F.R.I. PROJECT RECORD
NO. 1532

CURRENT WORKPLANS USED BY THE SOILS AND SITE AMENDMENT RESEARCH FIELD

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PRUNING * THINNING * NITROGEN FERTILISER IN ESTABLISHED STANDS

WORKPLAN

OBJECTIVES

To quantify the effect of and interactions of pruning, thinning and nitrogen fertiliser application.

BACKGROUND

The first trial in this series, located in a 6 year old stand in Kaingaroa, showed that N fertiliser and silviculture interact. It produced some interesting results:

(1)Pruning depressed basal area growth but nitrogen fertiliser partly overcame the growth depression.

(2)Selectively pruned stems in unthinned stands normally lose dominance; application of nitrogen fertiliser to such a stand prevented loss of dominance.

(3)The unthinned, unpruned plots responded only slightly to nitrogen fertiliser, but a fairly strong response was recorded in thinned or pruned plots.

SUITABLE LOCATIONS

Most forests. Those with other nutrient deficiencies than nitrogen should provide a preliminary foliage sample so that other deficiencies can be corrected prior to starting the experiment.

One main application of this trial design will be in 5 to 6 year old stands which are just about to receive their first tending. In this situation silviculture will be applied to some of the plots, the remainder being left untended. Another application will be at a later stage in silviculture where the effect of different stockings and different pruning lifts can be evaluated.

DESIGN

In each block there will be eight treatments:

Treatment Number	Treatment
1	No silviculture or fertiliser
2	No silviculture, fertilise
3	Prune part only, no fertiliser
4	Prune part only, fertilise
5	Thin only, no pruning no fertiliser
6	Thin and fertilise, no pruning
7	Thin and prune, no fertiliser
8	Thin, prune and fertilise

There should be 3 replications.

Prune the same number of stems per hectare in all pruned plots.

Fertilise with 200 kg N/ha as urea (435 kg/ha). Other fertilisers may be applied to all plots if foliage analysis so indicates.

Number the plots from 1 to 8 in each block. Assign treatments at random within blocks.

ESTABLISHMENT DETAILS

Each plot will be 20 x 20 metres plus a 5m treated surround (total plot area .09 ha). Main plot and measurement plot corners should be clearly identified with different coloured battens.

Larger plots may be necessary in older crops to achieve 15 trees in the measurement plot.

Trees in the measurement plot should be clearly banded at breast height and numbered with paint or a suitable secure tag.

A central tree should have the plot number in case corner pegs are lost.

Draw a map.

Since we wish to follow the growth not only of the total plot but also of the crop element, the final crop trees in the unthinned plots should be marked with a painted "C".

Urea fertiliser should be applied between 1 August and 31 October; early in the season in warmer areas, later at cooler moister sites. Ideally, fertiliser should be spread on a cool overcast day with rain forecast.

Take great care to ensure that fertiliser is evenly spread at the correct rate on both the measurement plot and the surround. Noting the number of rows of trees and tying string across the outer pegs can help achieve this.

Silviculture must take place immediately (within 48 hours) the fertilising is complete.

MEASUREMENTS

Measure at start of trial and annually in winter for 5 years. The PSP series of forms is available from the F.R.I.

(1)Thinned plots

Measure all diameters at breast height and record on PSP2 forms. Measure 10 heights per plot and record on PSP3 forms. Use the same height trees in successive years unless malformation makes substitution necessary.

(2)Unthinned plots

Record the diameters of the "crop trees" on PSP2 as subplot /0. Record the diameters of the remaining trees on a separate PSP2 as subplot /1.

Measure 10 heights per subplot, recorded on separate PSP3 forms.

SOIL AND FOLIAGE ANALYSES

A composite soil sample from each block will be collected before treatment. Each composite will be made up of at least 40 0-10cm cores taken throughout the block. A full analysis of each sample will be carried out by F.R.I.

Foliage will be collected during the period 15 February - 31 March prior to establishment and during the same period for 5 subsequent years. Collect a good handful of foliage from each plot from secondary branches (the small side branches attached to the big main branches) in the upper crown. Collect from 7 trees per measurement plot.

FURTHER SILVICULTURE

While pruning, if necessary, may continue as normal there will be no change in stocking for at least 4 years.

RECENT RESULTS

BASAL AREA AND HEIGHT RESULTS AFTER 2 YEARS IN THREE SILVICULTURE AND FERTILISER TRIALS

SITES: AUPOURI AK977
WOODHILL AK911
KAINGAROA R01083

All sites had: 200 kg N/ha as urea
Thinning to 600 s/ha at Aupouri and Kaingaroa
to 750 s/ha at Woodhill
and to 1200s/ha at Aupouri
Pruning of all the crop element. In the unthinned plots the crop element was also pruned.
All these treatments were in a factorial arrangement.

RESULTS

TABLE 1. TOTAL BASAL AREA (m^2/ha) two years after establishment

	600/750 s/ha		1200s/ha		UNTHINNED	
	Unpruned	pruned	Unpruned	prun	Unpruned	prun
	(Unfert) (+N)					
AK911	14.7 16.9	12.9 15.5	------Unfertilised------- ----- +Nitrogen----------		22.7 24.9	21.2 24.0
R01083	10.2 11.9	9.3 10.2			27.6 28.7	25.3 28.4
AK977	14.8 14.7	8.5 11.3	19.2 19.8	20.0 19.5	23.0 28.7	22.5 23.9

TABLE 2: BASAL AREA OF THE CROP ELEMENT(same layout as above)

AK911	11.9	10.4			10.2	9.0
	13.6	12.5			11.1	10.4
RO1083	10.2	9.3			8.4	7.6
	11.9	10.2			8.8	8.3
AK977	14.8	8.5	12.2	11.6	10.5	8.9
	14.7	11.3	12.1	10.5	10.7	10.3

TABLE 3: PREDOMINANT MEAN HEIGHT (SAME AS ABOVE)

AK911	9.2	8.9			9.8	9.3
	8.6	8.2			9.1	9.0
RO1083	9.5	8.9			9.7	10.1
	9.6	9.1			9.6	9.6
AK977	10.5	9.3	10.7	11.0	11.1	10.6
	10.6	9.9	10.7	10.9	11.2	10.8

CONCLUSIONS: The same general tendencies are present in all of the trials. Aupouri is merely , but significantly , more extreme. Nitrogen has had more effect at Aupouri and pruning has more severely reduced growth. Kaingaroa differs slightly because the unthinned plots were at a very high (3000 s/ha) stocking. So not only is total basal area higher, but crop ba, because of the very severe thinning ,is slightly lower.

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OPTIMUM COMBINATION OF NITROGEN AND PHOSPHORUS IN YOUNG STANDS

WORKPLAN

OBJECTIVES

To determine the economic and biological growth optima from the application of nitrogen and phosphorus fertiliser to radiata pine on soils suspected to respond to those elements.

BACKGROUND

There are a number of soil types on which radiata pine responds in growth to the application of more than one element. For the very poor gravel soils of Nelson this conclusion is based on a factorial trial with a limited range of rates in N and P such that a very approximate optimum fertiliser rate could be calculated. In North Auckland however the fact that on the more degraded clay soils radiata will respond to N as well as P, was discovered from a series of trials in which one element was varied while the other was kept constant.

Trials with limited rates of N and P have identified the podzolised sand soils of North Auckland, parts of southern Kaingaroa and the pakihi soils of the West Coast of the South Island as responsive to at least N and P. It is not possible to determine the optimum rate of N and P fertiliser from trials with such a limited spread of rates.

SUITABLE LOCATIONS

Because both N and P are liable to be growth limiting to some degree on nearly all forest soils, a wide range of sites is possible. The availability of other nutrients should also be checked by means of a foliage sample.

Young crops (4-5 year old) should initially be chosen as it appears that response to fertiliser approximates a certain percentage of the base growth rate i.e. greatest in young vigorous crops.

For practical purposes it is assumed that the pattern of response identified in these young crops is applicable to older ones. However there are several scientific reasons to doubt this assumption and it is hoped that rescources will enable some testing in older crops.

Trials of this design are currently situated on 5 soil types.

(1)A podzolised sand in North Auckland. (AK976/1)

(2)A leached to podzolised clay in North Auckland. (AK976/2)

(3)A shallow flow tephra soil on the volcanic plateau. (R01889)

(4)A granite soil near Motueka. (NN518)

(5)A pakihi site on the West Coast of the South Island. (WD399)

DESIGN

The stated objectives lead to a choice between two types of trial design: a factorial arrangement of treatments or a response surface design (Central Composite type). The factorial arrangement has advantages in that it is not necessary to presume an optimum combination but has disadvantages in that, to test a reasonable range of rates, the trial becomes very large. Forest sites are always very variable and fractional replication would be necessary to contain this variability. On the other hand it is necessary to pre-select a probable optimum combination of N and P for the central composite design, but there is considerable saving in total experiment size.

A modified central composite design has been adopted to include other points as well.

Because it is always useful to know what growth would have been without any fertiliser, one modification is to include a complete control. At some sites the need for other elements is strongly suspected. Another modification is therefore to include plots fertilised with these elements as well as N and P. Even without the extra plots the experiment would have 13 plots per replicate which is rather too many for the variability experienced on forestry sites. A further modification is to block the experiment such that each of the four blocks of four treatments contains the central treatment, either a complete control or a central treatment plus other nutrients, and two treatments from the standard design balanced so as to minimise unfavourable treatment by block confounding.

The treatments are:-

TREATMENT No.	NITROGEN (kg/ha)	PHOSPHORUS (kg/ha)	OTHERS
1.	80	40	
2.	80	120	
3.	240	40	
4.	240	120	
5.	0	75	
6.	400	75	
7.	150	0	
8.	150	200	
9.	150	75	(Central Composite)
10.	0	0	
11.	150	75	+ (a) Cu 10 kg/ha and K 80 kg/ha for AK976/1 and WD399; OR (b) Mg 100 kg/ha for RO1889 OR (c) minus Boron (base dressing of 8 kg/ha to all other plots at NN518)
12.	75	38	+ Cu 10 kg/ha and K 80 kg/ha for AK976/1 and WD399
13.	75	38	+ Cu 5 kg/ha and K 40 kg/ha for AK976/1 and WD399
14.	150	75	+ Cu 5 kg/ha and K 40 kg/ha for AK976/1 and WD399

At each site there are two replications of treatments 1 to 8, eight of treatment 9, and four of treatments 10 and 11. Treatments 12 to 14 were replicated twice at the sites where they were present.

The Fertiliser:

In nearly all previous experiments the source of P was single superphosphate. This was satisfactory when it was the only commercially available P fertiliser. However, single superphosphate is a particularly dirty fertiliser containing appreciable quantities of S, K, Mg, Cu and Zn as well as the prime ingredient calcium phosphate. Nowadays higher analysis somewhat purer fertilisers are more freely available and it is highly likely that if a profitable NP rate is identified by these trials it is such a fertiliser (e.g. DAP), possibly diluted with urea, that would be the most economical way to apply that rate.

Unfortunately the contaminants in single superphosphate are such as to limit the practical application of information on the desirability of NP fertilisation. A rise in foliar K, Mg, Zn and Cu is frequently observed on the more degraded soils of North Auckland when single superphosphate is applied. It is not possible to determine if this is directly due to the contaminants or indirectly due to increased root activity. It is of practical significance for K and Cu are present in marginal concentrations only in the foliage of radiata pine on podzols. Use of purer high analysis fertilisers could provoke deficiencies masked by single superphosphate.

A major innovation in this trial series is the use of pure monocalcium phosphate as the source of P. Nitrogen will be applied as urea.

ESTABLISHMENT DETAILS

Each plot will be large enough to contain about 20 trees plus a 5m treated surround. Main plot and measurement plot corners should be clearly identified with different coloured battens.

Trees in the measurement plot should be clearly banded at breast height and numbered with paint or a suitable secure tag.

A central tree should have the plot number in case corner pegs are lost.

Draw a map.

Urea fertiliser should be applied between 1 August and 31 October; early in the season in warmer areas, later at cooler moister sites. Ideally, fertiliser should be spread on a cool overcast day with rain forecast.

Take great care to ensure that fertiliser is evenly spread at the correct rate on both the measurement plot and the surround. Noting the number of rows of trees and tying string across the outer pegs can help achieve this.

MEASUREMENTS

Measure at start of trial and annually in winter for 5 years. The PSP series of forms is available from the F.R.I.
Measure all diameters at breast height and record on PSP2 forms.
Measure 10 heights per plot and record on PSP3 forms. Use the same height trees in successive years unless malformation makes substitution necessary.

SOIL AND FOLIAGE ANALYSES

A composite soil sample from the entire site will be collected before treatment. The composite will be made up of at least 50 0-10cm cores taken throughout the site. A full analysis of the sample will be carried out by F.R.I.

Foliage will be collected during the period 15 February - 31 March prior to establishment and during the same period for years 1, 3 and 5. Collect a good handful of foliage from each plot from secondary branches (the small side branches attached to the big main branches) in the upper crown. Collect from 7 trees per measurement plot.

SILVICULTURE

Thinning of the crop to approximately 1000 s/ha prior to trial layout (but before plot size determination) is desirable but there must be no further thinning for at least 3 years and preferably not for 5 years. By implication this is a framing type regime.

There is a good theoretical reason for prefering stands of this type. Response to N at least seems to be a maximum at stand canopy weights of between 3 and 7 tonnes/ha, the probable range for lightly thinned 4 to 5 year old crops. Direct regime crops (approximately 1 tonne of canopy/ha after thinning) appear to have a similar pattern of response but with a smaller magnitude.

RECENT RESULTS

THE 3 YEAR RESULTS OF THE CURRENT N * P TRIALS

The statistical analysis of these trials was made using the regression package of GENSTAT. From the analysis, a formula was derived to produce a three dimensional graph showing the fertiliser response surfaces to each of basal area, mean height and volume.

The formula is:-

$$\text{constant} + (\text{estimate of value} * \text{average for 1983}) + N + P + N^2 + P^2 + (N * P)$$

The basal area, mean height and volume for treatments 1 -10 were all analysed in the above way.The three dimensional graphs were drawn as shown, the volume data from each trial are featured as an example.

All sites have shown a response to fertiliser.

To date the three North Island trials have shown linear responses to N in basal area, while the two South Island trials have shown responses to N and P. The quadratic surface was significant only in the Nelson trial. However the strength of the quadratic response appears to be increasing and in the interests of consistency all the sites have been graphed with the full quadratic response.

These trials have proved to be very powerful.

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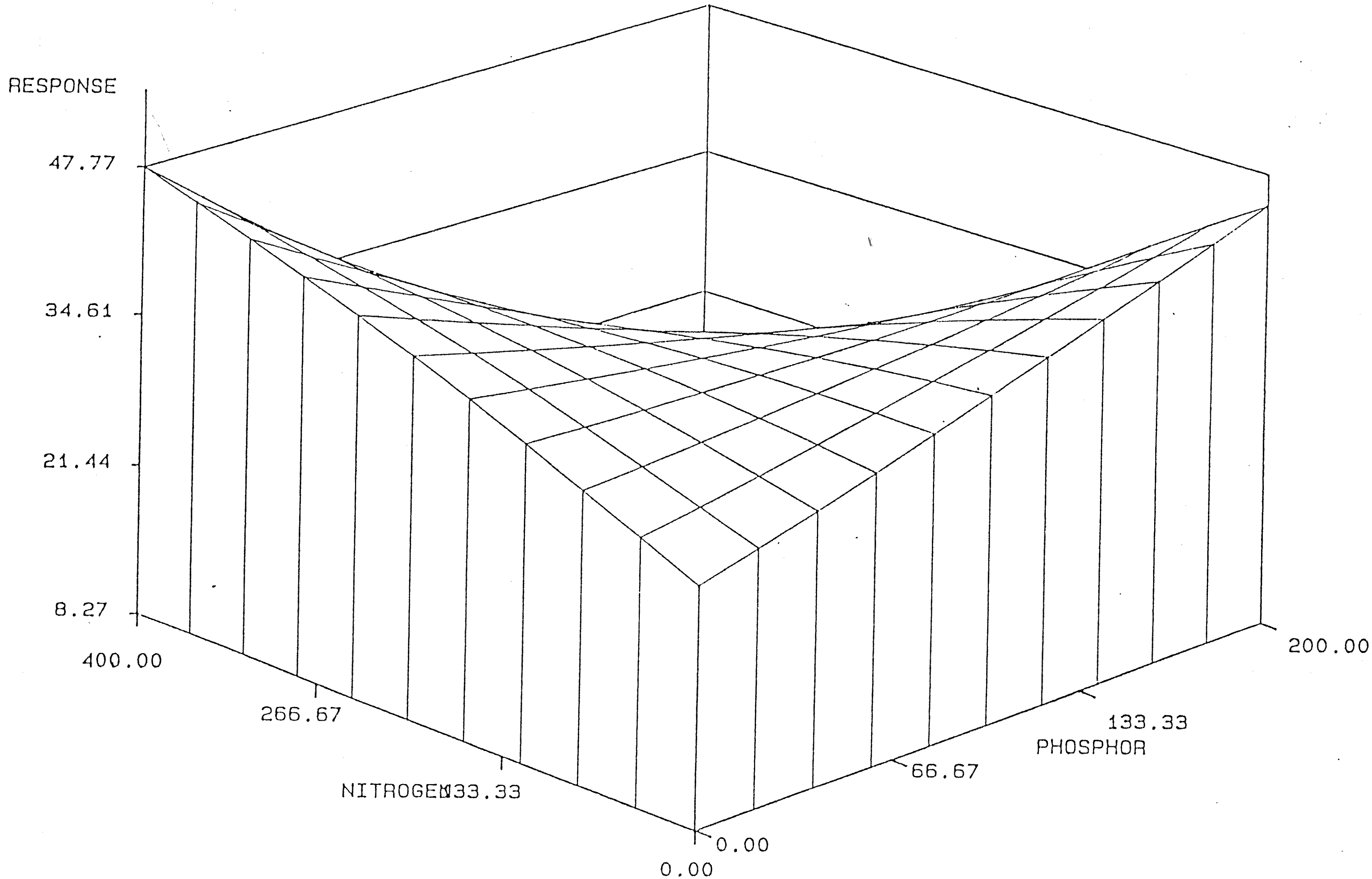
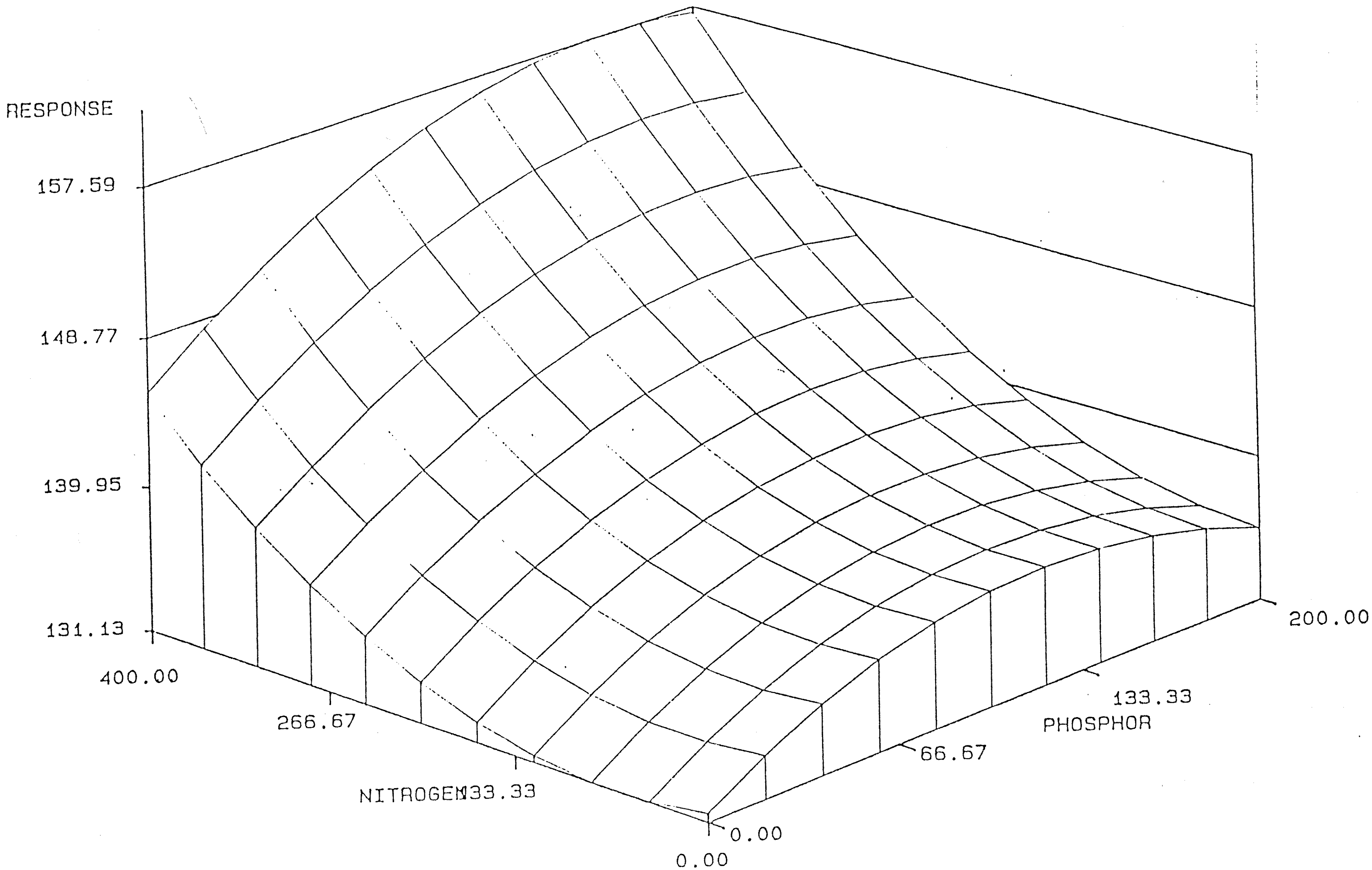
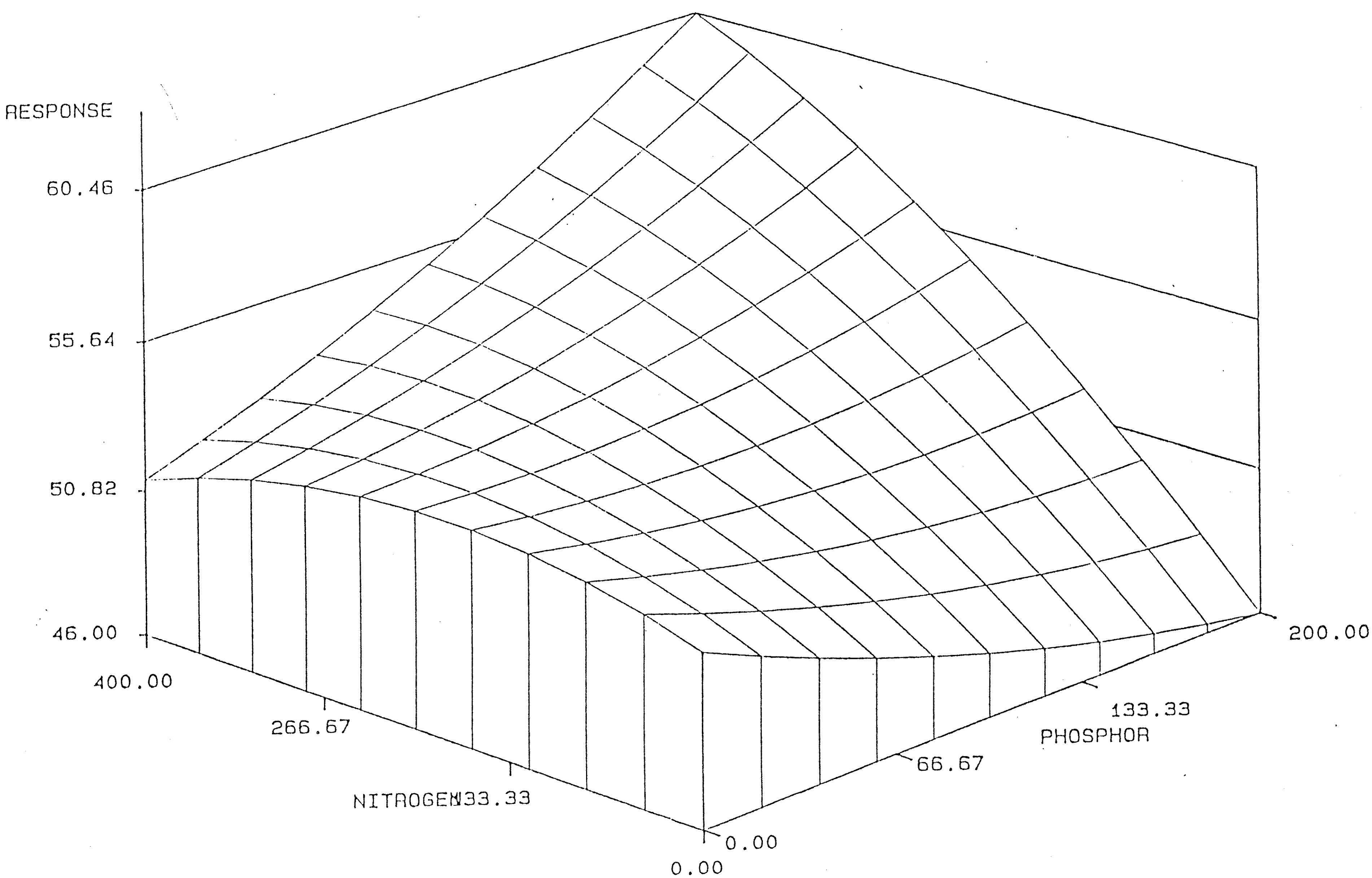
1986 AK976/1 Volume Response



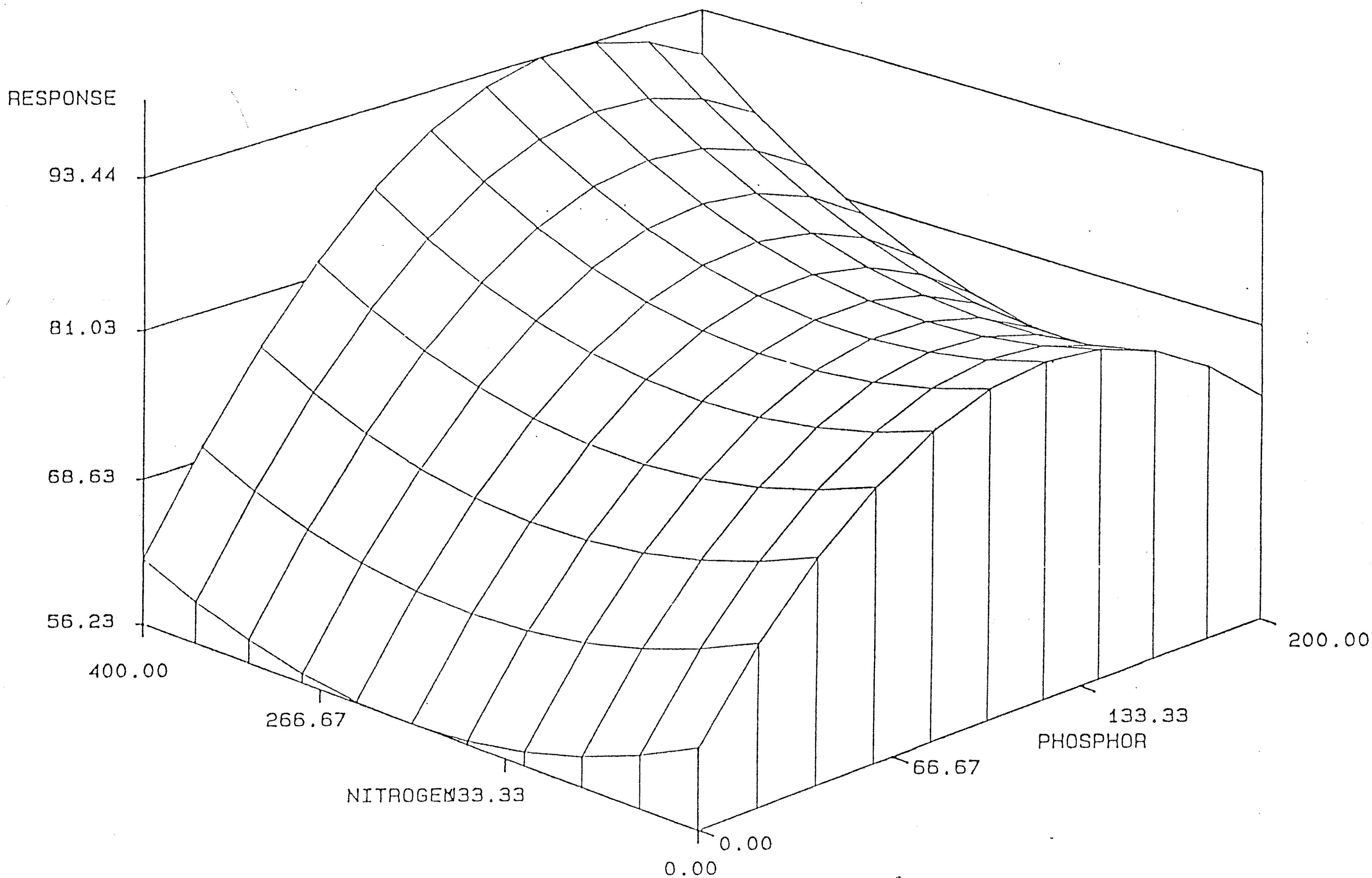
1986 AK976/2 Volume Response



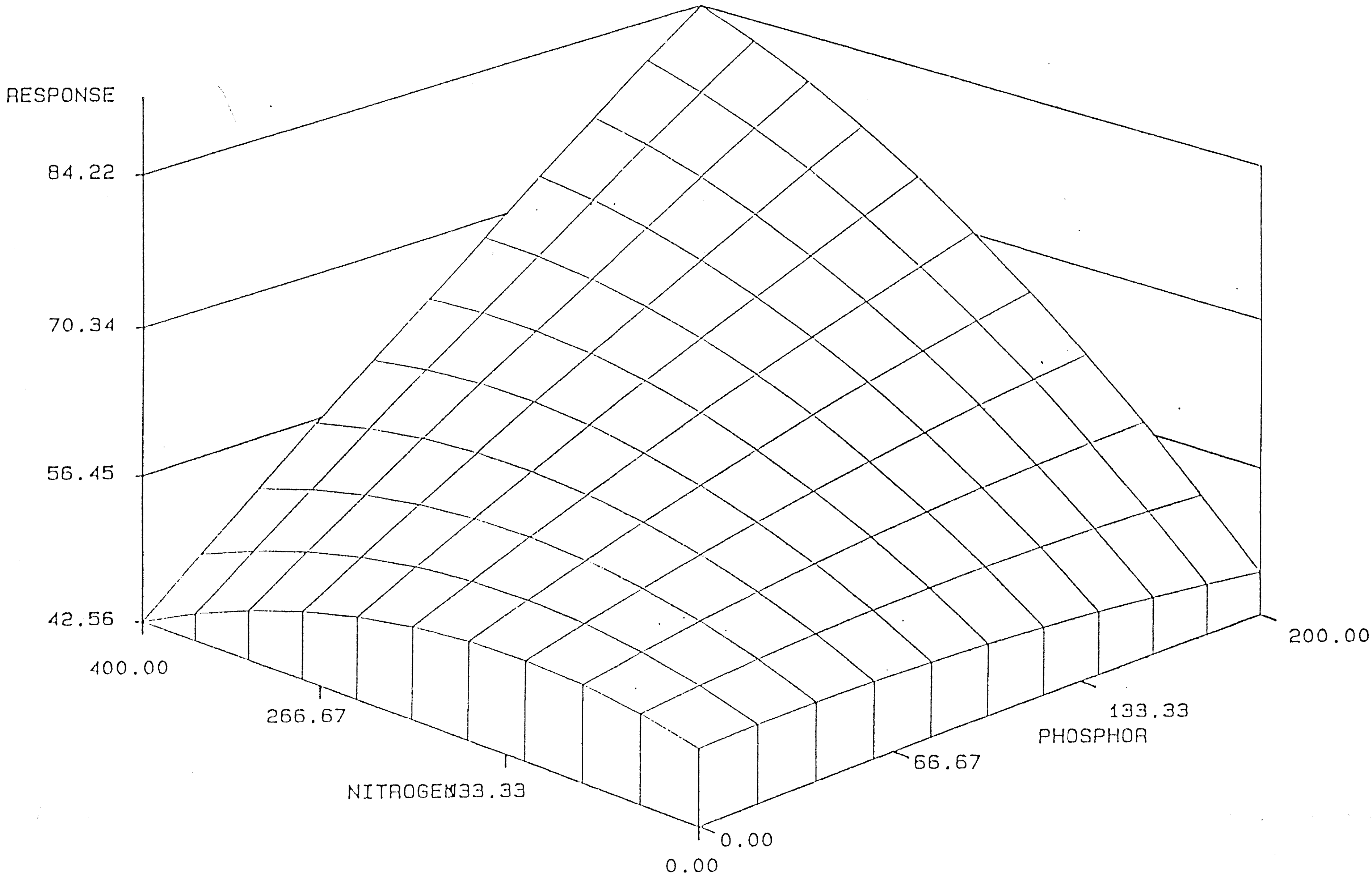
1986 R01889 Volume Response



1986 NN518 Volume Response



1986 WD399 Volume Response



CROP NUTRITION AFTER WHOLE TREE THINNING

WORKPLAN

OBJECTIVES

(a) to determine the effect on residual trees of completely removing cull trees during thinning.

(b) to determine between waste and normal log thinning in their effect on the residual tree growth.

(c) to determine the role of nitrogen in any reduction in residual tree growth.

BACKGROUND

Conventional thinning practises leave large quantities of branch, leaf and stem material on the site. This material is potentially valuable to the remaining crop trees both as a nutrient source and as a mulch to preserve soil moisture.

With greater mechanisation of thinning or a greater demand for existing products, the thinning residue may be removed from the site. On sites where the supply of some nutrients is limited, whole tree extraction may have a detrimental effect on the remaining crop.

When a stand is thinned there is a high demand for nitrogen for crown expansion. Therefore this is the element most likely to limit growth at that time under normal conditions.

SUITABLE LOCATIONS

Any plantations that contain easy topography are possible sites for mechanical whole tree extraction.

DESIGN

Treatments may vary from site to site depending on the thinning regime being followed and the local utilisation of cull trees. To assess the use of fertiliser nitrogen in replacing that removed by thinning the trial should contain at least the following treatments:

1. Waste thinning
2. Waste thinning + urea fertiliser (200 kg N/ha)
3. Conventional production thinning (extract stem to 10cm SED)
4. Conventional thinning + fertiliser
5. Whole tree removal (including branches)
6. Whole tree removal + fertiliser
7. Unthinned

If stands are too highly stocked to admit current extraction machines then treatments 3 - 6 can be simulated by hand.

There should be three replicates with attention being paid to vehicle extraction routes.

ESTABLISHMENT DETAILS

Each plot will be large enough to contain about 20 trees plus a 5m treated surround. Main plot and measurement plot corners should be clearly identified with different coloured battens.

Trees in the measurement plot should be clearly banded at breast height and numbered with paint or a suitable secure tag.

A central tree should have the plot number in case corner pegs are lost.

Draw a map.

Urea fertiliser should be applied between 1 August and 31 October; early in the season in warmer areas, later at cooler moister sites. Ideally, fertiliser should be spread on a cool overcast day with rain forecast.

Fertiliser should be spread immediately after thinning. It can be applied beforehand if thinning can be guaranteed to take place within 2 days and take no longer than 5 days.

Take great care to ensure that fertiliser is evenly spread at the correct rate on both the measurement plot and the surround. Noting the number of rows of trees and tying string across the outer pegs can help achieve this.

MEASUREMENTS

Measure at start of trial and annually in winter for 5 years. The PSP series of forms is available from the F.R.I.

Measure all diameters at breast height and record on PSP2 forms.

Measure 10 heights per plot and record on PSP3 forms. Use the same height trees in successive years unless malformation makes substitution necessary.

SOIL AND FOLIAGE ANALYSES

A composite soil sample from the entire site will be collected before treatment. The composite will be made up of at least 50 0-10cm cores taken throughout the site. A full analysis of the sample will be carried out by F.R.I.

Foliage will be collected during the period 15 February - 31 March prior to establishment and during the same period for years 1, 3 and 5. Collect a good handful of foliage from each plot from secondary branches (the small side branches attached to the big main branches) in the upper crown. Collect from 7 trees per measurement plot.

SILVICULTURE

No further thinning or pruning should take place for at least 4 years.

BIOMASS ESTIMATION

To accurately assess the quantity of nutrients removed during thinning a small biomass survey may be desirable. Contact the F.R.I. for details of this operation.

RECENT RESULTS

RESULTS OF A BIOMASS ESTIMATION IN A WHOLE TREE THINNING TRIAL

The mean basal area for the unthinned area = 31.67 m2/ha, and the thinned area = 17.35 m2/ha. The mean basal area for the sample trees was 0.02269 m2.

Table 1 shows the results of the GENSTAT analysis used to determine the weights of each tree component.

TABLE 1. Weights of Tree Components (tonnes/ha).

	UNTHINNED	THINNED	DIFFERENCE
1 YR FOL	5.125	2.818	2.307
2 YR FOL	4.087	2.247	1.840
3 YR FOL	0.593	0.326	0.267
> 3 YR FOL	0.013	0.0072	0.0058
WOOD (branch)	17.877	9.832	8.045
DEAD WOOD	15.067	8.286	6.784
BARK	10.304	5.667	4.637
STEM WOOD	87.315	48.023	39.292
TOTAL	140.381	77.206	63.175

TABLE 2. Weight of Nitrogen in each Tree Component (kg/ha).

	UNTHINNED	THINNED	DIFFERENCE
1 YR FOL	64.59	35.53	29.06
2 YR FOL	41.89	23.04	18.85
3 YR FOL	4.97	2.73	2.24
> 3 YR FOL	0.08	0.05	0.03
WOOD (branch)	43.45	23.90	19.55
DEAD WOOD	19.15	10.53	8.62
BARK	26.85	14.77	12.08
STEM WOOD	59.22	32.57	26.65
	260.20	143.12	117.08

TABLE 3. Weight of Phosphorus in each Tree Component (kg/ha).

	UNTHINNED	THINNED	DIFFERENCE
1 YR FOL	8.17	4.50	3.67
2 YR FOL	5.19	2.85	2.34
3 YR FOL	0.72	0.40	0.32
> 3 YR FOL	0.02	0.01	0.01
WOOD (branch)	9.00	4.95	4.05
DEAD WOOD	2.29	1.26	1.03
BARK	4.96	2.73	2.23
STEM WOOD	14.20	7.81	6.39
TOTAL	44.55	24.51	20.04

To estimate the amount of stem and branch matter in the tops of the trees (< 10 cm) we incorporated results from another trial in Woodhill Forest, AK 287. We found that the ratio between dry weight and wet weight of the tops to be 1 : 3.114. We had already obtained weights from a selection of trees at the time of thinning, and recorded the corresponding DBH, (so that a basal area ratio could be obtained). The tops weighed an average of 24.8 kg (wet), which when multiplied by the dry/wet ratio = 7.97 kg. The basal area ratio was then applied. We assumed a mean concentration of 0.186 for N and 0.032 for P. The amount of tops left on the site after thinning in the conventional way = 5.97 tonnes/ha, and those tops contained 11.1 kg N/ha and 1.9 kg P/ha.

Therefore in Table 4, the results for the conventional thinning equal the difference between the thinned and unthinned in Tables 1-3, but taking out the amounts the tops contribute.

The amount of biomass removed and remaining on site after each of the thinning operations is presented in Table 4.

TABLE 4. Amount of Biomass removed and remaining after thinning.

	REMOVED FROM SITE			REMAINING ON SITE		
OPERATION	Biomass (tonnes)	N (kg/ha)	P	Biomass (tonnes)	N (kg/ha)	P
Thin to Waste	-	-	-	63.17	117.08	20.04
Conventional Thin	37.96	27.63	6.72	25.21	89.45	13.32
Whole Tree Removal	63.17	117.08	20.04	-	-	-

Therefore by whole tree removal, there is 117 kg N/ha and 20 kg P/ha removed from the site.

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ROCK PHOSPHATES TO REPLACE SUPERPHOSPHATE AT TIME OF PLANTING

WORK PLAN

OBJECTIVE

To define the minimum quantity of P as broadcast phosphate rock required at establishment to maintain tree growth and nutrition through the establishment phase.

BACKGROUND

On soils poor in nutrients the current technique for fertilising trees at establishment is to apply the nutrients in a spade slit by the base of the tree. The life of the applied fertiliser as an effective supplier of nutrients is however short. The problem lies in a mismatch of fertiliser solubility with the trees' nutritional requirements at establishment. The soluble fertiliser releases too much nutrient too quickly. Within 12 - 24 months when the tree is making sustained demands on soil nutrients, the fertiliser source is very much less effective. By age 2 years when the established tree crop is under nutrient stress, a broadcast dressing of additional fertiliser is required to maintain good growth.

Recent work with phosphate rock as a broadcast fertiliser for radiata pine at establishment (the Ak850 series) on soils deficient in P has shown the maintenance of adequate foliar P concentrations through the first 6 growing years. This negates the need for repeated applications of single or triple superphosphate.

EXPERIMENTAL DESIGN.

Requirements.

1. To assess the effectiveness of various rates of phosphate rock during the establishment phase, and

2. To provide an adequate base for further experimentation during pole stage growth.

Treatments.

1. Broadcast phosphate rock
2. Spade slit application 15 g P + 14 g N, as DAP
3. The experiments will be laid out as randomised complete block designs with 8 or 10 blocks
4. Refertilisation - if refertilisation is required at a later date, pairs of adjacent blocks will be combined to form double sized blocks. Within these one plot of each treatment will be refertilised and one left. The resulting design will be analysed as a randomised complete block with 12 treatments (the 6 original and the 6 refertilised) and 4 or 5 blocks.

A typical pair of blocks is shown below:-

<-------------BLOCK 1------------><-----------BLOCK 2------------->

25 kg P /ha REFERT	280 kg P /ha REFERT	CONTROL 0 P/ha	25 kg P /ha	125 kg P /ha REFERT	56 kg P /ha REFERT
125 kg P /ha	56 kg P /ha	Slit Applied REFERT	280 kg P /ha	Slit Applied	CONTROL 0 P/ha REFERT

MEASUREMENTS

There will yearly measurements during winter for tree heights and root collar diameters. Diameters at breast height will be taken when appropriate.

SOIL AND FOLIAGE SAMPLES

Pre-test soil samples (composites of 5 per plot) will be taken to depth 10 cm for analyses of total N, total P, Bray P and exchangeable cations. During the course of the experiment, samples will be taken from all plots on a yearly basis for total P and Bray P.

A composite foliage sample will be collected from each plot during late summer.

RECENT RESULTS

Radiata pine, from planting through to age 3 on a range of P deficient soils, has shown varying requirements for broadcast rock phosphate. These range from 25 kg P/ha on a highly podzolised sand to between 56 kg P/ha and 125 kg P/ha on podzolised clay loams.

An analysis of costs for the rock phosphate strategy indicates likely management savings of between 20% and 50% compared with traditional techniques using soluble P fertiliser.

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