CONSTRUCTING A DECISION SUPPORT SYSTEM FOR NITROGEN AND PHOSPHORUS FERTILISERS AND WEED CONTROL

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1 INTRODUCTION

The introduction of a decision support system for phosphate (P) fertilising (Skinner et al, 1998) has gone some way to enabling foresters to estimate the returns to P fertiliser applied early in the life of an establishing radiata pine crop. However, the model was built from data collected where soil nitrogen (N) levels varied across sites, and where weed control was not practiced. Both soil N level, and the intensity of weed competition, will have marked effects on the magnitude of the growth response to applied P.

The objective of the work reported here was to:

1. further our understanding about the interaction between applied P fertiliser, soil N and weeds on the growth of young pines through to rotation age
2. ascertain whether or not objective 1 could be advanced through existing knowledge.

2 METHODS

2.1 General Approach Overview

At the highest level our plan was to construct a model the output from which was information on how the rotation length could be shortened with the application of fertiliser(s) and weed control. This was believed to be the most appropriate step given the difficulty in believing that a national growth model could be constructed from a limited trial base. We believed that integration of the output from existing growth models (either Forest Research, or Company originating) with the output from the N*P*weeds as a modifier of rotation length, would have the strongest appeal to end-user.

The first step was to examine the magnitude of the fertiliser and weed control effects on pine growth to establish broad patterns of similarity and difference between sites. The second step, in 2 parts, was to examine the relationship between soil variables (numerous) and the magnitude of the growth response (years saved) to the fertiliser(s) and weed control treatments. At the same time, we also examined the use of foliar nutrition at the time the treatments were applied as predictors of the magnitude of the growth responses. In essence we were using foliar information as indicators of soil fertility given reservations about the usefulness of soil chemical measures as predictors of pine response.

2.2 Growth and Soils Data

Archived data was extracted for the growth of pines from a young age (4-7 years), as well as from a series of N Rates Trials (older age trials). The growth parameters were height, dbh and stocking. For each trial, archived soil data was retrieved where possible for all available soil chemical parameters. Where the data sets were limited, and where soils had been physically archived, complete soil chemical analyses were performed. Where experiments had no soils data associated with the growth information, soils were collected from the control plots, and analysed for soil nutrients. A list of trials contributing to one or more of the N, P and Weed Control parameters is shown in Tables 1 and 2.

Table 1. List of trials providing data mainly on nitrogen and phosphorus effects on pine growth and nutrition

Trial	No. plots	Max N rate	Max P rate	Age fertilised	Weed Control treatment	Years measured	Comments
AK 286/ 6	12	269	250	6	No	22	Control, 3 P rates, 1 rate of N
AK 976/ 1	38	400	200	4	No	7	NP composite
AK 976/ 2	32	400	200	4	No	7	NP composite
AK 1055/ 0	68	340	75	4	No	12	NP factorial
FR 90/ 0	40	200	100	7	Yes	5	NPW factorial + extra P
NN 518/ 0	36	400	200	5	Yes	7	NP composite + extra W
RO 1889/ 0	32	400	200	5	No	7	NP composite
WD 399/ 0	38	400	200	5	No	7	NP composite
WN 257/ 0	16	150	120	5	No	8	NP factorial
FR 105/ 0	12	0	0	5	Yes	11	0, P, NP, NPW additive
FR 190/ 4	18	0	0	0	Yes	12	Mg/W trial
RO 2002/ 1	28	0	0	5	Yes	11	Mg/W trial

[1]Foliage data for AK 286/6 and FR 190/4 not available until 2 years after fertilising

[2]Foliage data for WN 257/0 not available until 3 years after fertilising

[3]The Mg trials were included to provide information about weed control

Table 2. List of trial specifically containing weed control treatments.

Trial	Comments
FR 90/ 0	Weed control over full NxP factorial
FR 105/ 0	Weed control only for 200N 100P treatment
FR 190/ 4	Mg trial. Extra NP treatment were excluded from this analysis. No foliar assessment at year 1.
NN 518/ 0	Weed control only for 150N 75P treatment
RO 2002/ 1	Mg fertiliser trial

2.3 Statistical Approach

For each trial, the control plots were used to define base pine growth information for the site, i.e the effect of natural soil fertility coupled with the natural weed competition on growth. The results for the various fertiliser (N and P) and weed competition treatments were then expressed as years gained (lessened rotation length) at 2 and 4 years from the application of the treatment(s).

3 RESULTS

3.1 Relationships between fertiliser responses and soil properties

Of the soil chemical factors examined (pH, sequential Bray P, K, Ca, Mg, C, N and C/N) the only significant relationship was the growth response to P fertilising being related to Bray P (most strongly to the 2nd extraction, $r = -0.71$, $p = 0.023$). The growth response to N fertilising was unrelated to any soil property. The relationship is described in Figure 1 below.

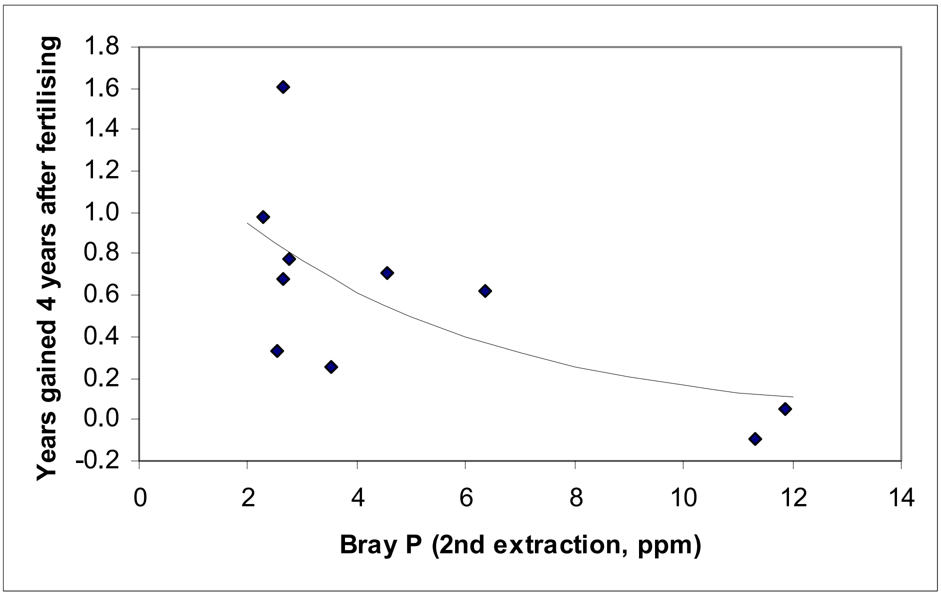


Figure 1. Relationship between DBH growth gain 4 years after fertilising with P, and Bray P.

The equation describing the relationship is $y = 1.47 \exp(0.219P_{bray})$, $R_2 = 0.43$)

3.2 Relationship between foliar P and growth responses to P fertiliser

This relationship is shown below on Figure 2. The shape of the curve is essentially that of the equation derived for the P Decision Support System (Skinner et al, 1998). However in this analysis, it is the years gained 4 years from fertilising rather than the extent to which productivity is below potential BA maximum.

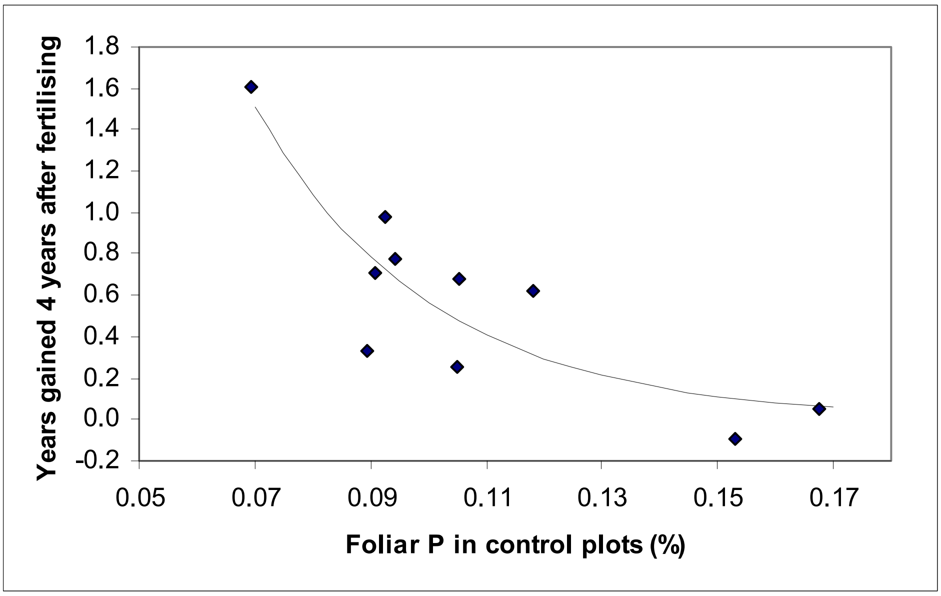


Figure 2. The effect of foliar P (%) on pine growth response to P fertiliser

The equation describing the relationship is $y = 14.81 \exp(-32.6 P_f)$, $R^2 = 0.76$.

3.3 Relationships between growth and fertilisers

3.3.1 Effect of fertilising on foliar N

Foliar N was elevated only during the year after fertilising. In subsequent years, treatment had no effect. Analysis of foliar N was therefore based only on this measurement. Trial WN 257/0 was excluded as it were not assessed during the year following fertilising. The analysis is summarised in Figures 3 and 4.

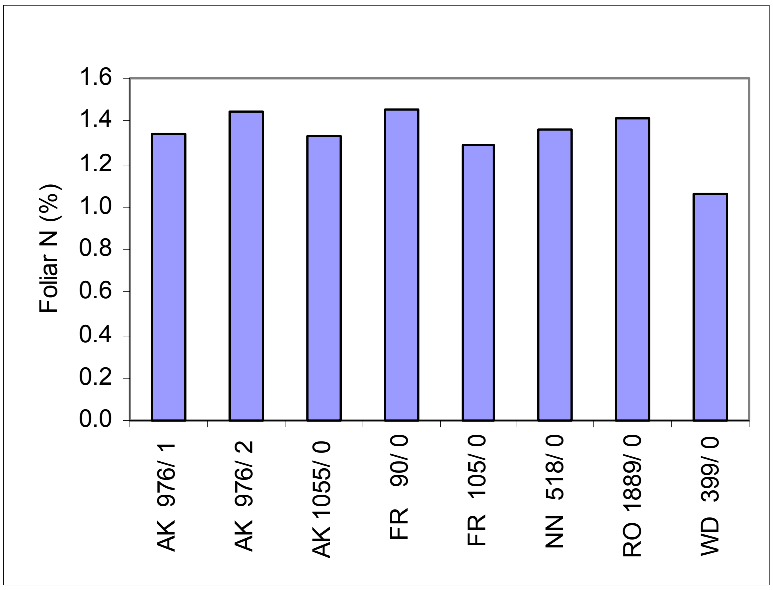


Figure 3. Base foliar N in plots without N fertiliser.

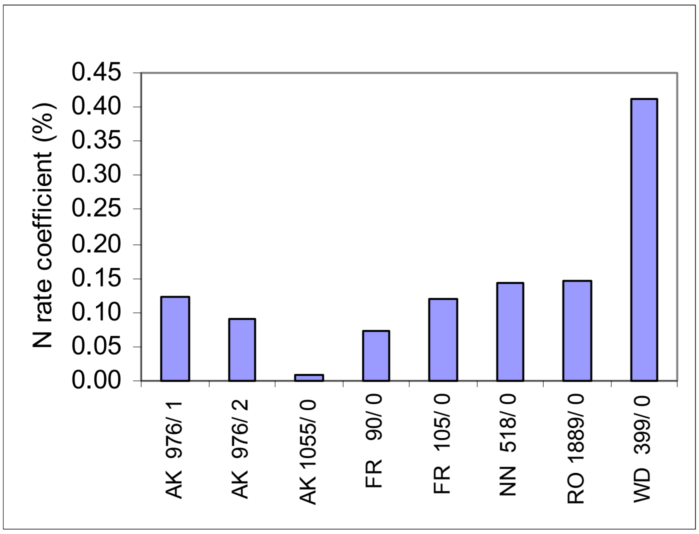
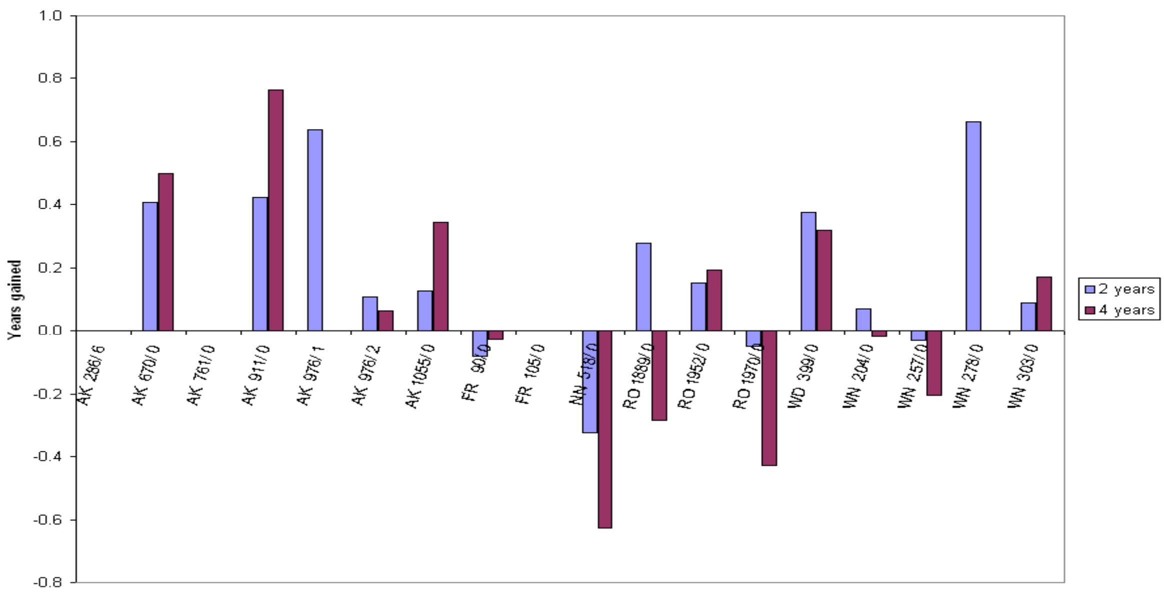


Figure. 4. N rate coefficient – the elevation in foliar N caused by 100 kgN/ha.

Fertilising with N alone can have both positive and detrimental effects on growth as documented elsewhere in the literature. Where soils are low in available P growth can retarded by the application of N. The range of growth responses (years gained or lost) is shown in Figure 5 below.

Figure 5. Years gained with nitrogen fertiliser alone



3.3.2 Effect of P fertilising on foliar P

In contrast to foliar N, foliar P remained elevated for many years after fertilising and the analysis was therefore based on all measurements. The analysis is summarised in Figures 6 and 7.

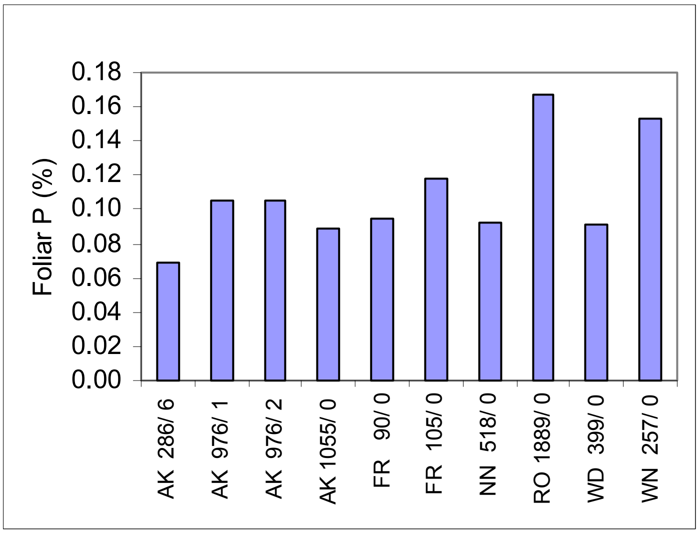


Figure. 6. Base foliar P in plots without P fertiliser.

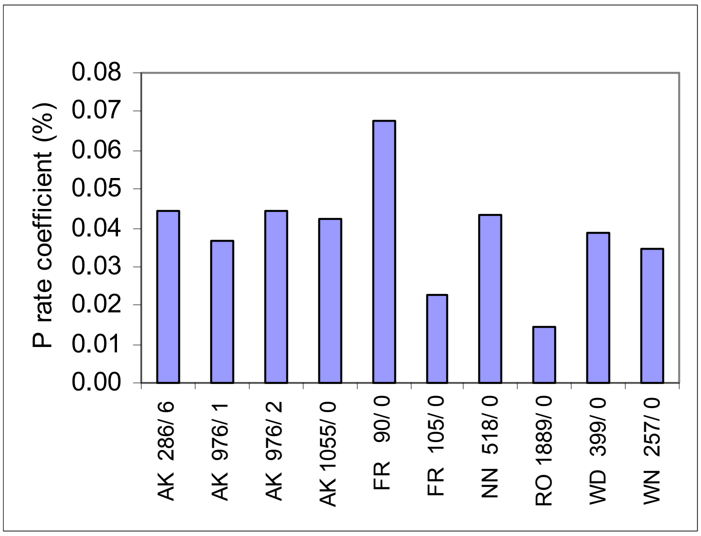


Figure. 7. P rate coefficient - the elevation in foliar P caused by 100 kgP/ha.

Where P fertiliser is applied alone, growth responses are either neutral or positive, as shown below in Figure 8. This is the more common response pattern to fertiliser nutrients. Figure 8 shows the responses to range from zero to a maximum of 1.6 years four years after fertilising.

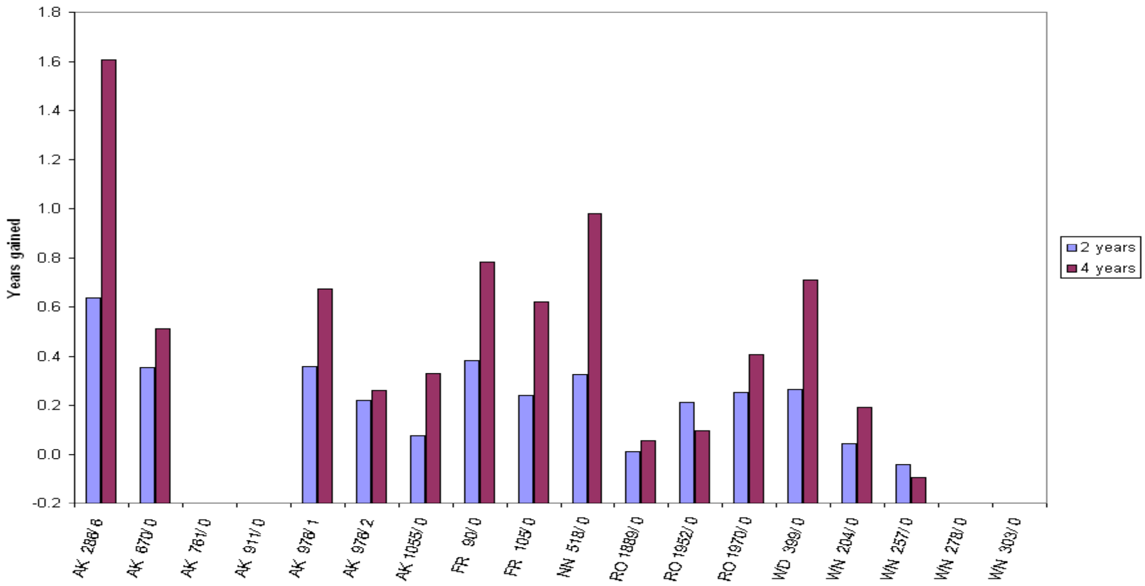


Figure 8. Years gained with phosphorus fertiliser alone

The effect of adding N fertiliser in the presence of P fertiliser is shown below in Figure 9. The effect (as years gained) is shown as additional response to N fertiliser over what would have been obtained to N fertiliser alone.

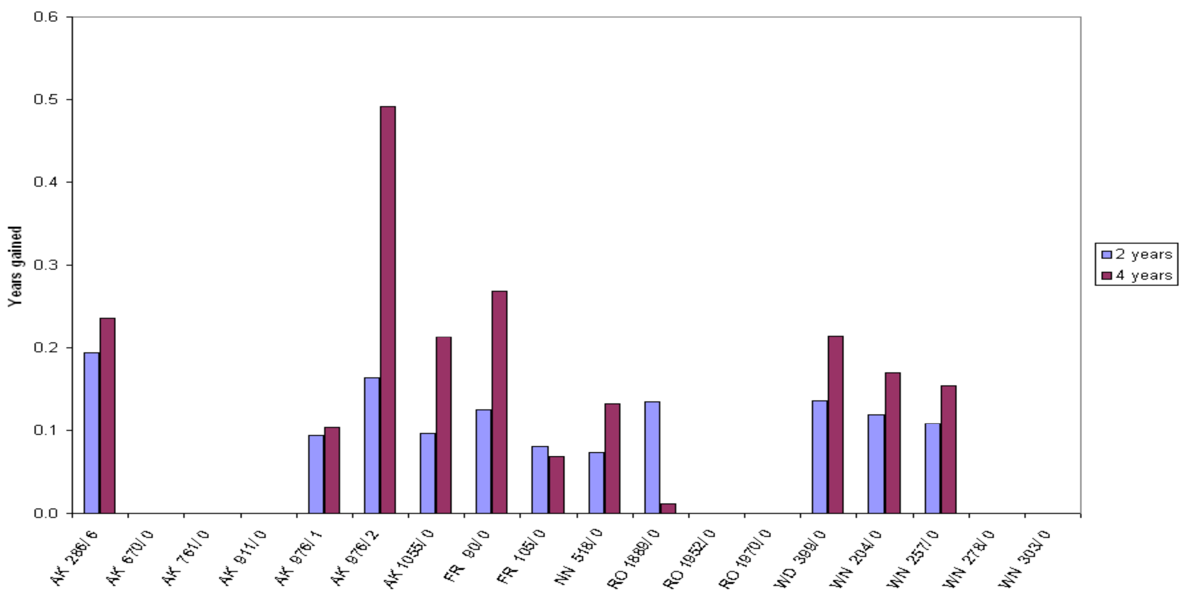


Figure 9. Additional response to N fertiliser in the presence of P fertiliser

In the presence of P fertiliser all responses to N fertiliser were positive.

3.4 Building the relationship between foliar P and the response to N fertiliser in the presence and absence of P into the DSS

This relationship between foliar P and the response t N fertiliser in the presence and absence of P is a key component of the DSS. Foliar P can be derived from the relationship between soil extractable P (Bray P in the second extract), but if foliar P information is available directly through foliage analysis it is the preferred measure.

This component of the model is shown below in Figure 10.

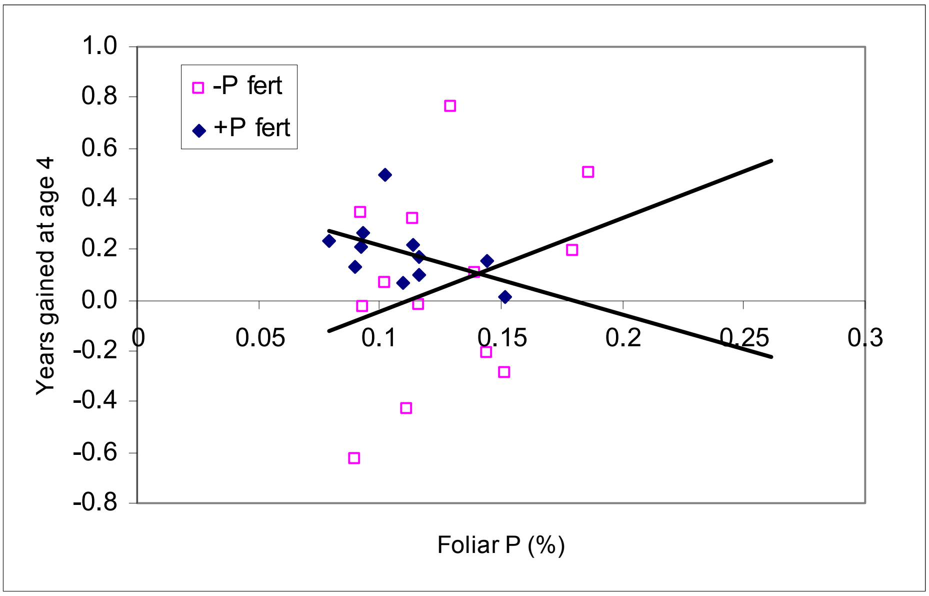


Figure 10 The response to N fertiliser (years gained or lost) at age 4 in the presence (diamonds) and absence (squares) of P fertiliser

The relationships shown in Figure x represent the sum of the information available from the ***Forest Research*** fertiliser trial database. Both regressions, although statistically weak, are biologically reasonable. The equation for the response to N in the presence of P shows that the biggest gains to NP fertiliser are made when foliar P is low. Gains to N fertilising alone will be negative when P nutrition is low (inhibition of P uptake under conditions of low P nutrition by N).

3.5 Relationship between growth (years gained) and weed control

3.5.1 Effect of weed control treatments on foliar N

Foliar N was analysed separately for the summer following fertilising (year 1) and for subsequent years. Separate analyses were performed for each trial. Analysis consisted of ANOVA, with all relevant factors and interactions for each trial.

Table 3. Effect of weed control on foliar N.

Trial	Year after fertilising			Subsequent years		
	Elevation in foliar N	s.e.	p-value	Elevation in foliar N	s.e.	p-value
FR 90/0	0.13	0.04	0.006	0.09	0.02	<0.001
FR 105/0	0.07	0.05	0.23	0.01	0.05	0.88
FR 190/4	-	-	-	0.07	0.03	0.025
NN 518/0	0.12	0.06	0.057	-0.04	0.04	0.28
RO 2002/1	0.20	0.03	<0.001	0.05	0.02	0.012
Mean	0.13			0.04		

The results show that

- Overall, there was a significant elevation in foliar N with weed control in year 1, averaging 0.13.
- In subsequent years the effect was reduced, although still generally apparent, averaging 0.4.
- There was no significant interaction between N rate and weed control in FR 90/0, the only trial where this could be tested. In other words, weed control produced an equal increase in foliar N across all fertiliser treatments and the control.
- There was a significant interaction between weed control and age in FR 190/4. No foliage sampling was carried out in year 1. In year 2, there was an extremely pronounced elevation in foliar N (elevation=0.31; s.e.=0.05; p<0.001). However, there was no significant elevation in years 3 and 4.

3.5.2 Effect of weed control treatments on foliar P

The influence of weed control on Foliar P (Table 4) was analysed separately for each trial. Analysis consisted of ANOVA, with all relevant factors and interactions for each trial.

Table 4. Effect of weed control on foliar P.

Trial	Elevation in foliar N	s.e.	p-value
FR 90/0	0.0073	0.0040	0.075
FR 105/0	0.0036	0.0060	0.58
FR 190/4	0.0013	0.0055	0.82
NN 518/0	0.0028	0.0032	0.39
RO 2002/1	0.0018	0.0035	0.62
Mean	0.0034		

The results show that:

- Weed control generally had little effect on foliar P. Only in FR90 was foliar P significantly elevated
- There was no significant interaction between P rate and weed control in FR 90
- There was a significant interaction between weed control and age in RO 2002/1. For the three years following establishment, weed control produced a significant reduction in foliar P (reduction=0.029; se=0.008; $p<0.001$ in year 2). By year 6, this had reversed to a significant elevation in foliar P with weed control (elevation=0.018; se=0.008; p=0.025). However, overall, foliar P levels were high in this trial.

4. THE N BY P BY WEEDS DECISION SUPPORT SYSTEM

4.1 What you need to know before using the DSS

The model uses either foliar P or Bray P. The predictions are more accurate if foliar P is used. It is no possible to enter more than 200 kg N per hectare (one application only). All treatments must be applied between ages 4 and 10 years. The model does not account for normal weed control at establishment. Currently the model is ***not suitable for use in dry-land forestry***. The DSS is growth model independent.

4.2 The Model

The DSS was built as a Microsoft Excel spreadsheet The Model is located on a 3.25" floppy disk enveloped on the back page of this report.

The output from the model is in 2 parts. Firstly the Reduction in Rotation length (years) is provided. This information can be used with whichever growth model is selected by the user. Secondly, the effect of the site treatments is also examined in terms of profitability of the cost of those site treatments.

5 SUMMARY

A Nitrogen by phosphorus by weeds DSS was constructed using Forest Research trials where all 3 factors were present, either singly or in multiple combinations. An attempt was made to establish relationships between soil chemical variables and responses to site treatments. In this domain, only soil extractable P (Bray P 2nd extraction) provided a useful relationship (predicting foliar P). The model operates with either Bray P or foliar P, but not both. The output from the model is both years saved on rotation length, and an examination of the cost effectiveness of the site treatments.

6 REFERENCES

Skinner, M.F., Payn,T.W., and Kimberley, M.O., 1998. A Phosphate Fertiliser Decision Support System – An Aid to Making Decisions on the Application of P Fertilisers for Radiata Pine Plantations. Part 1. Introducing Functions derived from the NZ Forest Research Institute Ltd Long-term Phosphate Studies. Nz Site Management Report 102 (unpublished)

7 ACKNOWLEDGEMENTS

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