Project Record No 2026

BASAL AREA AND VOLUME RESPONSE OF PINUS RADIATA TO APPLICATION OF PHOSPHORUS FERTILISERS OF VARYING SOLUBILITY ON SITES DISPLAYING DIFFERENT DEGREES OF PHOSPHORUS RETENTION :
- 7 YEARS AFTER APPLICATION
- PREDICTION OF VOLUME GAINS TO ROTATION AGE
- VALUATION AT ROTATION AGE

by

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EXECUTIVE SUMMARY

Three experiments comparing rock phosphate and superphosphate at two rates were measured 7 years after fertilising.

Results show :

1. A strong response at Riverhead Forest with superphosphate giving slightly better growth than A grade rock and much better growth than C grade rock. The higher rate of P applied (150 kg/ha) gave slightly better growth than the lower rate (75 kg/ha).

2. A less strong response at Waipoua with no difference between types and rates.

3. The least response at Tairua, but at this site A grade rock appears to be the most productive.

The pattern of growth in the long term P trials was used to project the growth in this trial series forward. A new discovery was made during this investigation. Response to P could be approximated by :

response = (time since fertilising)**k

and the k is proportional to unfertilised foliar P. Projecting growth in this trial series forward showed that fertilising would be profitable at all sites.

INTRODUCTION

A series of three trials was established in 1978 to evaluate the response of P. radiata to superphosphate against the response to less soluble pelletised rock phosphates on soils of different P retention. Sites were chosen in Waipoua, Riverhead and Tairua forests in order to obtain soils with varying degrees of P retention. The Waipoua site has a P retention of 1%, Riverhead of 42% and Tairua a P retention of 90%. No silvicultural treatment had been undertaken on any of the sites prior to the establishment of the trial. Although the trees were all of similar size, those in Tairua and Riverhead were age four, while at Waipoua the trees were age seven.

The results of these trials up to 7 years after establishment are presented here, and an evaluation of the economics of fertilising on these three sites is made.

METHOD

The trials were laid out in a randomised block design, with three blocks at each site. The following treatments were applied within each block;

1. Control
2. Pelletised A-grade rock at 75 kg P/ha
3. Pelletised A-grade rock at 150 kg P/ha
4. Pelletised Citraphos at 75 kg P/ha
5. Pelletised Citraphos at 150 kg/ha
6. Superphosphate at 75 kg P/ha
7. Superphosphate at 150 kg P/ha
8. Pelletised C-grade rock at 75 kg P/ha
9. Pelletised C-grade rock at 150 kg P/ha

Waipoua has treatments 1 to 7 only. Riverhead and Tairua have all nine treatments. Riverhead also had some additional lime treatments. The treatments were;

10. Lime at 3 ton/ha
11. Lime at 3 ton/ha plus Superphosphate at 150 kg P/ha

The measurement plots were 20 x 20 m. The diameters of the trees within these plots were measured and the basal areas calculated. The basal area figures were then adjusted for the covariate prior to analysis. This should reduce the between plot variation within a treatment by allowing for differences in initial plot basal areas.

RESULTS AND DISCUSSION

1. EFFECT OF LIME

At the Riverhead site lime was applied to a non-fertilised plot and to a plot receiving 150 kg P/ha as Super. The aim of the exercise was to try to increase the amount of Phosphorus available to the trees by increasing the rate of conversion of organic P to inorganic P.

TABLE 1 : RIVERHEAD LIME TREATMENT BASAL AREA RESULTS M2/HA

	Po	P 150	
Lo	24.29	33.23	57.52
L150	22.71	28.28	50.99
	47.00	61.51	108.50

Where
Po = no added Phosphorus
P 150 = 150 kg P/ha applied as Super
Lo = no added lime
L 150 = Lime applied at a rate of 3 ton/ha

The results (Table 1) show that Lime addition was certainly not beneficial to the trees on this site and may have depressed growth. In retrospect Riverhead may not have been the best choice of sites for a study of this type. The total soil Phosphorus was quite low initially, and the amount of organic P was not significantly large. If this trial had instead been established at Tairua where the amount of organic material is quite high, we might have expected an increase in the amount of Phosphorus available to the trees.

2. EFFECT OF PHOSPHORUS TYPES AND RATES

The covariate adjusted basal area results for all the other 734 series plots are given in Table 2.

TABLE 2 : COVARIATE ADJUSTED BASAL AREA RESULTS FROM THE 734 SERIES

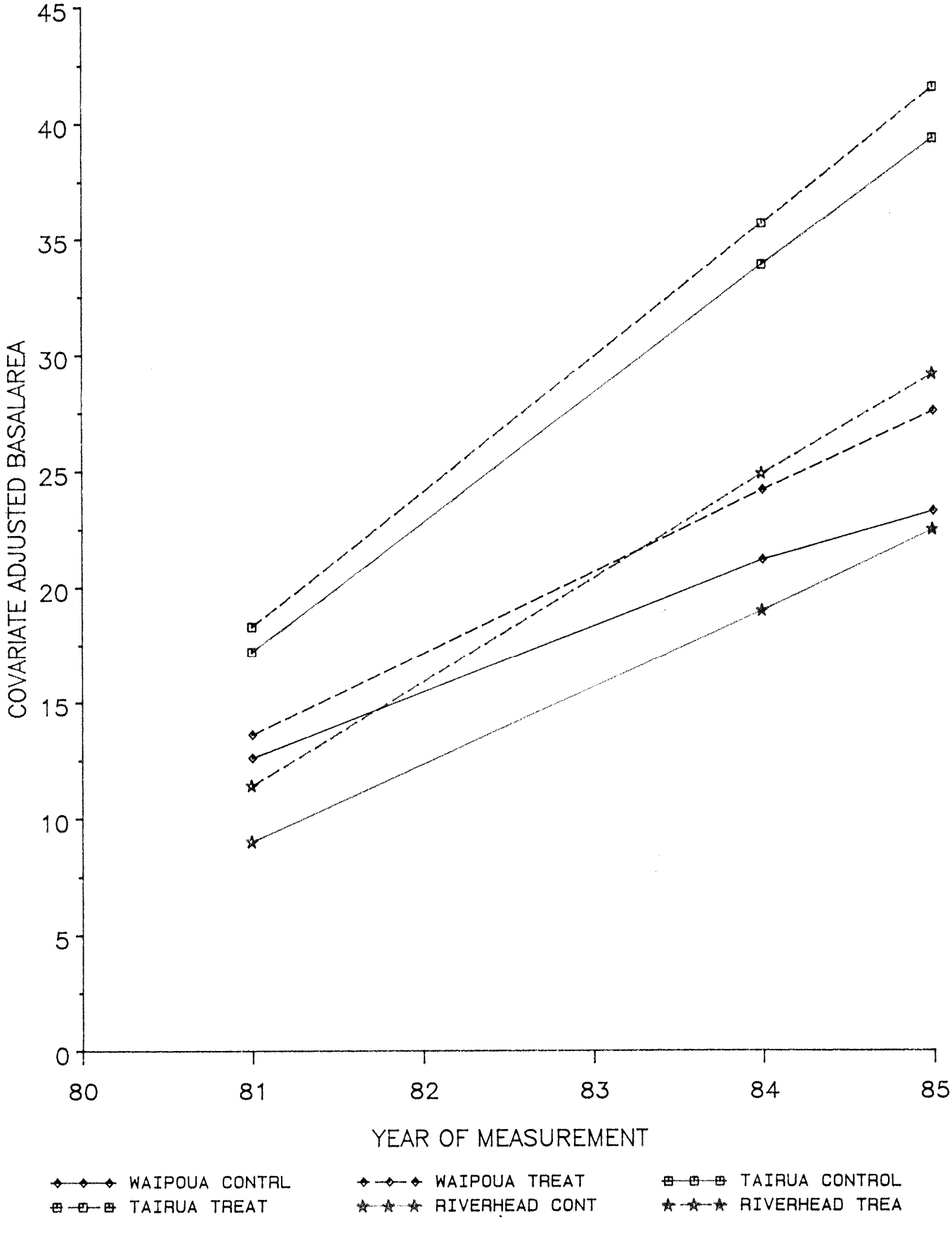
Site	RIVERHEAD			WAIPOUA			TAIRUA		
Year	81	84	85	81	84	85	81	84	85
kg P/ha	basal area (covariate adjusted) m2/ha								
CONTROL	9.0	18.9	22.5	12.6	2.12	23.3	17.2	33.9	39.4
C-grade 75	9.9	20.7	24.4				19.1	36.6	42.5
C-grade 150	10.9	23.5	27.5				18.0	33.9	39.3
A-grade 75	11.4	24.3	28.8	13.2	24.4	27.9	18.6	36.3	42.2
A-grade 150	11.9	26.2	30.6	13.8	24.4	27.6	19.0	38.3	44.6
Super 75	11.1	26.6	31.1	13.7	24.5	27.9	17.3	35.8	41.3
Super 150	13.3	28.1	32.7	14.0	23.9	26.8	18.0	36.0	42.1
Citraphos 75	11.3	24.5	28.8	13.2	24.1	28.2	18.1	34.7	40.7
Citraphos 150	11.6	25.4	29.7	13.6	23.9	27.4	18.0	34.4	40.1

At all three of the 734 series sites there appears to be an improvement in growth following Phosphorus fertilising (Graph 1). However only those results from Riverhead are statistically significant by 1985. The data from all three measurement years shows that the fertilised plots at Riverhead are significantly better than the control.

Graph 2 details the basal area response to the different fertiliser treatments at Riverhead. Apart from a significant difference between the control and the treatment mean basal areas, there were some differences observed between the types of fertiliser. By 1985 the C-grade rock when applied at the lower rate was giving basal areas significantly lower than any of the other fertiliser treatments. In addition there was a significant difference between the rates of P application. A higher mean basal area was observed for the plots receiving 150 kg P/ha than for those that received 75 kg/ha. The best basal area response at

BASAL AREA RESPONSE TO PHOSPHORUS FERTILISERS

CONTROL VS TREATMENT FOR ALL THREE SITES



Riverhead was obtained on those sites that had received 150 kg of Phosphorus/ha as Superphosphate.

Graph 3 illustrates the difference between the control and the treatment basal area at Waipoua. The Waipoua results were not statistically significant, although by 1985 the difference between the mean basal area for fertilised plots and the control were approaching a level of significance. It should also be taken into consideration that there was a very high degree of variability within the Waipoua site due to waterlogging. This variability masked to a large degree the effect of the treatments. The differences between the fertiliser types and rates are negligible.

Due to the waterlogging on this particular site and the low P retention of the soils it is possible that any P added in the way of fertiliser could be transported from one plot to another, thereby masking the effect of the fertiliser treatments. However the lack of response is more likely to have stemmed from the Phosphorus being carried down the profile out of the range of the root systems. Hunter I. *et al.* (unpubl.) reported on the amount of available P in the soil at different depths down the profile. At Waipoua most of the increase in both total P and available P occurred in the lower portion of the profile. At Riverhead and Tairua most of the increase in P following fertilisation occurred in the top 10 cm of the profile.

The basal area results from Tairua are given in Graph 4. Tairua has a P retention of 90%. The response to P fertiliser was very small on this site. No statistically significant treatment differences have arisen. However Graph 4 does indicate that an increase in basal area can be obtained when 150 kg P/ha in the form of A-grade rock phosphate is applied to this site.

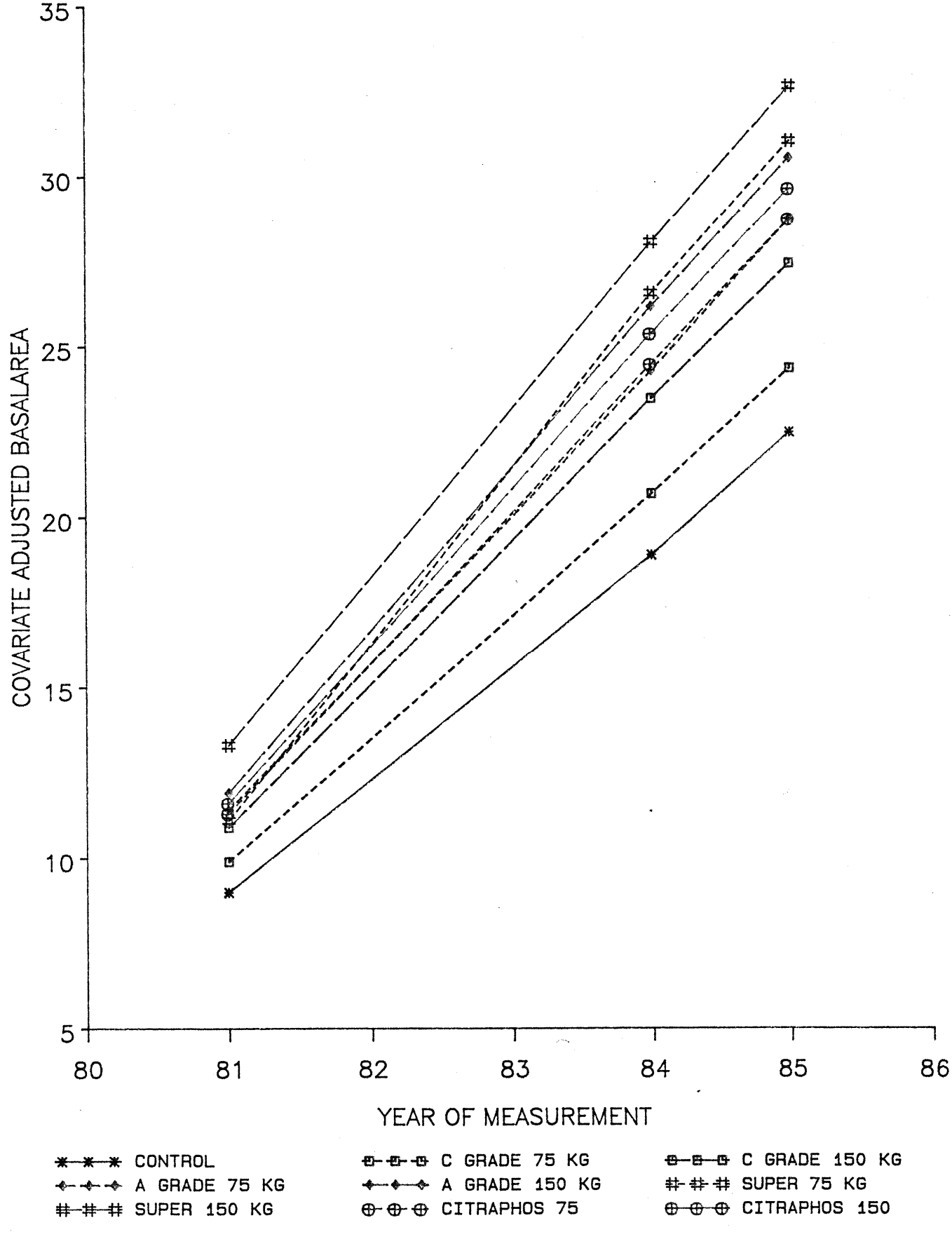
2.1 Prediction of Yield Increases Due to Fertilising

In order to evaluate the economics associated with application of the fertiliser on these sites it is necessary to predict the increased volume at the end of the rotation that results from fertilising. The returns gained from the increased wood production must exceed the cost of the fertiliser application.

Volume differences between the control plots and those receiving 125 kg of P/ha as Super in the 286 trial series were utilised to help predict the future volume gain of the plots in the 734 series receiving P fertiliser. Although no data is available to make a direct comparison with the rock phosphates, it is assumed that since

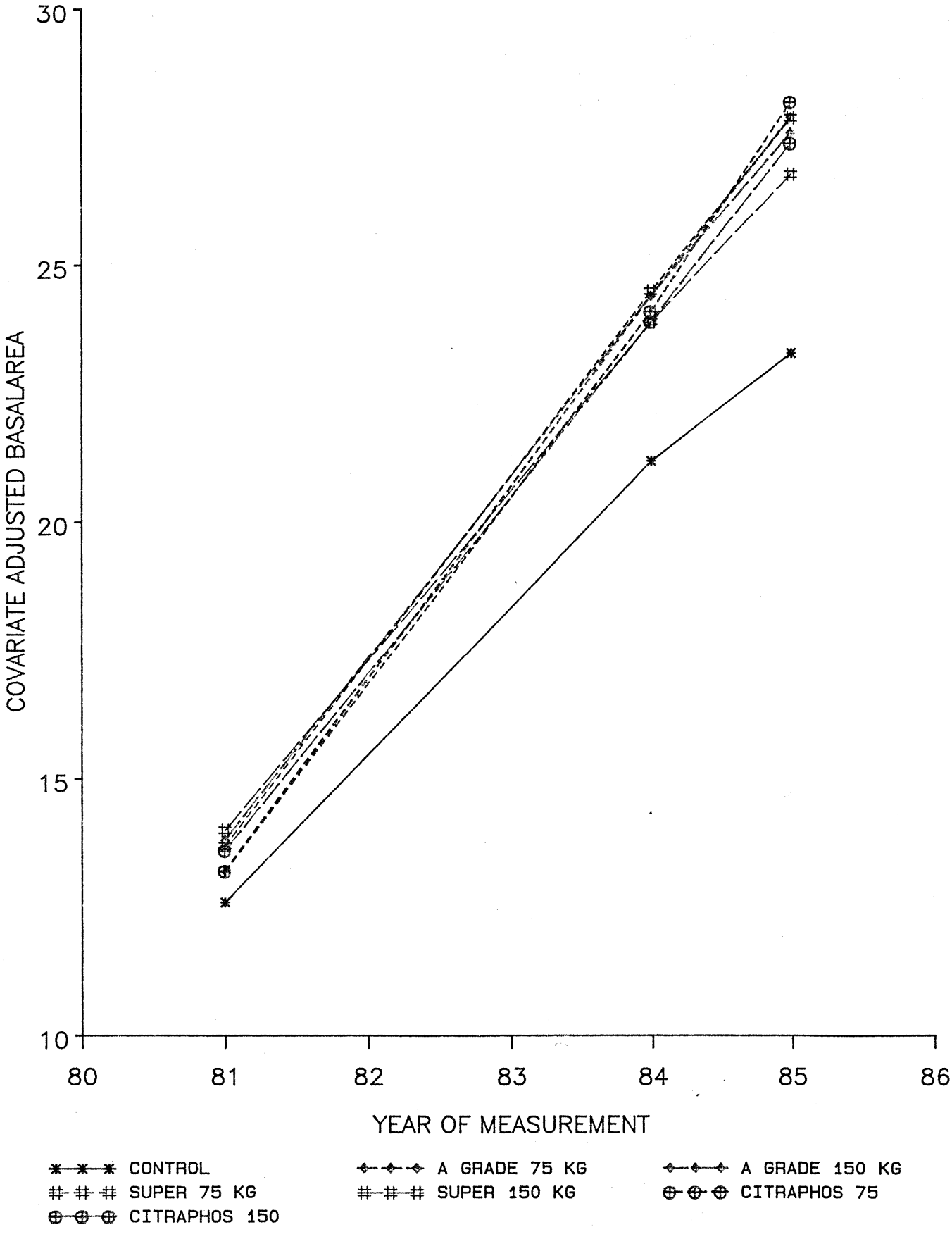
BASAL AREA RESPONSE TO PHOSPHORUS FERTILISERS

RESPONSE TO DIFFERENT FERTS & RATES AT RIVERHEAD



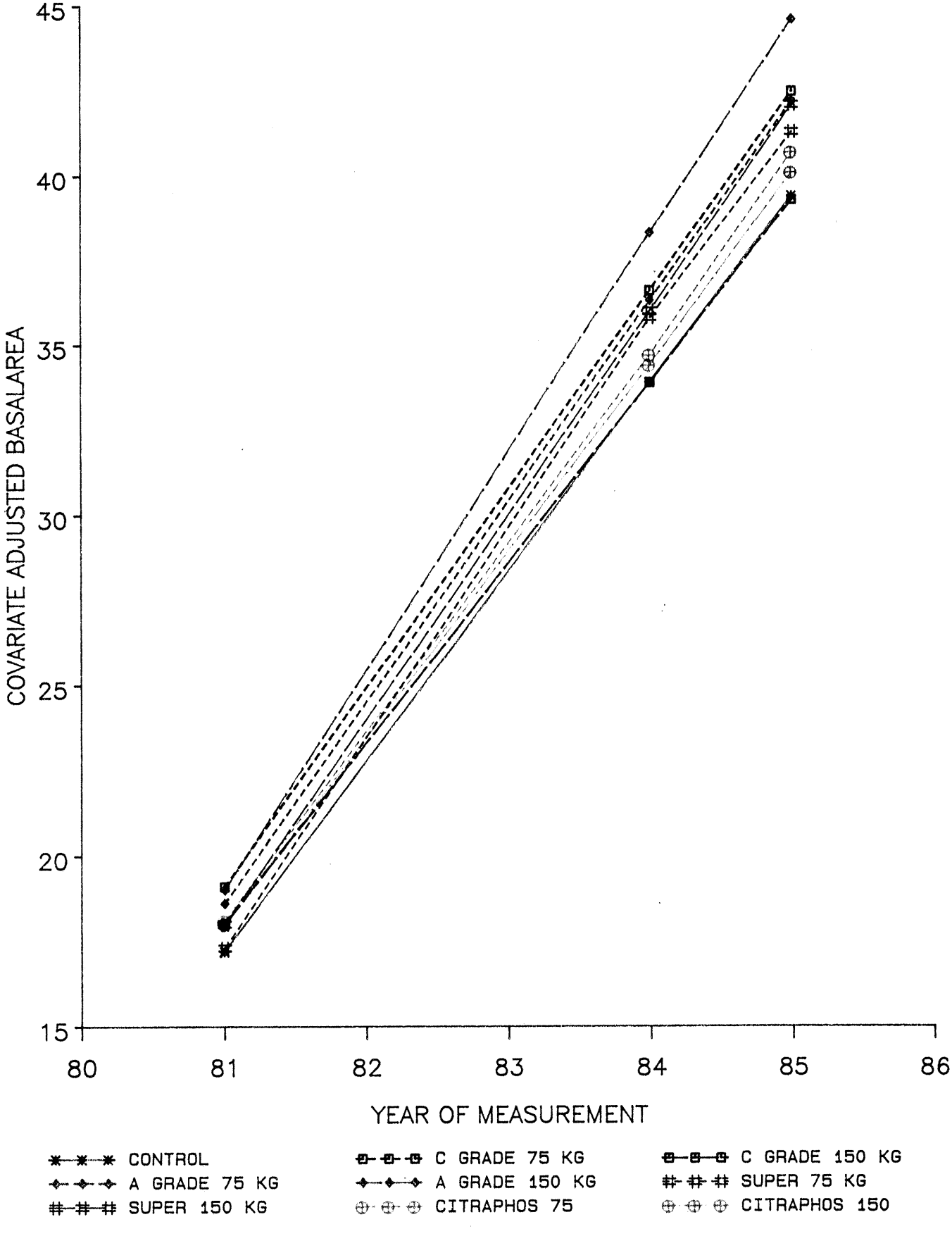
BASAL AREA RESPONSE TO PHOSPHORUS FERTILISERS

RESPONSE TO DIFFERENT FERTS AND RATES AT WAIPOUA



BASAL AREA RESPONSE TO PHOSPHORUS FERTILISERS

RESPONSE TO DIFFERENT FERTS AND RATES AT TAIRUA



the transformations of the applied fertilisers in the soil are ultimately similar to superphosphate and the plant uptake pathways are identifical, a similar tree growth pattern will be achieved.

Using data from the 286 series it was established that the volume increment due to fertilising with 125 kg P/ha as Super could be approximated by the equation :

Volume increment = (time since fertilising)**k
k having a value between 1.25 and 2.25

A family of curves was then drawn using a series of values for k. Graph 5 shows the volume differences resulting from the 286 trials as well as the family of curves derived from the above equation. The slope of the curves reflect the extent to which phosphorus deficiency is limiting tree growth. On the 286/2 and 286/4 trial sites P deficiency was not severe so the gain due to fertilising was minmal. A steep curve such as 286/3 indicates that the trees were not growing to their full potential, and large gains in volume can be obtained by the addition of super. The curves are useful provided that projection is limited to less than 25 years from fertilising. Being exponential, they eventually give ridiculous answers.

The volume gain results from the 734 plots receiving 150 kg P/ha as Super are also plotted on this graph.

Graph 5 shows Waipoua as following a curve similar to that of k = 1.75. A volume gain of around 175 m3/ha at age 25 or 18 years since fertilising can therefore be expected. Riverhead results follow a much steeper curve. At age 25 or 21 years after fertilising we can expect an extra 525 m3/ha from the plots fertilised with 1500 kg of Super. Tairua was plotted on this graph to equate to Ak 286/2 where at the same time after fertilising there was a similarily small response resulting from fertiliser application. A volume gain at age 25 of 96 m3/ha could therefore be expected at Tairua. The foliage analysis carried out on the Tairua site indicate that the P levels are still high enough at present in the control plots for growth not to be severely limited. As time progresses, however, P will most likely become deficient in the control plots and a volume increment due to fertilising would then appear, as in the 286/2 trial (Graph 5).

GRAPH 5

VOLUME GAIN VS TIME SINCE FERTILISING

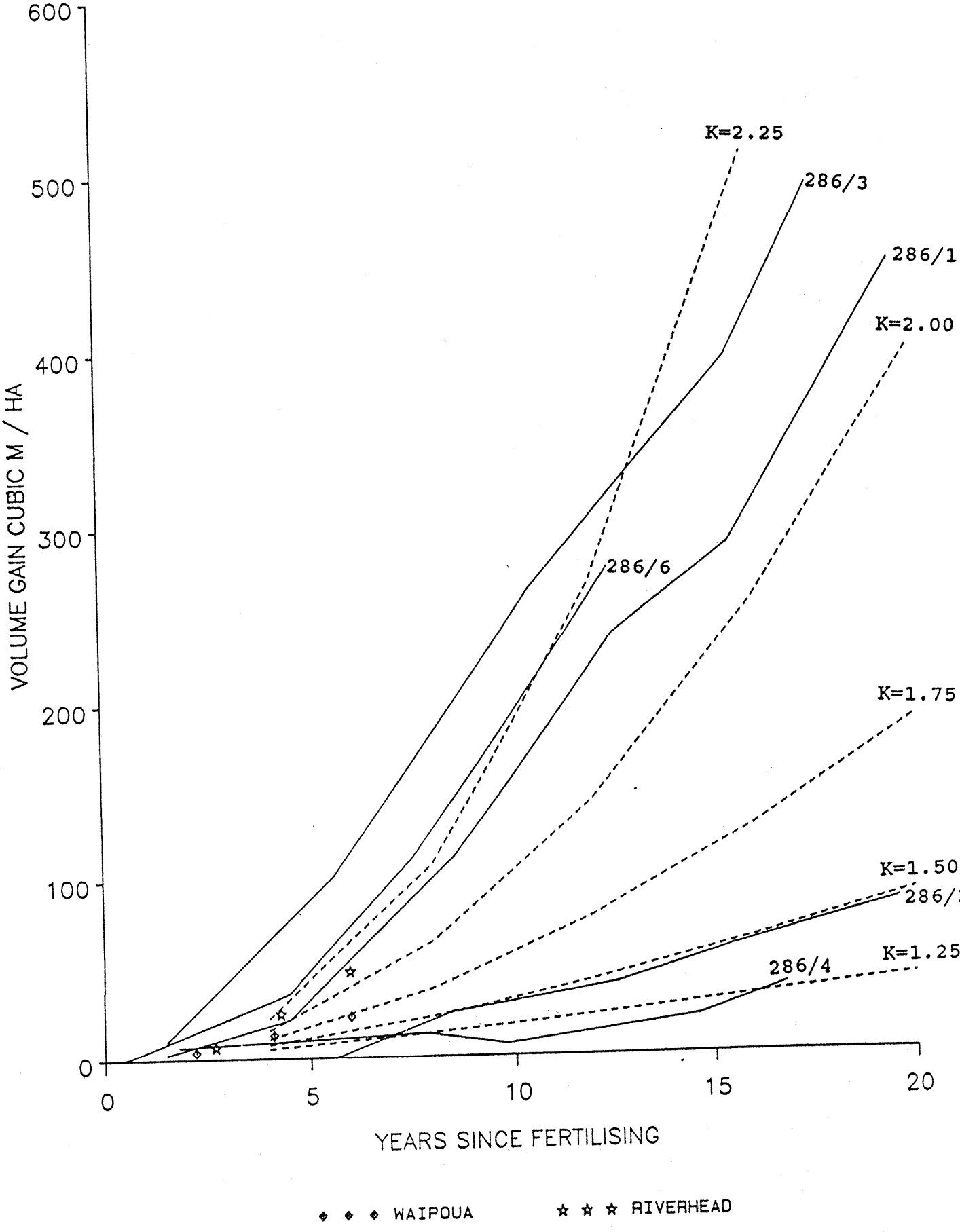


TABLE 3 : K AND FOLIAR P VALUES FOR THE 286 AND 734 TRIALS

Trial	Foliar P	K
286/1	.075	2.10
286/2	.108	1.50
286/3	.088	2.20
286/4	.119	1.25
286/6	.060	2.15
374/1	.081	1.75
374/2	.084	2.05
374/3	.106	1.50

Table 3 lists both the K values and the results of foliage analysis for Phosphorus conducted on foliage collected from the control plots in the year of fertiliser application.

In Graph 6 the k value is graphed against foliar P in the control at time of fertilising. The greater the foliar P the less the response. The equation for the line fitted to these points is Y = 3.27 + (-16.13X) and has a correlation coefficient of -0.87.

Using the above graph in conjunction with the information presented in graph 5 it is possible to predict the volume gain at say age 20 resulting from fertilising, given the initial foliar P level in the control plot at the time of fertilising.

2.2 Economic Analysis of Fertiliser Application

Two interest rates were utilised in the economic analysis, 7 & 10%. The cost of the fertiliser and its application has been calculated to be $350.00/ha in the base year (MAF 1987).

GRAPH 6

K VS FOLIAR P IN THE CONTROL

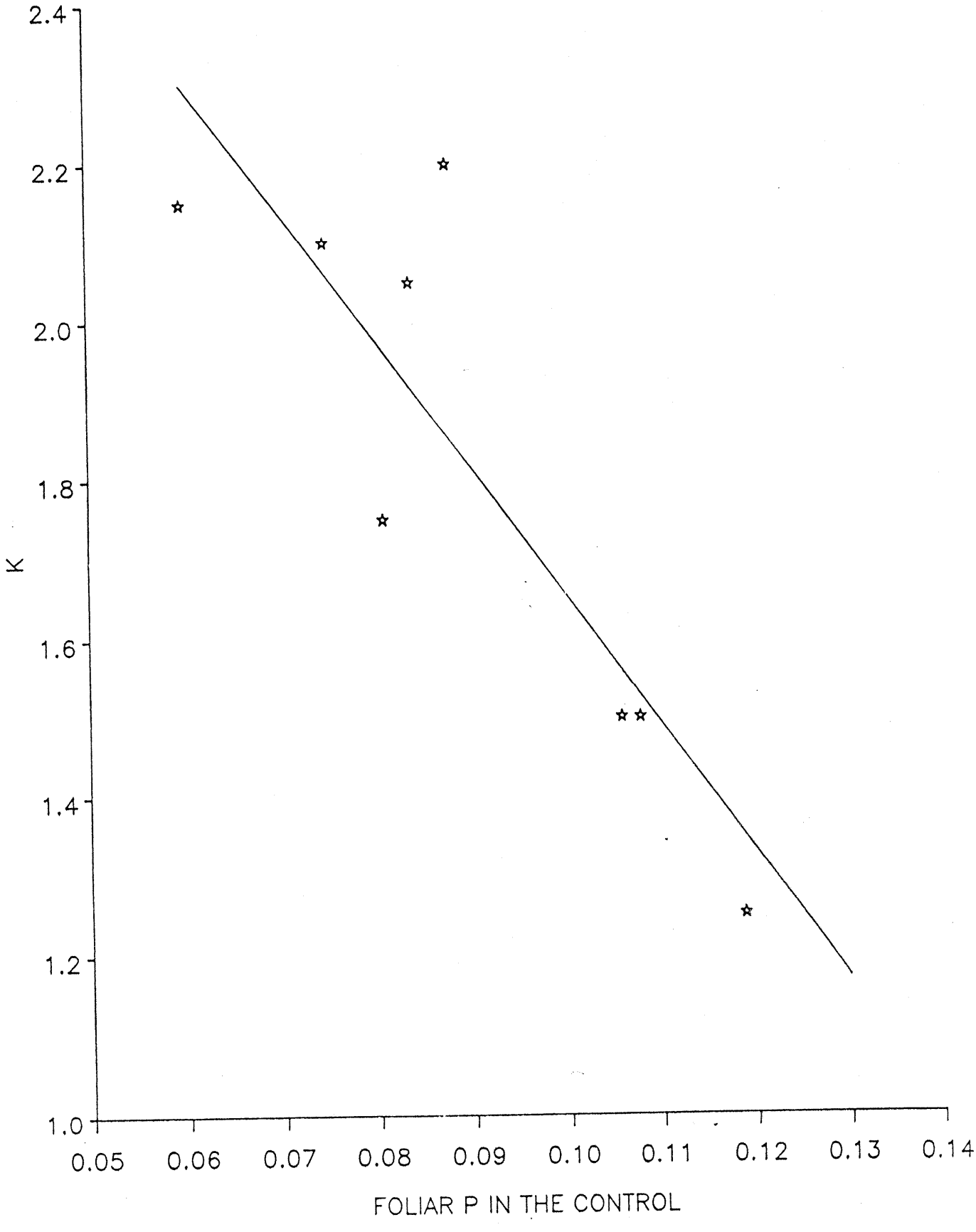


TABLE 4 : CALCULATION OF BREAK EVEN WOOD PRICE

Site	Interest Rate %	Years	Interest Factor	Compounded Cost of Fert. $	Volume gain m3/ha	Break Even Wood Price $/m3
WAIPOUA	7	18	3.380	1183.00	175	6.76
WAIPOUA	10	18	5.560	1946.00	175	11.12
RIVERHEAD	7	21	4.141	1449.35	525	2.76
RIVERHEAD	10	21	7.400	2590.00	525	4.93
TAIRUA	7	21	4.141	1449.35	96	15.10
TAIRUA	10	21	7.400	2590.00	96	26.98

The 1987 stumpage price for domestic sawlogs was $31.93 (MOF 1987). At all three sites the break-even wood prices as given in Table 4 are below the base year stumpage price at both the 7 and 10% interest rates. Addition of P fertiliser is therefore economically viable at these interest rates.

ACKNOWLEDGEMENTS

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Hunter *et al* (Unpublished) : Phosphorus uptake of Radiata Pine on soils of different Phosphorus retention, fertilised with Superphosphate and A-grade rock. Fert. Co-op report 16.

MAF (1987) : Farm Costs and Prices 1987.

MOF (1987) : Statistics of the Forests and Forest Industries of New Zealand 1987.