From 1995 to 2000, collection was done with pole-mounted cutters or by climbing during late summer/early autumn. The winter 2004 collection was achieved by shooting down appropriate branches.

On each occasion 10 trees were sampled. All samples were oven dried and analysed by the Forest Research laboratory.

(b) Measurements

On all trees, diameter at breast height (1.4m) was measured on each occasion. Stems that forked below breast height were treated as two (or more) separate trees.

Twelve trees in each plot were measured for total height. Where tree form permitted, the same height sample trees were used each time.

Plot calculations of mean top height, basal area and volume were done by the Forest Research Permanent Sample Plot (PSP) system. Site Basal Area Potential (SBAP), Site Index (SI) at age 40 and the 500 Index (volume mean annual increment at age 40 under a standard stocking of 500 stems per hectare) were calculated from the basic data. SBAP is an index of a site's ability to support basal area growth. It can be site, forest or region-specific and needs to be determined *a priori* from growth data (Knowles and Hansen 2004).

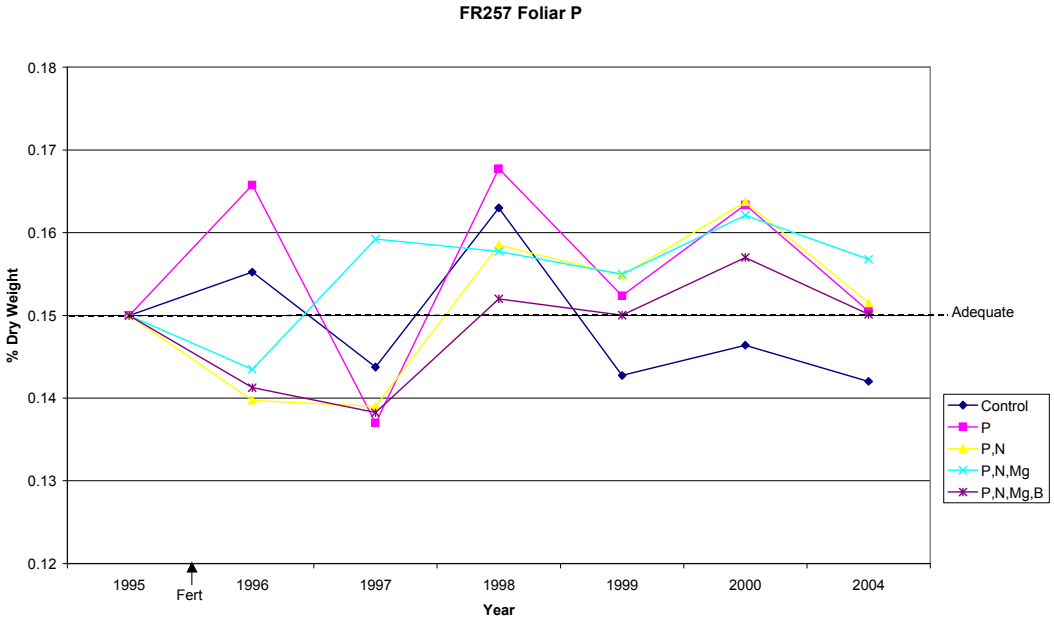
RESULTS

(a) Trends in Foliar Nutrient Concentrations

The following seven figures illustrate the change in foliar levels of phosphorus (P), nitrogen (N), potassium (K), magnesium (Mg), calcium (Ca), boron (B) and copper (Cu). There are no B or Cu data available for 1998.

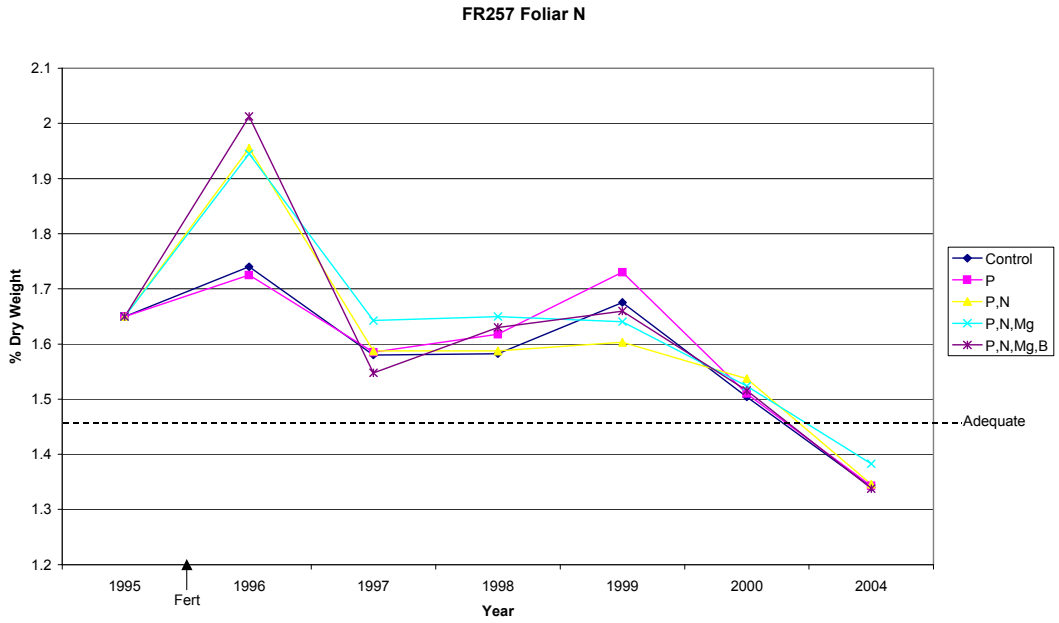
Added phosphorus has increased foliar concentration though there was an early dilution effect of treatments containing nitrogen as well. After stabilising again, all treatments except the control maintained adequate levels of P

Fig 1: Douglas-fir foliar phosphorus (percent of oven-dry weight) in FR257



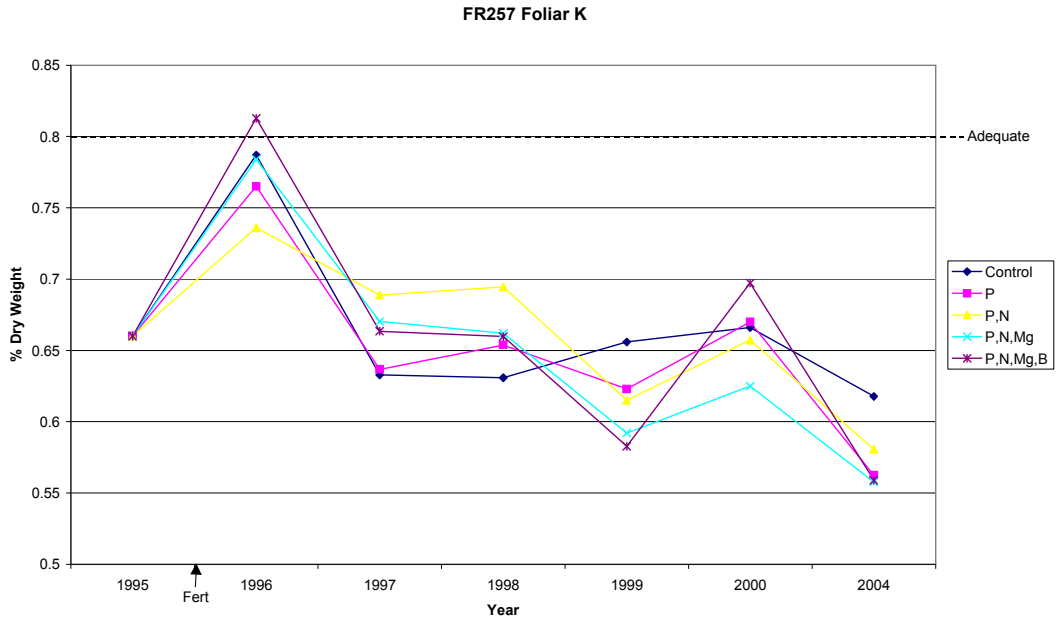
Nitrogen is in adequate supply for early growth and showed an additional short term boost from fertiliser. There is a strong signal that extra N may be required from age 15 on.

Fig 2: Douglas-fir foliar nitrogen (percent of oven-dry weight) in FR257



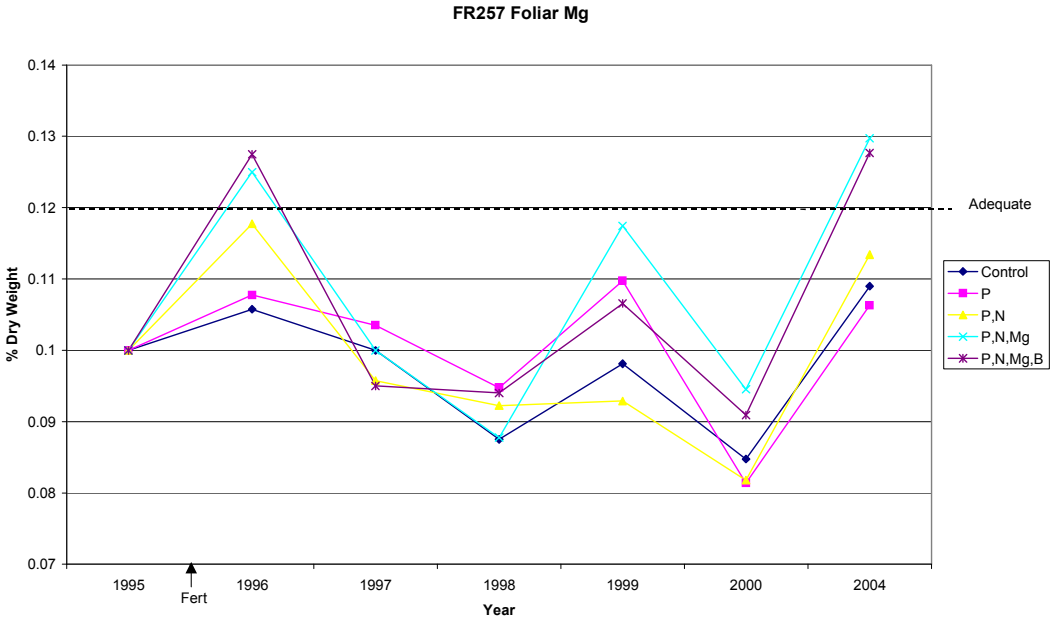
There is enough native potassium to ensure marginal supply.

Fig 3: Douglas-fir foliar potassium (percent of oven-dry weight) in FR257



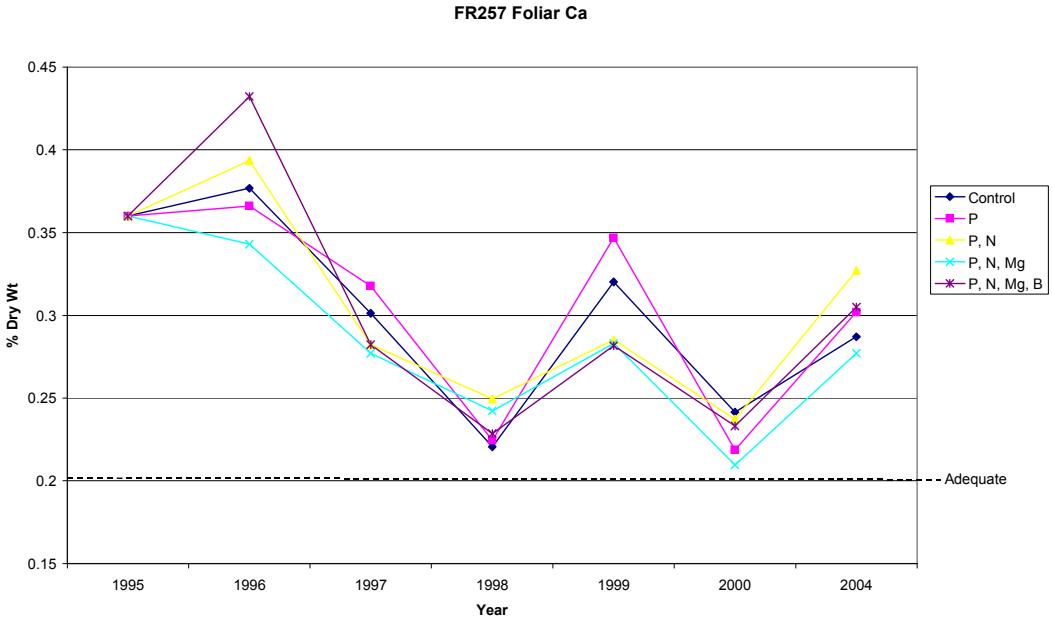
The differing solubilities of the added Mg fertilisers is reflected in an initial boost from the epsom salts, a reversion to pre-treatment levels or less, then a gradual effect of the calcined magnesite. Levels are steadily in the marginal range.

Fig 4: Douglas-fir foliar magnesium (percent of oven-dry weight) in FR257



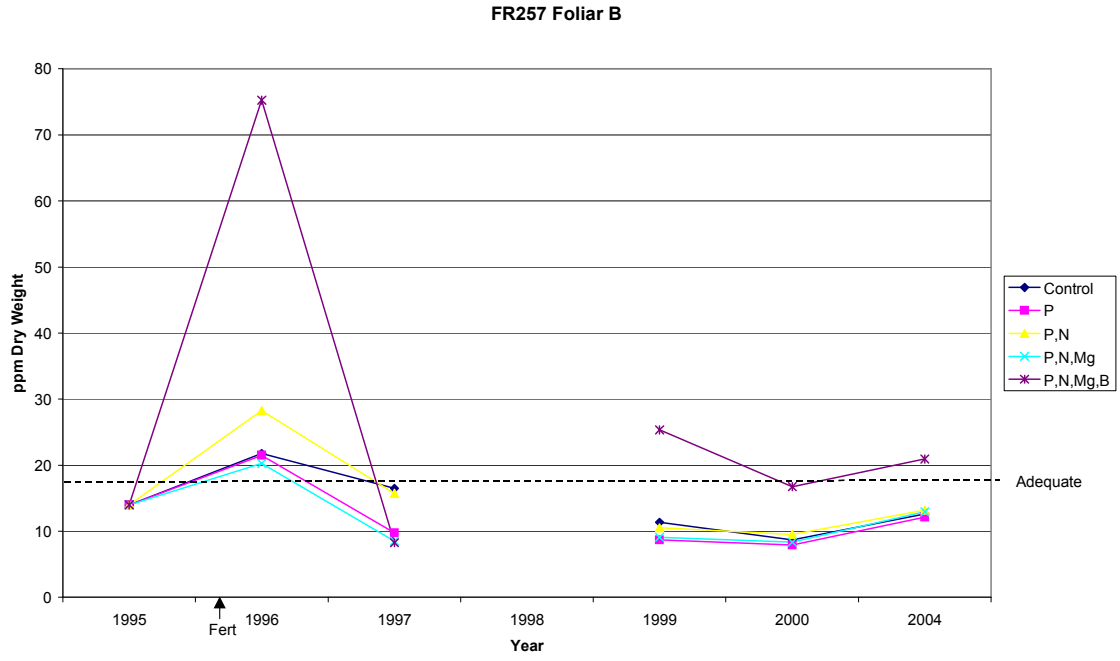
Calcium is present in both the P and Mg fertilisers. Annual variation is quite marked but levels are always adequate.

Fig 5: Douglas-fir foliar calcium (percent of oven-dry weight) in FR257



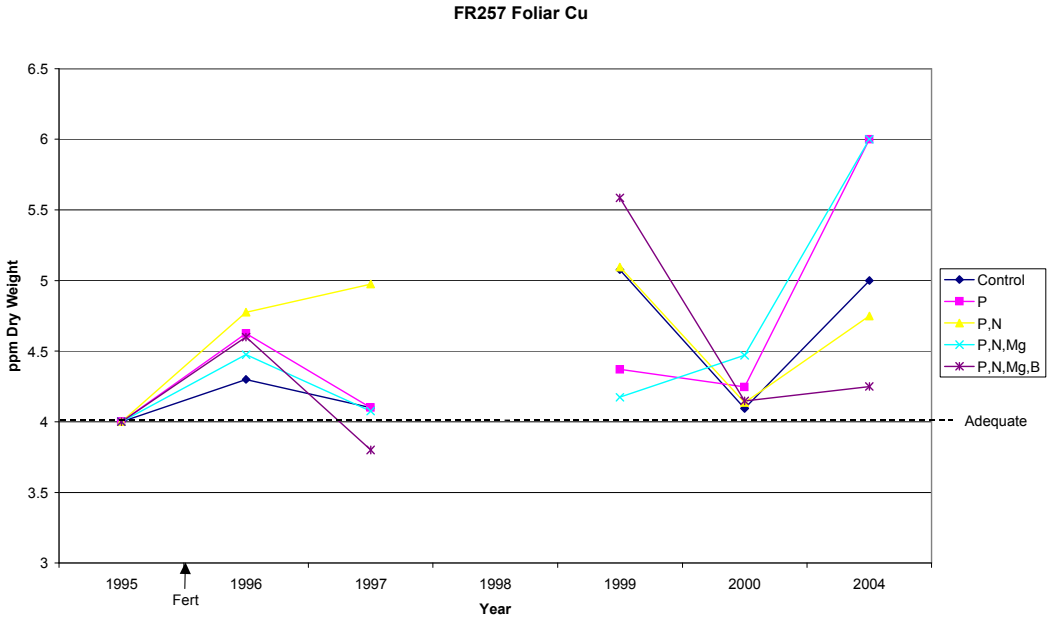
The rapid rise and decline of foliar boron levels following ulexite application occurred in all replicates of the treatment. Higher levels could give rise to concerns of B toxicity.

Fig 6: Douglas-fir foliar boron (parts per million of oven-dry weight) in FR257



Copper uptake shows a fairly strong effect of collection year. There were no copper spraying operations over the trial.

Fig 7: Douglas-fir foliar copper (parts per million of oven-dry weight) in FR257



(b) Growth Response

Analysis of covariance (SAS, 2000) was carried out on the increments in basal area, mean top height and volume using the pre-treatment values as covariates. In all cases the covariates themselves were highly significant, reflecting the differences in stocking (and therefore tree size) at initial measurement. No statistically significant differences between treatments were found although there was a hint of b.a. response to N during the first year.

Similarly, the derived estimates of site basal area potential, site index and 500 index showed no significant treatment differences.

The two bar charts of annual volume increment since fertilising (Fig 8) and the 500 index (Fig 9) illustrate the very small differences between treatments. The error bars show one standard error either side of the treatment mean. A difference of three standard errors is required for significance at the 5% level.

Figure 8: Volume MAI for the four years after fertilising FR257

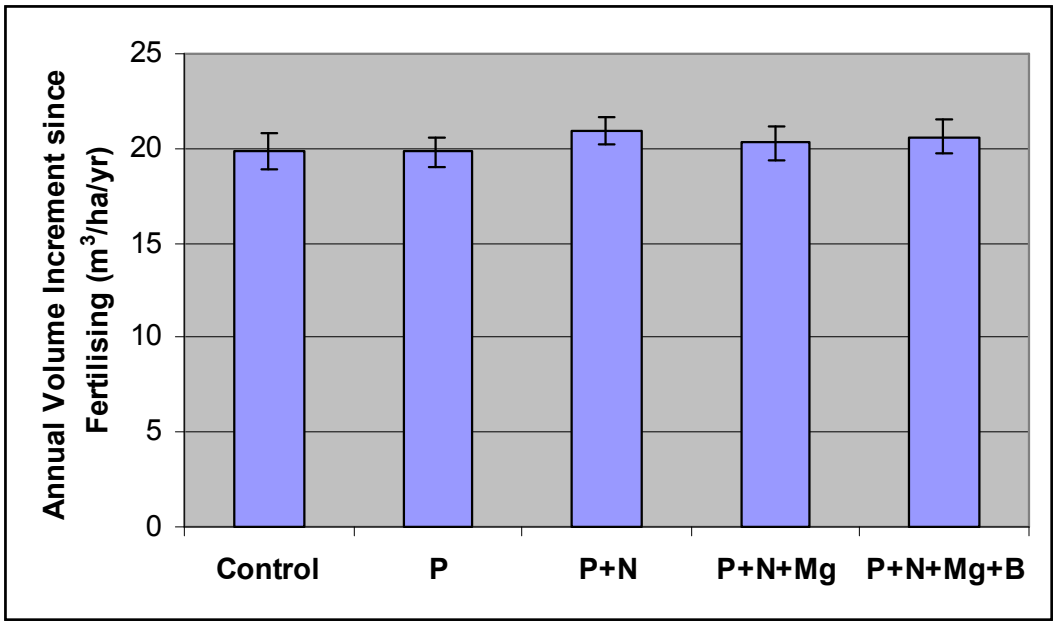
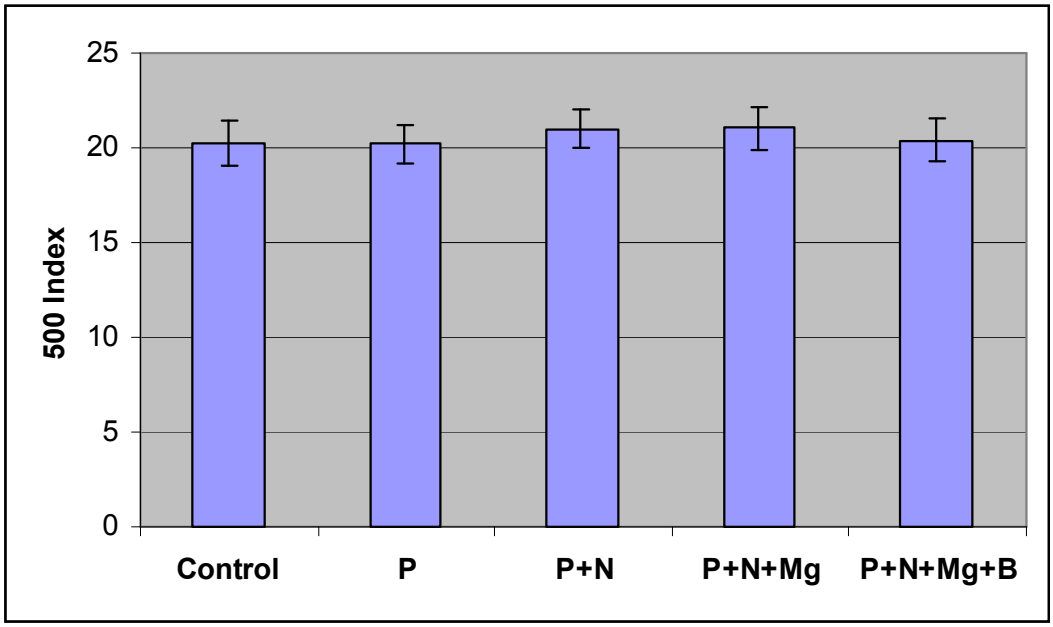


Figure 9: The 500 Index calculated 4 years after fertilising FR257



DISCUSSION

Annual fluctuations in foliar nutrient concentrations are common and can usually be traced to different rainfall totals in the months preceding sampling. Data obtained from a private rainfall gauge in Taupo (W de Bont, pers comm) indicate that the November – January totals prior to the 1996 and 1999 collections were 84mm and 58mm above average, and the same 3 month total prior to 1998 sampling was 90mm below average. Although the trial site would receive more precipitation in total it is assumed that distribution by month is similar. Taking the variable rainfall into account, tracing the nutrition of the control plots indicates that the stand health is in a fairly steady state, with no major effects of insect pests or diseases.

The huge rise in foliar B concentration (to 350% of the control level) due to the B application happened uniformly across all replicates. Combined with the subsequent sharp fall then elevation to reasonable levels, this suggests that the ulexite applied (Turkish source) contained a relatively high proportion of the more soluble sodium borate compared to the less soluble calcium borate.

Anderson (1996, unpublished data) investigated the difference in needle weights between treatments at the 1996 collection. This enabled a comparison of nutrient content as well as concentration. Her conclusions were that the site was non limiting in terms of P. However, N and B were judged to be slightly deficient as nutrient concentration, nutrient content and needle weight all increased following application of those elements.

A growth response to added N could be expected following the increase in needle weights (size) and, presumably, photosynthetic capability. The slight N response we observed in the first year did not persist and was never significant. Perhaps this indicates that the stand required a slight "top up" of nitrogen but the extremely small gain in volume to the N treatments overall (less than 1 m^3/ha/yr) would not be economic. Currently an application of urea to supply 200kg N/ha would cost about $270/ha.

TRIAL FUTURE

It would be fair to say that the lack of response in the initial years at this site is a little disappointing. However, the knowledge gained may well lessen the chances of applying un-necessary operational dressings to similar sites. A final measurement of the trial in its current state is due in winter 2005, prior to thinning in early 2006. It would be relatively inexpensive to collect another set of foliage samples at that time, but only do the chemical analyses if the growth differences are shown to be significant. If there are no startling changes to the established growth patterns, and given the key location (800m asl) and seed source (Fort Bragg), it is recommended that the site be used for a thinning response trial.

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