ANALYSIS OF RESPONSES OF FIELD PEAS TO IRRIGATION AND SOWING DATE
1. CONVENTIONAL METHODS

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ABSTRACT

Conventional methods of analysis in agronomic research often produce results specific to the site and season in which an experiment was conducted. In this paper, standard statistical methods are used to analyse the results of an experiment with field peas. Deficiencies of the methods are discussed.

The experiment was conducted to establish optimum sowing time and irrigation treatments for field peas in Canterbury. Plots were sown at Lincoln on 3 dates, at approximately monthly intervals from early September 1983. Six irrigation treatments, based on either soil moisture deficit or plant development criteria, were applied to each sowing time treatment.

The highest yield was obtained from the late September sowing, with irrigations scheduled according to a water budget. Although yield differences between the irrigated treatments were small, the results suggested that early irrigation was more effective than late irrigation. However, this was to be expected because the 1983-84 season was dry early and wet late. In a dry season, late irrigations may be required for maximum yields.

The results are of limited practical use because they are specific to the site and season in which the experiment was conducted. Although the analysis shows that the treatments affected yields, the reasons for the variations are not clear and the prediction of likely responses in other circumstances is difficult.

Additional Key Words: Experimental design, seed yield, yield components

INTRODUCTION

A need for changes in agronomic research procedures in New Zealand was discussed at a symposium on "Approaches to Agronomic Research" held at the Agronomy Society of New Zealand Conference in 1980. A common deficiency of agronomic experiments was that results are usually specific to the sites and seasons in which experiments were conducted. Hence, extrapolation to other circumstances is difficult. In this paper, we illustrate this deficiency by using conventional statistical methods to analyse the results from a field pea experiment. In a companion paper (Jamieson *et al.,* 1984), we show how alternative methods of analysis can be used to enable results from an experiment to be applicable to other sites and seasons.

The experiment was conducted to establish optimum sowing time and irrigation treatments for field peas in Canterbury. It is well established that pea crops are sensitive to water deficit, and often produce increased yields when irrigated (Salter and Goode, 1967; Stoker, 1973, 1977; Pate, 1977). However, yield responses to irrigation vary because of the variability of seasonal rainfall. Time of sowing also affects yield by changing the length of the growing season and the degree of water deficit experienced by crops during growth. Therefore, the principal objective was to establish how sowing time affected the irrigation requirements of the pea crop.

MATERIALS AND METHODS

A factorial experiment comprising 3 sowing dates and 6 irrigation treatments was laid down as a split-plot design on a Templeton sandy loam at Lincoln in 1983. The soil had an available water holding capacity in the top metre of about 160 mm. Soil physical characteristics are given in Table 1. 'Rovar' peas were sown in 15 cm spaced rows in 4 blocks of eighteen 13 m x 1.35 m plots. The sowing rate was designed to establish a population of about 100 plants per m^2. Good weed control was achieved by a pre-emergence application of 1.5 kg a.i. per ha of cyanazine and a post-emergence application of 0.75 kg a.i. per ha of fluazifop-butyl (Fusilade). The crop followed 1 year in cereals after 2 years fallow. Superphosphate was broadcast to apply 8 kgP/ha and 10 kgS/ha, and was incorporated before sowing.

TABLE 1: Soil physical characteristics.

Depth (cm)	Bulk density (g/cm^3)	Field capacity (Vol %)	Wilting point (Vol %)
0 - 20	1.23	32.0	13.6
20 - 40	1.49	29.8	14.9
40 - 60	1.62	32.4	16.2
60 - 80	1.57	31.4	15.7
80 - 100	1.52	30.4	15.2

The sowing dates were 2 September, 30 September and 27 October. The irrigation treatments were designed to induce a range of soil moisture deficits during growth. Besides a control treatment with no irrigation (NI), 2 criteria were used to schedule irrigations. In 2 treatments, water was applied according to the results of water budget

TABLE 2: **Dates and amounts of irrigation water applied.**

Sowing Date	Irrigation treatment	Number of irrigations	Dates of irrigations	Amounts applied (mm)
2 September	NI	0	—	0
	WB1	2	26-11, 30-12	50, 55
	WB2	1	26-11	50
	FL	1	26-11	50
	PF	1	12-1	55
	FLPF	2	26-11, 12-1	50, 55
30 September	NI	0	—	0
	WB1	3	3-12, 30-12, 12-1	50, 55, 50
	WB2	2	3-12, 12-1	50, 50
	FL	1	3-12	50
	PF	1	30-12	55
	FLPF	2	3-12, 30-12	50, 55
27 October	NI	0	—	0
	WB1	2	30-12, 12-1	50, 55
	WB2	1	12-1	50
	FL	1	30-12	50
	PF	1	12-1	55
	FLPF	2	30-12, 12-1	50, 55

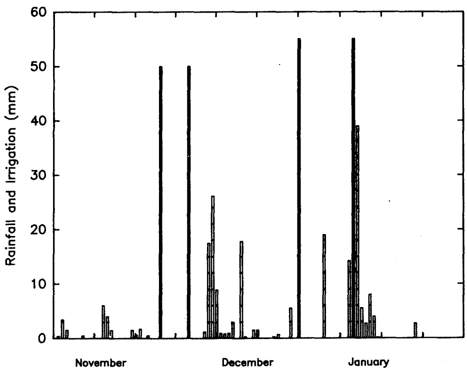

Figure 1: Daily rainfall and irrigation distribution during the summer of 1983/84. Solid bars indicate irrigation events.

calculations. In the first (WB1), the aim was to irrigate to 25 mm soil moisture deficit every 14 days if required. In the second (WB2), a volume equal to half the deficit was applied every 28 days if required. In the other 3 treatments, stage of growth criteria were used, with irrigation at 10% flowering (FL), early pod fill (PF), or both (FLPF), but only if water budget calculations showed a deficit of more than 50 mm. Water was applied to plots through a metered trickle system (8 outlets per m^2) to allow precise measurement of water application.

Dates and amounts of water applied to each treatment are given in Table 2. The seasonal rainfall pattern meant that some irrigation treatments were duplicated in 2 sowing date treatments. Rainfall distribution from November through January had important consequences for the experiment because substantial rain followed 3 of the irrigations and may have caused drainage losses (Figure 1).

Monthly weather information for the season is given in Table 3. October and November had less rainfall than average while September, December and January were wetter than normal. December and January were cooler

TABLE 3: **Weather for 1983/84 season, and 9 year means.**

Month	Rainfall (mm)		Mean temperature (C)		Potential evaporation (mm)	
	1983/84	Mean	1983/84	Mean	1983/84	Mean
September	105.8	49.9	8.0	8.1	54.9	52.6
October	34.3	63.9	10.2	10.0	86.4	88.6
November	21.7	50.6	12.2	12.0	100.6	108.4
December	87.6	68.9	12.2	14.0	126.3	128.0
January	95.3	60.1	12.7	15.7	128.0	131.4

TABLE 4: Effect of irrigation treatments on seed dry weight yields (kg/ha) for three sowing dates.

Sowing Date	Irrigation NI	WB1	WB2	FL	PF	FLPF	Mean
2 September	6520	7350	7640	7510	6800	7630	7250
30 September	6820	8000	7370	7280	7380	7720	7470
27 October	6150	6510	6280	6400	6260	6570	6360
Mean	6500	7290	7100	7150	6820	7310	
LSD 5%	210 for comparison of sowing dates at each irrigation level						
	290 for comparison of irrigation at each sowing date						

than average, but potential evaporation was about average throughout growth.

At maturity, 5 m^2 samples were removed from each plot, threshed, and seed dry weights obtained. Subsamples of 1000 seeds from each plot were weighed. Harvest dates for the 3 sowing time treatments were 23 January, 2 February, and 13 February respectively.

RESULTS

Seed Yields

All irrigation treatments significantly increased yields (Table 4). Differences among the irrigation treatments were small, but PF, a single late irrigation, yielded significantly less than the others. There were significant yield differences among the sowing dates. The late September sowing gave the highest yield and the late October sowing the lowest. There were differences among sowing times in the response of seed yield to the irrigation treatments. In the 2 September sowing, the yield of WB2 was greater than WB1, and FL was greater than PF, whereas in the other sowings these rankings were reversed or the differences were not significant. These changes were associated with rainfall following irrigation (Figure 1).

TABLE 5: Effect of treatments on yield components.

Treatment	Number of seeds per m^2	Mean seed weight (mg)
Sowing Date		
2 September	2380	305
30 September	2600	289
27 October	2540	251
LSD 5%	90	5
LSD 1%	120	7
Irrigation		
NI	2320	281
WB1	2580	284
WB2	2520	282
FL	2590	277
PF	2370	289
FLPF	2660	276
LSD 5%	125	8
LSD 1%	165	10

Components of Yield

Mean seed weight decreased progressively as sowing was delayed (Table 5). There was a small but significant effect on seed weight between irrigation treatments but there was no obvious trend.

Numbers of seeds per m^2 were about the same for the 2 later sowing dates, but were less for the first sowing (Table 5). Except for treatment PF (a single late irrigation), irrigation increased the number of seeds per m^2.

DISCUSSION

The crop sown in late September produced the highest yield, mainly because it had most seeds per unit area; this more than compensated for a 5% reduction in mean seed weight in comparison with the earliest sowing. The crop sown in late October had the lowest yield. Its mean seed weight was 17% less than the first sowing, and this was not balanced by a 7% increase in seed number.

Except for the single late irrigation (PF), all irrigation treatments increased yield primarily by increasing seed numbers. The main effect of the single late irrigation was to increase seed weight. These results are consistent with the pattern of seasonal rainfall. Irrigation water was applied at flowering in all treatments except NI and PF. Consequently seed numbers were reduced under these treatments because the rainfall pattern allowed the crop to be stressed during flowering. However, adequate rain or irrigation during seed fill meant that seed weight in NI was not reduced, and was increased in PF.

A primary objective of the experiment was to determine whether irrigation requirements varied with sowing time. However, the objective was not fulfilled adequately because the experiment suffered from a common problem of irrigation studies, viz. a wet season. This probably caused the anomolous results for the first sowing in which treatments WB1, WB2 and FLPF were all irrigated at flowering. Treatment WB2, with no further irrigation, yielded best. The second irrigation of WB1 on December 30 reduced the yield, probably because it was followed immediately by 19 mm of rain, with another 74 mm a week later. However, treatment FLPF had its second irrigation on January 12, just preceding the 74 mm rain and its yield was similar to WB2. This irrigation was too late to have any effect on yield. Therefore, although the results indicate that an early sowing may need irrigating only once, and later sowings more often, they are very dependent on the pattern of rainfall in the particular season. In a dry year the results are likely to be quite different.

CONCLUSIONS

The results of this experiment confirmed that the yield of field peas is increased by irrigation and that it varies with sowing time. The problem is that the results are specific to the site and season in which the experiment was conducted. Repeating the experiment may produce different results, leading to inconclusive answers to the questions raised by the objectives, because the responses are very dependent on the pattern of seasonal rainfall. Yield variation has been "explained" in terms of variation of yield components. However, the reasons for the variations are not clear, and differences are not separated from site and seasonal influences. Therefore, prediction of likely responses to irrigation in other circumstances is difficult.

The traditional approach is to repeat this experiment at several sites and/or in several seasons to obtain measures of the variation caused by environmental effects relative to the variation caused by the management variables being studied. However, it is well established that crops respond to agronomic treatments, so it is pointless to continue experiments and analyses that merely reinforce the point. Future research needs to develop quantitative relationships between crop yield and agronomic treatments. This cannot be achieved without reference to the weather. Conventional analysis of variance approaches cannot take adequate account of the weather. This is well illustrated by the results of Stoker (1977) who found that the mean yield increase of peas with irrigation varied from 25% to 188% over 3 years, more as a reflection of the variation of unirrigated yield than high yield under irrigation.

In the companion paper (Jamieson *et al.*, 1984), alternative methods of analysis which take account of the weather, and produce results that have more general applicability, are proposed.

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