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EVALUATION OF THE CLAYSFERT STAND GROWTH MODEL: PREDICTION OF CHANGE IN FOLIAR P AFTER APPLICATION OF LESS SOLUBLE FERTILIZERS

by

A.D. GORDON and J.D. GRAHAM

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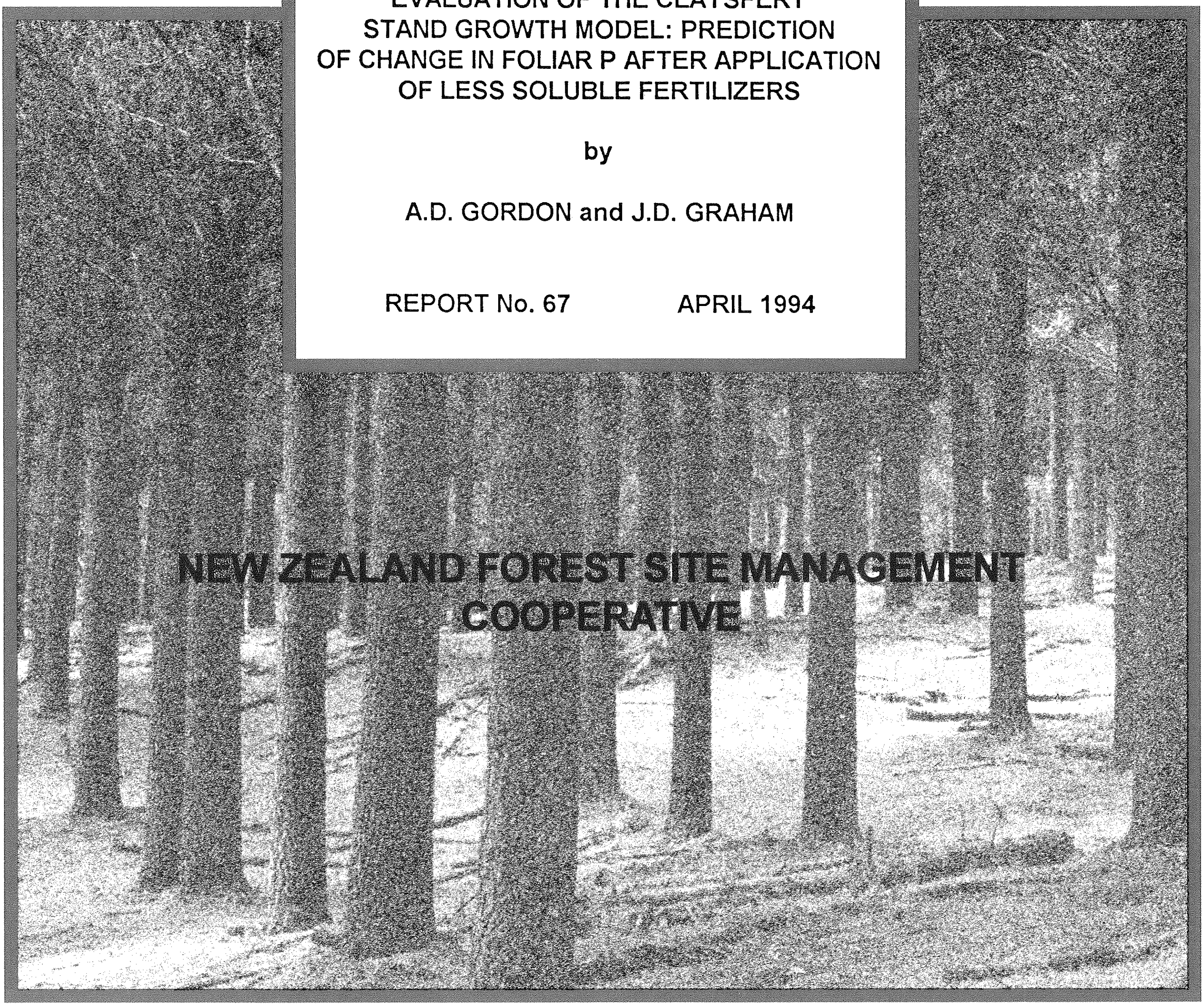

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EXECUTIVE SUMMARY

The ClaysFert growth model (Shula 1987b) was designed to predict stand growth on Auckland Clay soils in the presence of phosphorus fertilizer.

This report presents the results of an evaluation of the fertilizer effects in the ClaysFert model using data from two less-soluble fertilizer trials (AK 734/2 and AK 1055).

ClaysFert predicts the rise in foliar *P* adequately for these fertilizers.

Although the trial results indicated that the peak foliar *P* concentration was reached 18 to 24 months after application, the ClaysFert assumption that foliar *P* reaches a maximum after only 12 months is a reasonable simplification and does not appear to invalidate the overall prediction of foliar *P*.

The decline of foliar *P* through time is predicted reasonably well by ClaysFert.

The ClaysFert fertilizer effect models are logical and robust and appear to be capable of predicting the changes in foliar *P* concentration resulting from the application of less-soluble phosphate fertilizers.

INTRODUCTION

The ClaysFert growth model (Shula 1987b) was designed to predict stand growth on Auckland Clay soils in the presence of phosphorus fertilizer. The model was based on earlier work (Shula 1987a) in which the main growth relationships were derived for stands which exhibited "adequate" phosphorus nutrient status. This status is based on the concentration of foliar *P*, which must exceed 0.11% on average for a stand's nutrient status to be considered adequate.

The fertilizer effects were produced by three distinct relationships:

- The time required to achieve a unit of growth was predicted as a function of foliar *P*. Two time-scale multipliers (lambda values) were predicted; one for basal area and one for mean top height.

- The rise in the foliar *P* concentration one year after fertilization was predicted as a function of fertilizer rate in kg ha^{-1} of super-phosphate equivalent. Super phosphate is generally considered to supply 9% to 10% elemental *P*. The foliar *P* level prior to fertilization was shown to be related to the rise but could not be satisfactorily incorporated in a prediction function.

- The decline in the foliar *P* concentration was related to the time since fertilization.

This report presents the results of an evaluation of the fertilizer effects in the ClaysFert model using data from two fertilizer trials (AK 734/2 and AK 1055). These trials included treatments using phosphate fertilizers that are less-soluble than the "super-phosphate" used in the trials on which ClaysFert was built. Less-soluble fertilizers were considered likely to show a lower but more prolonged response in foliar *P* concentration than ClaysFert would predict.

The evaluation focussed on comparing actual and predicted rise and decline of the foliar *P* concentration, with a view to generalising the fertilizer effect functions in the growth model if this was shown to be necessary.

DATA

The trials used for this evaluation were both established in Riverhead forest.

AK 734/2 was located in compartment 23 which was planted in 1974. The trial was designed to test the response to different rates of pelletised rock phosphate and was laid out and treatments applied in 1978. Plots were 40 x 40 m (0.16 ha, including a 20 x 20 m inner measurement plot) with three replicates of each treatment. The treatments examined here were two rates of Christmas Island A-grade rock phosphate, at 75 and 150 kg ha^{-1} elemental *P*.

AK 1055 was located in compartment 9 which was planted in 1983. The trial was designed to test the response to different rates and levels of acidulation of phosphate rock and was laid out and treatments applied in 1987. Plots were 25 x 25 m (0.0625 ha, including a 15 x 15 m inner measurement plot) with two replicates of each treatment. The treatments examined here were 50 and 75 kg ha^{-1} elemental *P* as either unacidulated or 30% acidulated North-Carolina phosphate rock.

The treatment labels used here are:

Label	Treatment
control	un-treated
50kg30	50 kg ha^{-1} elemental *P* of 30% acidulated North Carolina phosphate rock.
75kg30	75 kg ha^{-1} elemental *P* of 30% acidulated North Carolina phosphate rock.
50kgNCR	50 kg ha^{-1} elemental *P* of unacidulated North Carolina phosphate rock.
75kgNCR	75 kg ha^{-1} elemental *P* of unacidulated North Carolina phosphate rock.
75kgA	75 kg ha^{-1} elemental *P* of Christmas Is. A grade rock phosphate.
150kgA	150 kg ha^{-1} elemental *P* of Christmas Is. A grade rock phosphate.

METHODS

The foliar *P* measurements were averaged across the replicates of each treatment for each trial. These means were arranged as a time series and compared with the predicted foliar *P* values produced by the ClaysFert fertilizer effect functions. A generalised response function was fitted to provide an objective estimate of when the rise in foliar *P* ceased, that is, the time since fertilization of the maximum foliar *P*.

The results were examined graphically and comparisons made between actual and predicted by considering the precision of the existing ClaysFert functions.

RESULTS

The trial results are shown in tables 1 and 2.

Table 1. Trial AK1055 - Mean Foliar *P* concentrations (% oven dry weight)

Treatment	Months Since Treatment					
	0	6	18	30	42	54
control	.098	.098	.097	.081	.094	.090
50kg30	.098	.102	.128	.099	.115	.126
75kg30	.098	.146	.160	.122	.138	.137
50kgNCR	.098	.098	.122	.102	.118	.104
75kgNCR	.098	.110	.132	.113	.124	.122

Table 2. Trial AK734/2 - Mean Foliar *P* concentrations (% oven dry weight)

Treatment	Months Since Treatment						
	0	6	18	30	42	66	78
control	.084	.084	.087	.081	.077	.085	.098
75kgA	.084	.094	.123	.108	.102	.101	†
150kgA	.084	.099	.131	.112	.106	.106	.126

† This measurement was not completed.

Figure 1 shows the changes in Foliar *P* concentration with time in trial AK1055. The means for each of the four treatments and the control are shown for each measurement.

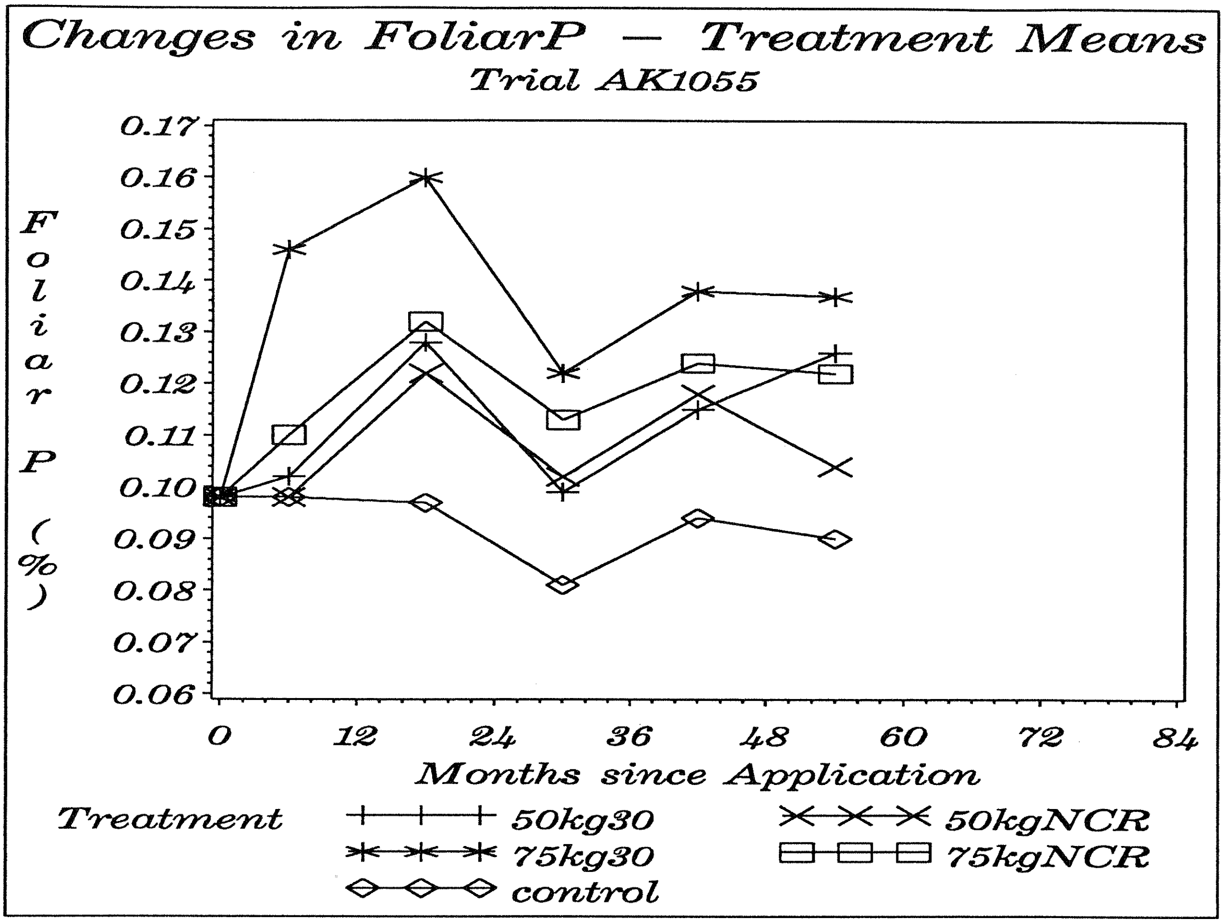

Figure 1. Trial AK1055 - Changes in Foliar *P*

The measurement at 30 months after application appears to have been generally depressed across all the plots, but if these values are adjusted up to compensate, the pattern of rise followed by decline is quite clear. Foliar *P* rose rapidly after fertilizer application to reach a peak value somewhere between 6 and 18 months later. From that point on the concentration declined at a rate slightly faster than the rate of decline of the control. The last measurement in the 50kg30 treatment (54 months) was the only observation that contradicts these trends.

The size of the change increased with the rate of *P* applied. The NCR and 30% acidulated fertilizers appear very similar at 50 kg *P* per hectare but more response was shown by the 30% than the NCR at 75 kg per hectare.

The changes for trial AK734/2 are shown in Figure 2. This trial started at a slightly lower foliar *P* but the pattern is similar. The peak value occurred between 6 and 18 months followed by a decline.

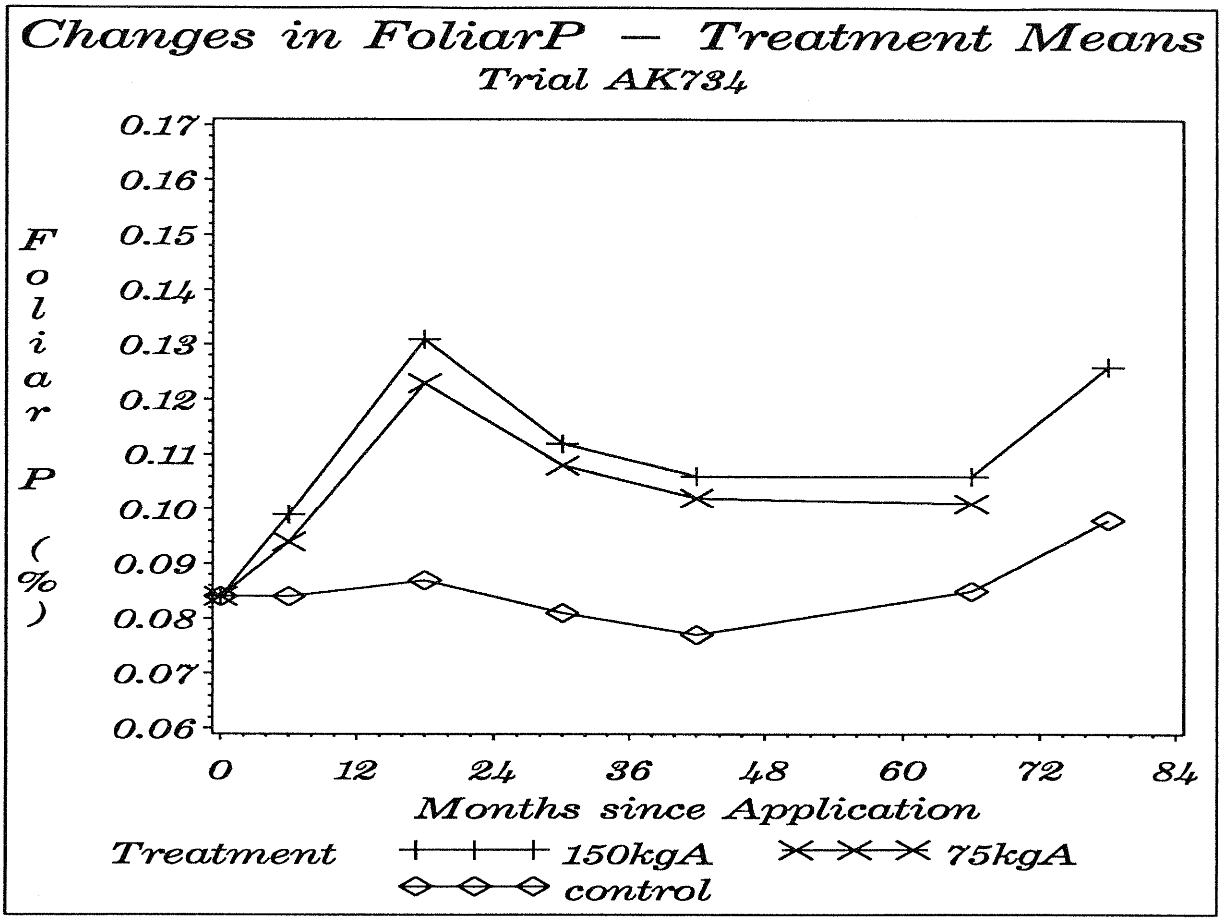

Figure 2. Trial AK734/2 - Changes in Foliar *P*

The final measurement at 78 months was not completed in the 75kgA and appears to have been generally high across all the plots, although the relativity between the control and the 150kgA treatment was maintained. The increase in response between the 75kgA and 150kgA rates was quite small compared to the 30% treatments in the AK1055 trial.

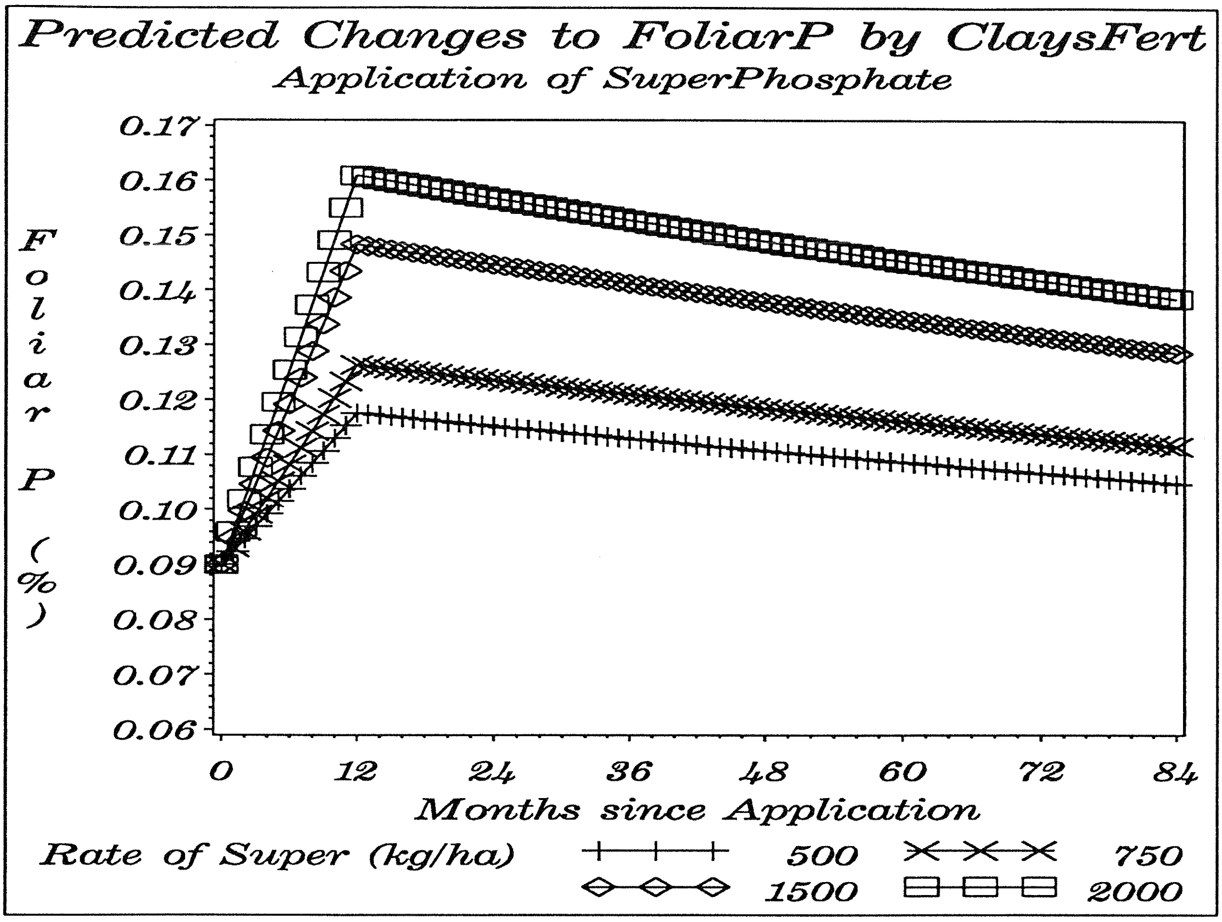

Figure 3. Changes in Foliar *P* Predicted by ClaysFert

The changes predicted by ClaysFert are shown in Figure 3. This figure is a composite of the rise and decline models for 4 different rates of super-phosphate corresponding approximately to 50, 75, 150 and 200 kg ha^{-1} of elemental *P*. It clearly shows the assumption that foliar *P* reaches a maximum 12 months after treatment and then declines.

Comparisons showed that the differences between predicted and actual foliar *P* concentrations were all well within the error limits of the ClaysFert functions.

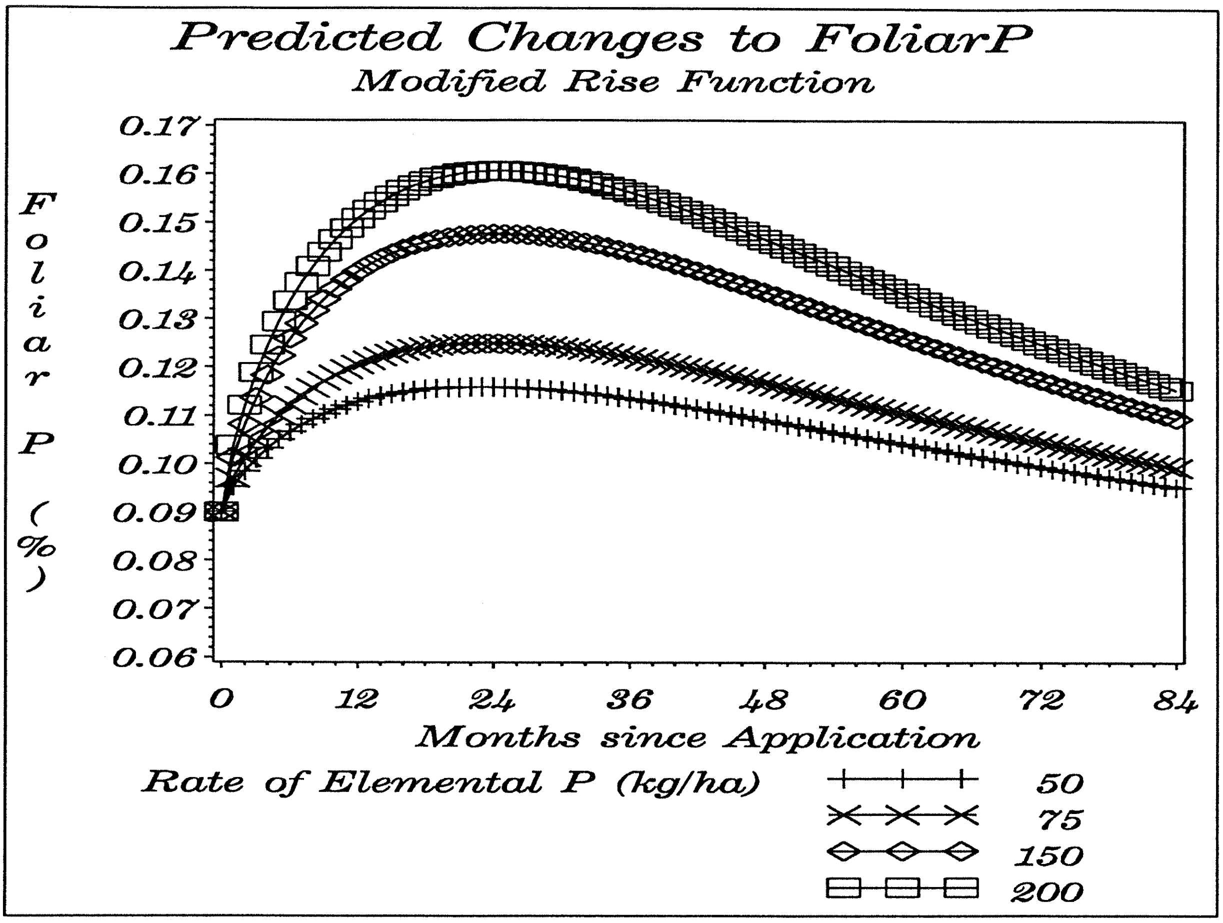

Figure 4. Extended Foliar *P* Rise Function

The ClaysFert rise function was extended to incorporate time since treatment and fitted to the data from these trials. The results are shown in Figure 4. The maximum foliar *P* occurs between 18 and 24 months after treatment according to this extended function.

DISCUSSION

The ClaysFert rise function was based mainly on trials using a 600 kg ha^{-1} super-phosphate rate (Shula 1987b §4.1.2). Shula's data showed considerable variation with residuals of up to 0.04% foliar *P* and an R^2 of only 0.13.

The 30% treatment at 75 kg ha^{-1} *P* rate in AK1055 resulted in a larger rise than predicted with an error of -0.025% foliar *P* at 18 months. In the AK734/2 trial the 150kgA treatment resulted in a smaller rise than predicted with an error of 0.01% at 18 months. The other treatments were predicted reasonably well by the rise function.

Without a measurement at 12 months after fertilization, direct comparisons with the predicted maximum rise could not be made. However plotting the modified rise function (Fig. 4) showed that the maximum foliar *P* was reached between 18 and 24 months after application. Thus there is slight evidence that the response may have peaked later than ClaysFert assumes.

The ClaysFert decline function (Shula 1987b §4.1.3) was also fitted to a variable data set, although 75% of the variation in the final foliar *P* was accounted for. It predicts the drop in foliar *P* with time adequately for all the treatments examined here. There is no indication that these less-soluble fertilizers maintain higher foliar *P* levels through time than the levels predicted by the super-phosphate based decline function used in ClaysFert.

CONCLUSION

ClaysFert predicts the rise in foliar *P* adequately for these less-soluble fertilizers.

The fertilizers used in these trials may result in a peak foliar *P* concentration being reached 18 to 24 months after application, but the ClaysFert assumption that foliar *P* reaches a maximum after only 12 months is a reasonable simplification and does not appear to invalidate the overall prediction of foliar *P*.

The decline of foliar *P* through time is predicted reasonably well by ClaysFert.

Although the data used to fit the ClaysFert models showed a large amount of variation that could not be accounted for, the models chosen were logical and robust and appear to be capable of predicting the changes in foliar *P* concentration resulting from the application of less-soluble phosphate fertilizers.

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