Yield response of process beans to fertiliser application

A report prepared for

Process Vegetable Sector, New Zealand & Potato Growers' Federation Inc.

D R Wilson, P H Williams &
C S Tregurtha
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New Zealand Institute for Crop & Food Research Limited
Private Bag 4704, Christchurch, New Zealand

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1 EXECUTIVE SUMMARY

Results from a trial conducted for Vegfed in 1995-96 suggested that traditional high fertiliser applications to process bean crops could be unnecessary and/or uneconomic, at least in higher fertility situations. Therefore, a multi-site experiment was established in 1996-97 to measure the yield response of beans to fertiliser application across a range of soil fertility conditions. The objective was to develop guidelines and, ultimately, a forecasting system for using fertilisers more efficiently.

The experiment was conducted at five sites in commercial process bean crops in the Lincoln-Irwell-Leeston area of central Canterbury. The sites were selected to obtain a diverse range of soil fertility levels. At each site the crop was managed in the same way as the rest of the paddock except that the usual fertiliser application was not applied to the experimental area. Instead, three replicates of three fertiliser treatments (0, 150 or 300 kg/ha of Cropmaster 15 (N:P:K:S = 15:10:10:7)) were applied.

At all sites the crop responses were dominated by a major contrast between the experimental area, where the fertiliser treatments were broadcast by hand and mixed with the surface soil by raking, and the surrounding growers' crops where most fertiliser was applied "down-the-spout" at planting. In all cases the beans responded vigorously to the fertilisers applied "down-the-spout" but not to the broadcast fertilisers. This large difference between methods of fertiliser application was unexpected. There were no visual differences among the plots in the experimental area at any of the sites. This suggests that the practice used by some growers of broadcasting fertiliser before planting as well as applying some "down-the-spout" is probably unnecessary.

In consultation with Vegfed, it was decided to abandon the trials on 14 February 1996 because it seemed very unlikely that the original objectives could be achieved. However, this failure does not reduce the need to continue research to develop methods for using fertiliser more efficiently in intensive crop production systems. The problem of how to interpret soil test results to decide how much fertiliser to apply to bean crops remains unresolved.

2 INTRODUCTION

Process bean crops are grown in intensive cropping systems, and high fertiliser application rates are usually used. For example, typical applications to crops grown for Wattie Frozen Foods Ltd (WFF) in central Canterbury are 250-300 kg/ha of Cropmaster 15 (N:P:K:S = 15:10:10:7) or Nitrophoska (N:P:K:S = 12:10:10:1). The yield response to about this level of fertiliser input was measured in a foliar fertiliser trial conducted for Vegfed in 1995-96 by Crop & Food Research, and was much smaller than expected (Wilson *et al.*, 1996). This suggested that the traditional high fertiliser applications could be unnecessary and/or uneconomic, at least in higher fertility situations. The total value of fertiliser applied to the 600 ha of process beans grown in central Canterbury is about $65,000 annually, and growing costs could be reduced significantly if fertiliser requirements could be forecast more effectively. Therefore, Crop & Food Research was asked by Vegfed to further investigate the yield response of beans to fertiliser application in 1996-97.

This report describes the project in which the objective was to define the responses of beans to the availability of three major nutrients (N, P and K), from both soil reserve and fertiliser sources, in a field experiment with fertiliser treatments applied to crops at several sites with diverse soil fertility conditions. It was expected that the results from the project would benefit process bean growers by:

- indicating the extent to which fertilisers are currently being over- or under-applied to bean crops and, therefore, lead to guidelines for more efficient use of fertilisers;

- making a start on the longer-term goal of building a fertiliser forecasting system for beans based on the yield response and soil test results. It was anticipated that more experiments would be needed in future to further develop and test the system.

3 METHODS

A major difficulty with fertiliser trials is that crop responses are very site-dependent. Every paddock has a different fertility level, depending on its cropping and fertiliser application histories. Better information is needed on how to interpret these histories, along with the results of soil tests, to decide the rate and type of fertiliser application that will produce the optimum yield and economic return. A major challenge for research is to develop a reliable fertiliser forecasting system that will achieve these objectives for each site. The traditional research approach has been to conduct detailed fertiliser response trials in several paddocks, often without adequate associated soil testing. This has usually produced a different result for each paddock, and results have been difficult to translate into fertiliser forecasts for other situations.

In this project, we used a multi-site experimental approach to the problem. This meant less detail than usual for each site. However, soil testing and crop response measurements across a diverse range of sites were expected to make it possible to start to build a general statistical picture (i.e. a model) of bean yield response to N, P and K. Once developed and tested, such a model could be used with soil test results as a tool for forecasting fertiliser requirements.

The experiment was conducted at five sites in commercial process bean crops (cv. Labrador) in the Lincoln-Irwell-Leeston area of central Canterbury during the 1996-97 season (Table 1). The sites were selected from eleven possibilities in October-November, well before planting in late November-early December. Selections were made in consultation with representatives of Vegfed and WFF, using previous growers' soil test results and paddock history information, with the aim of obtaining a diverse range of fertility levels, especially for N and K.

At each site, the crop in the experimental area was managed by the grower the same as the rest of the paddock except that the usual fertiliser application was not applied to the trial area. This application differed among the five growers (Table 1). In two cases some fertiliser was broadcast and incorporated by cultivation before planting. In all cases the main fertiliser application was "down-the-spout" with the seed at planting, but the fertiliser applicator was turned off each time the planter crossed the experimental area. Immediately after planting, the trial areas were marked out and the fertiliser treatments were broadcast on the plots by hand and mixed with the surface soil by raking. Plot size differed among sites. In all cases, plots were 8 m long and one drill-width wide, but the widths of the precision-seeders varied from six to twelve rows. Row spacing was 0.4 m. Planting dates ranged from 29 November to 20 December 1996 (Table 1).

The experiment at each site consisted of nine plots, with three replicates of three treatments in a Latin square design. Although less than used in most field trials, three replicates were expected to allow an approximate assessment of the yield response at each site. However, the main emphasis of the project was to define the yield response across sites. The treatments were Cropmaster 15 (N:P:K:S = 15:10:10:7) fertiliser applied at 0, 150 and 300 kg/ha at planting.

A soil sample was taken from each plot just before the fertiliser treatments were applied. It consisted of a sub-sample from a mixture of ten random 0-15 cm cores per plot. Standard analytical procedures were used to measure exchangeable K and Olsen P in the Crop & Food Research soil science laboratories at Lincoln and available N was measured by Analytical Research Laboratories Ltd., Hastings.

It was planned to hand-harvest a sample area from each plot immediately before WFF harvested each paddock to measure yield and uptake of N, P and K by the crops. The results were then to be used to calculate a nutrient balance for each treatment and to calculate yield responses to fertiliser application and total nutrient availability. In the across-site analyses, each site was to be treated as a replicate in developing a preliminary model of the yield responses to the three nutrients. The value of the model was expected to depend on the range of N, P and K values and corresponding yield responses in the 15 treatments across the five sites. More experiments in future seasons were proposed to allow further development and testing of the model.

Table 1: Details of the five trial sites.

Grower	Location	Planting date	Soil type	Soil test/fertility levels			Grower's fertiliser application	
				P*	K*	N**	Broadcast	Down-the-spout
John Smith	Broadfield	29 November	Templeton	20	7	Med	150 kg/ha Ammophos Pea Hycrop (N:P:K:S = 8:15:15:1)	200 kg/ha Cropmaster 15 (N:P:K:S = 15:10:10:8)
Geoff Heslop	Irwell	9 December	Wakanui	26	20	Med	None	280 kg/ha Cropmaster 15
Murray Stephens	Irwell	10 December	Templeton	37	11	High	None	300 kg/ha Cropmaster 15
Peter Lowery	Leeston	17 December	Paparua	29	10	Low	None	250 kg/ha Cropmaster 15
Geoff McFadden	Southbridge	20 December	Waimakariri	53	11	Low	450 kg/ha 30% K Super (N:P:K:S = 0:6:15:8) with Mg and B additives	250 kg/ha Potash Gold 15 (N:P:K:S = 15:10:10:12)

* Previous growers' P and K quick test results

** No soil N test results were available. Subjective assessments were based on paddock cropping histories.

4 RESULTS

The aim of obtaining a diverse range of fertility levels among the sites was achieved successfully (Table 2). Mean available N values ranged from 36 to 115 kg/ha, mean exchangeable K values varied from 109 to 387 µg K/g soil (equivalent quick test values range from 5.5 to 19.4) and mean P values ranged from 8.4 to 23.3 µg P/g soil. The K values agreed quite closely with those provided by three of the growers (Smith, Heslop and Lowery) but our values were considerably lower for the other two sites (Stephens and McFadden) (Tables 1 and 2). All our Olsen P values were lower than those provided by the growers; the differences were large at Smiths, Stephens and McFaddens. Two corner plots in the trial at Smiths had very high P values. It could be that some of the broadcast fertiliser may have reached them unintentionally.

Plant establishment was very good at all sites and, subsequently, the trials were visited about once per month. Initially there were no visual plant growth differences either within the trial areas or between each trial area and the rest of the paddock. By early January there were still no differences among the fertiliser treatments within the trial areas. However, it was becoming evident at all sites that a major contrast was developing between the trial areas, where fertiliser was only broadcast, and the surrounding growers' crops where fertiliser was applied "down-the-spout" at planting.

All trials were visited on 14 February. Mr Murray Stephens, Chairman of the Process Sector of Vegfed, saw all except the one at Smiths. In all cases it was clear that the beans were responding vigorously to the fertilisers applied "down-the-spout" but not to the broadcast fertilisers. There were no visual differences among the plots in the trial area at any of the sites. The vigour of the response differed among locations. It appeared to be greatest at Smiths, Stephens and McFaddens where soil N and K values were relatively low. Perhaps significantly, the soil K values were higher at Heslops and McFaddens where the vigour of the response seemed to be lower.

It was decided to abandon the trials on 14 February because it seemed very unlikely that the original objectives could be achieved. Considerable time and, therefore, costs would have been incurred by harvesting the trials and analysing the results but with little chance of obtaining results useful for bean growers.

Table 2: **Soil test results from the five sites.**

Grower	Plot	N*	K**	P***
Smith	1	72	109	16.5
	2	68	115	5.3
	3	65	133	5.7
	4	64	118	5.9
	5	74	120	6.2
	6	90	116	5.5
	7	71	112	6.9
	8	65	111	5.5
	9	80	125	17.8
	Mean	**72**	**118**	**8.4**
	SD	**8**	**8**	**5.0**
Heslop	1	133	443	20.4
	2	125	408	20.7
	3	141	447	20.9
	4	107	388	14.1
	5	120	363	17.1
	6	110	378	19.2
	7	87	331	16.5
	8	104	339	13.6
	9	110	385	13.4
	Mean	**115**	**387**	**17.3**
	SD	**16**	**41**	**3.1**
Stephens	1	87	108	17.5
	2	61	87	18.6
	3	53	101	18.3
	4	67	122	20.6
	5	71	97	18.1
	6	56	133	18.1
	7	85	113	19.1
	8	60	112	18.3
	9	77	109	20.0
	Mean	**69**	**109**	**18.7**
	SD	**12**	**14**	**1.0**

Grower	Plot	N*	K**	P***
Lowery	1	75	169	22.5
	2	54	182	23.3
	3	51	161	22.5
	4	56	147	21.3
	5	61	177	26.5
	6	62	177	19.8
	7	79	148	23.4
	8	57	150	25.7
	9	58	160	24.6
	Mean	**61**	**163**	**23.3**
	SD	**9**	**13**	**2.1**
McFadden	1	37	134	20.9
	2	40	121	22.0
	3	37	118	22.1
	4	35	144	21.5
	5	34	116	21.5
	6	45	135	21.7
	7	29	141	18.0
	8	33	128	20.0
	9	38	116	18.2
	Mean	**36**	**128**	**20.7**
	SD	**5**	**11**	**1.6**

* Available N in kg/ha

** Exchangeable K in µg K/g soil. Equivalent quick test values are found by dividing these results by 20.

*** Quick test Olsen P in µg P/g soil.

5 CONCLUSIONS

Everyone associated with the project was disappointed that the main objectives were not achieved. However, the large difference between methods of fertiliser application was unexpected. In hindsight it is clear that, instead of broadcasting, the fertiliser treatments should have been applied alongside the rows to simulate the practice used by most growers.

The main message for growers from the project was that process beans did not appear to respond to fertiliser broadcast and incorporated before planting—this result occurred at all sites. However, the beans responded to fertiliser applied "down-the-spout" in all cases, although the vigour of the response seemed to differ among sites. This suggests that the practice used by some growers of broadcasting fertiliser before planting as well as applying some "down-the-spout" is probably unnecessary. Although there will be a longer-term benefit for paddock fertility, an immediate response by the bean crop seems unlikely. Further investigations of crop response to fertiliser placement may be worthwhile.

The failure to achieve the objective does not reduce the need to continue research to develop methods for using fertiliser more efficiently in intensive crop production systems. The problem of how to interpret soil test results to decide how much fertiliser to apply to bean crops remains unresolved.

6 REFERENCE

Wilson, D.R., Gillespie, R.N. and Wallace, A.R. 1996. Influence of eight foliar fertilisers on the yield of green beans. A report prepared for the Process Vegetable Sector of the New Zealand Vegetable and Potato Growers' Federation Inc. *CropInfo Confidential Report No. 266.* 43 p.

7 ACKNOWLEDGEMENTS

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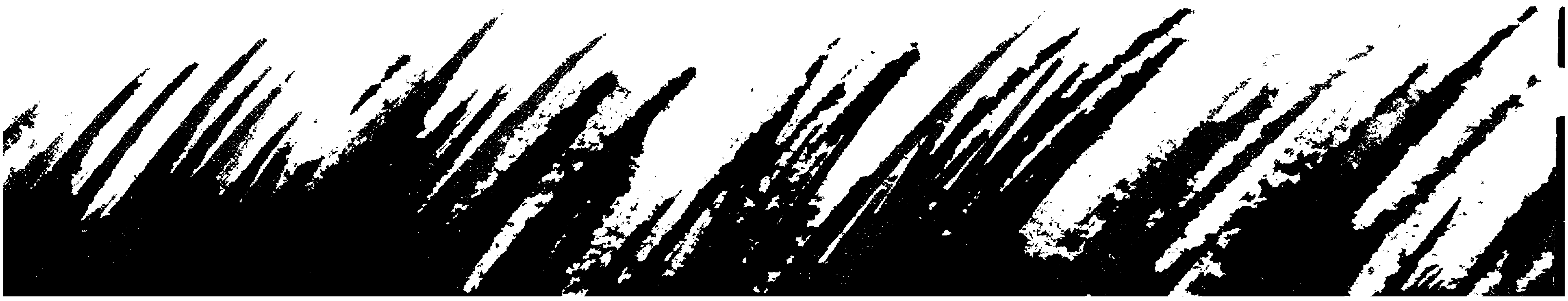

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