A SURVEY OF COMMERCIAL FIELD BEAN (VICIA FABA L) CROPS IN CANTERBURY

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ABSTRACT

Two hundred ha of field beans were grown in Canterbury during the 1977/78 season. Climatic, agronomic and management data were collected for all farms.

Most significant simple correlations were related to climatic factors and none of the 28 factors studied was highly correlated with yield. Multiple regression analysis indicated that the seven most important factors contributing to yield in this season were variety, weed dry matter at harvest, seed inoculation with rhizobia, number of beehives per hectare at flowering, and the number of frosts, and degree of water deficit (mm and days) that occurred during vegetative growth.

Average yield obtained was 2.59 t ha^{-1}, but actual yields ranged from 0.07 - 6.2 t ha^{-1}.

INTRODUCTION

Although field beans (*Vicia faba* L) have been a component of stock and human diets for almost as long as wheat and barley (Zohary and Hopf, 1973) they have received, in comparison, scant scientific attention. The only agronomic work published in New Zealand has shown that, under Canterbury conditions, field beans have the potential to yield well (Newton and Hill, 1977). A small number of farmers in the Canterbury region have obtained yields in excess of 4.0 tonnes ha^{-1}.

Although the success of the crop in New Zealand is dependent on continued scientific endeavour, the development of strong commercial backing and the location of stable markets, it's ultimate success will depend on the yield obtained by farmers growing the crop. In an attempt to isolate climatic, environmental and management components of field bean yields on a farm scale, a survey was conducted among 28 farmers who grew 200 ha of the crop in Canterbury in the 1977/78 season.

MATERIALS AND METHODS

A postal survey, sent to the 28 farmers who purchased seed for sowing in the Canterbury area in 1977, asked farmers to supply the following information on their field bean growing operations: area sown, previous experience with the crop, time of sowing, inoculation (with rhizobia), soil type, number of hives of honey bees per hectare and weed control methods.

Because the industry is still in the early stages of development, farmers were not given a choice of variety by the seed firms, and indeed, in most cases farmers were unaware of the cultivar sown. The varietal type was assessed from characteristics of seed collected from each paddock at harvest.

In late spring, visits were made to all farms in the survey and five plots of 1 m^2 were placed randomly within the crop and plants within these plots counted. At harvest seed yield, plant population, seed type and the amount of weed dry matter were estimated. Weeds were divided into grasses and other weeds. Fifty harvested plants from each paddock were assessed for disease at Lincoln College. Visual assessment of levels of *Ascochyta fabae* Speg. on the plant, and on the seeds was made. Plate counts of the fungi were made on a randomly selected group of 100 seeds.

Paddocks were allocated to a nominal soil type based on assessment from soil maps. Soils of similar characteristics were grouped together into four major groups based on water holding capacity and fertility level.

Detailed climatic records are not kept for most small farming districts and where this was the case data from the nearest recording station was used. The climate data was broken down in terms of the physiological stage of crop growth. The number of ground frosts during the vegetative flowering and podding growth were analysed. Water deficit was determined during the growth stages of the crop and was analysed in terms of total mm deficit at each growth stage and the number of days of water deficit. These estimates were not very precise as they were computed for a soil with a 75 mm soil moisture capacity.

After harvest total yield from each farm was analysed in relation to the 28 factors collected in the survey, small plot harvests and climatic data (by simple correlation and by multivariate analysis). An estimated header yield from each farm was also compared with the yield estimated from the small plots.

RESULTS

Success in many a new venture is dependant on striking a balance between being innovative and minimising risks. The extent to which Canterbury field bean growers experimented with the various management systems can be seen in Tables 1a and 1b. On most farms a relatively small area was sown. However farmers who had grown the crop previously tended to sow a larger area. All crops were sown in 15 cm rows.

Average yields were low and very variable (Table

TABLE 1a. Mean, standard deviation, and range of agronomic and climatic data obtained from a survey of 28 Canterbury field been growers during the 1977/78 growing season.

	Mean	Standard Deviation	Range
Yield	2.59 t ha^{-1}	0.78	0.07 - 6.2
Area	6.77 ha	1.39	1.6 - 18.5
Density	43.0 p m^{-2}	14.84	26.6 - 91.8
Time of sowing	last week in June	5.5 weeks	1 May - 2nd Oct.
Ascochyta fabae incidence			
seed (visual)	17.6%	3.42	1.0 - 55.0
plant (visual)	62.6%	3.38	20.0 - 100.0
seed (plate count)	4.1%	0.33	0.20 - 12.0
Weed D.M.			
total	107.5 g m^{-2}	54.9	0 - 235.0
grass	27.6 g m^{-2}	34.2	0 - 124.0
non grass	79.8 g m^{-2}	55.0	0 - 235.0
Frost			
Vegetative (air)	23.4 days	1.98	0 - 43
Vegetative (ground)	62.6 days	2.96	13 - 99
Flowering (ground)	3.3 days	0.08	0 - 9
Podding (ground)	0.8 days	0.31	0 - 3
Water Deficit			
Vegetative	24.4 mm	41.0	0 - 150
Vegetative	5.8 days	10.1	0 - 42
Flowering	57.5 mm	36.5	0 - 150
Flowering	15.5 days	9.4	0 - 30
Podding	62.1 mm	21.6	0 - 40
Podding	16.6 days	6.2	0 - 24

TABLE 1b. Non quantifiable characteristics obtained from the survey data.

Crop Experience	1st Crop	15	Previous Experience	13
Seed line used	Small seeded	13	Large seeded	15
Rhizobial Inoculation	Inoculated	5	Not Inoculated	23

Soil Group* 1) 5; 2) 8; 3) 8; 4) 7.

Weed Control Methods† None 15; Pre/Post-emerg. 1; Pre-emerg. 7; Post-emerg. 3; Mech. Cult. 2.

* Soils grouped in ascending order of water holding capacity and fertility.

† Weed control methods were also analysed as Chemical/Mechanical methods, and as an estimate of time of weed control application.

1a). In general farmers yields were only 67% of the estimated standing yield measured by small plot analysis.

Simple correlations

Analysis of the 140 samples (5 plots from each of the 28 farms) gave many low simple correlations among the 29 variables measured which were statistically significant. Only correlations of 0.4 ($P \leqslant 0.001$) or more are shown in Table 2 or discussed in the text.

i) *Agronomic factors:* None of the 18 agronomic, or ten climatic factors measured correlated well with final yield. Variety (r = 0.489) was the greatest single determinant of yield. The larger seeded line tended to yield more than the smaller seeded line, although it was generally grown on lighter soils (r = -0.441). Visual assessment of the level of *Ascochyta fabae* Speg., on the plant correlated well with other estimates of disease at harvest (Gaunt *et al.*, 1978). The correlation between this method of disease assessment and other factors are reported throughout, unless specifically mentioned. Disease correlated with variety, and was most marked in the larger seeded line (r = 0.520). This seed line may have had a greater degree of seed infection before sowing.

Early sowing increased the level of diseased seed at harvest (r = 0.440). Plants sown in autumn had a

TABLE 2. Simple correlations between agronomic and climatic factors obtained from survey data of 28 Canterbury farmers.

		FROSTS			H_2O Deficit	
		Veg. (gr)	Fl. (gr)	Pd. (gr)	Veg. (mm)	Veg. (days)
Area					-. 431*	-. 439
Variety				.421		
Time of Sowing		-.916	-.673	-.458	.751	.651
Visual Seed Disease			.616	.548		
Frost	V. (air)	.956	.778		-.674	-.590
	V. (gr)		.724		-.700	-.589
	Fl. (gr)			.634	-.588	-.561
	Pd. (gr)				-.431	-.418

* All correlations are significant $P \leqslant 0.001$.

longer period of vegetative growth than those sown in the spring and as a result an increased amount of disease spread within the crop may have occurred. The larger seeded line suffered more frosts at podding (Table 2), and correlation between the number of vegetative ground frosts and the level of seed disease (estimated by the plant count method) was 0.413. Frosts may damage the plant, and associated dew may enable the disease to spread.

Weed control methods employed did not influence the dry matter levels of weeds within the crop at harvest, although they may have reduced weed competition with the crop during the growing season. Weeds other than grasses were the main determinant of total weed dry matter at harvest (r = 0.806). Weed control methods employed after sowing tended to increase the dry matter levels of non-grass weeds. It is possible that the three farmers who used the chemical dinoseb as "Aretit", post emergence, did not recognise the need for early application, and did not obtain effective weed control. The spectrum of weeds sampled at harvest on these three farms indicated that wire weed (*Polygonum aviculare*) was the main weed. It is postulated that the wire weed was not killed by the application of Aretit, and it benefitted from the absence of other weeds.

The average plant population of field beans established, of 43 plants m^{-2} is considered too low for high seed yields (Ishag, 1973; Newton and Hill, 1977). Insufficient farmers established high population densities to give significant correlations between density and yield; density and weed level at harvest and density and water deficit during the three growth stages.

Sowing the crop later increased the probability that the crop would suffer water deficit during vegetative growth (Table 2). Most farmers who sowed the crop in spring irrigated during flowering and podding and water deficits at these growth stages were less likely.

ii) *Climatic factors:* It is not surprising to find in an autumn sown crop that early sowings correlated well with the number of frosts the crop was subjected to in all stages of growth. Air frosts and ground frosts which occurred during vegetative growth were very highly correlated (Table 2).

Because the water demand of an autumn sown crop matches available water supply over winter it was only in the later sown crops that vegetative water deficits occurred. The amount of water deficit measured in mm and the days that the deficit occurred are well correlated (Vegetative growth r = 0.853; Flowering r = 0.970; Podding r = 0.967).

It is likely that the correlations between vegetative water deficit and frosts throughout the growth stages of the plant are due to a combination of a cold climate and free draining soils rather than any causal climatic response.

Multiple Regression

When all 28 factors were analysed in respect to yield using a step up multiple regression programme (B.M.D.), a pattern of crop response was built up (Table 3). The individual contributions of each step to the final amount of variation explained is shown in this table.

The regression equation was:

Yield tonnes hectare^{-1} = 4.364 + 1.220 (variety) -0.680 (inoc.) -0.006 (total weed DM t ha^{-1}) -0.036 (no. of vege. gr. frosts) -0.030 (mm vege. H_2O def.) + 0.036 (days vege. H_2O def.) -0.270 (bees ha^{-1}).

All partial regression coefficients were significant ($P \leqslant 0.05$) except inoculation which was very nearly significant. The equation accounted for 54% of the variation.

Despite the simple correlation between seed disease and seed line, the larger seeded line contributed to increased yield in this analysis. Inoculation of the seed with rhizobia has previously been a recommended practice for increasing yields. (It is possible that the farmers who applied inoculant to their seed may have spread the seed disease

TABLE 3.

The percentage of total variation accounted for (R^2 x 100) by the addition of each, and the individual contribution to total variation of the 7 factors contributing significant partial regression coefficients to the multiple regression analysis.

Step No.	Variable	Variation accounted for	Increase in % Variation
1	Variety	29.93	23.99
2	Frost V. gr.	31.26	7.33
3	H_20	42.65	11.39
4	Weed T DM	49.33	6.68
5	Inoc.	50.51	1.18
6	Bees (hives ha^{-1})	52.21	1.71
7	H_20 V days	53.61	1.39

A. fabae as they inoculated the seed. Had they merely damaged the seed by excessive maltreatment so that the seed split, germination would have been reduced, and as all population counts within the survey were made after germination this effect would not have occurred in the analysis.)

It was only during the vegetative growth stage that water deficit appeared to be important. While the water deficit in mm reduced yield, increasing the number of days over which the deficit occurred increased the yield. This was possibly because of increased disease level, since *A. fabae* can be splash dispersed, or perhaps because of reduced early weed infestation. The overall effect of the two vegetative water deficit factors is to cancel each other in the multiple regression equation. Many farmers who sow their crop late and apply early irrigation do not appear to recognise that soil water deficits may occur before flowering – the generally recognised time when water deficits can effect yield in grain legumes (Stolp, 1955; Salter, 1962).

Sowing in late autumn or early winter reduces water stress during plant growth because water is generally available. At the same time however the number of frosts which the crop suffers during the vegetative stage of growth is increased. The crop losses however did not appear to be sufficient to deter farmers without irrigation from sowing the crop at these times to take advantage of water levels over winter.

Weed levels within the crop at harvest did not reduce yields substantially. The weed levels might be further reduced by increased plant density.

Surprisingly, the presence of honey bees within the crop apparently decreased yields although there is at present no plausible scientific explanation to account for this reduction.

DISCUSSION

Yields of commercial field beans grown in Canterbury are similar to those of the United Kingdom (FAO Production Yearbook, 1976) and many authors have commented on variability of yield (Soper, 1952a; Hebblethwaite, 1970). This survey indicates that increasing farmer knowledge of the agronomic requirements of the crop could lead to improvements in yields in Canterbury. Furthermore, header losses associated with crop harvest appear to be large, (40%) and these may be able to be reduced. A header efficiency of 72%, compared with hand harvested plots has been reported (Hall priv. comm.), a result very similar to those reported here.

Analysis of 28 agronomic, climatic and management factors in multiple regression accounted for only 54% of the variation, suggesting that factors other than those in the survey were operative, or that the factors included here require more precise determination. For example a more accurate assessment of the soil type and climate for each farm is obviously required. Although the multiple regression equation did not account for a large proportion of the variation in yield in this survey, it did indicate that it is a useful tool in determining the major determinants of crop yield and suggesting further areas of possible research. The equation indicated that seed inoculation and the presence of bees were associated with yield reduction. As both these treatments are easily applied by farmers, it seems that further research is urgently required to investigate the causal relationships of these treatments.

In the 1977/78 season Canterbury farmers had little scientific information on which to base the management decisions they made in growing their field bean crops, and were themselves experimenting to determine the best place for field beans within their farming system. A similar situation occurred during the development of the industry in England (Soper, 1952b) and, no doubt, it will be some years yet before, as in the case of oilseed rape in the South Island (Davidson, 1976), farmer experience with the crop will become a major determinant of yield.

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