SEASONAL GROWTH AND FINAL YIELD OF AUTUMN SOWN SPRING AND WINTER FIELD BEAN (*VICIA FABA* L.) CULTIVARS

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ABSTRACT

Seasonal growth and final yield of autumn sown (24 May 1988) field bean (*Vicia faba* L.) cultivars were measured at Lincoln. Comparisons were made amongst the winter cultivars Banner Winter (BW), Bourdon (Bdon), Bulldog (Bdog) and Punch (Pch) and spring cultivars Maris Bead (MB) and Puma (Pma) imported from the United Kingdom. Locally available seed sold as MB was also included in the trial.

By 1 July 1988, all cultivars showed > 80 % emergence except Bdog (67 %) and MB(UK) (43 %). Between this time and final harvest on 7 January 1989, plant number/m^2 decreased for MB(UK) and Pma but changed little in all other cultivars. On 20 September, 2 November and 12 December, individual shoot dry weight was greater for BW and Bdon than for MB(NZ). At final harvest, total dry matter (TDM/m^2) was greater for these winter cultivars than for MB(NZ). Seed yield/m^2 of MB(NZ) was as great as that for all winter cultivars. At the first two harvests on 20 September and 2 November 1988 the individual shoot DM of MB(NZ) was greater than that for MB(UK) and Pma. At later harvests it was similar or less. At final harvest, TDM and seed yield were greater in MB(NZ) than in MB(UK) and Pma.

It is concluded that for autumn sown field beans, in Canterbury, at least some winter cultivars can give greater TDM production than locally available seed, but that locally available seed is suitable for seed production. Also, seed sold as MB in Canterbury has greater cold tolerance than MB from the UK.

INTRODUCTION

Under a wide range of conditions, field beans (*V. faba* L.) commonly yield 3 to 5 t/ha of seed (Dantuma & Thompson, 1983). In Canterbury, seed yields of over 6 t/ha have been obtained (Newton & Hill, 1987). In trials carried out at Lincoln, TDM and seed yield of field bean were consistently greater from autumn sowings than from spring sowings (Newton & Hill, 1987; Husain *et al.*, 1988 a,b). In most of these trials, seed sown was produced in New Zealand and sold as Maris Bead (MB). This cultivar is considered cold sensitive in the United Kingdom and is normally spring sown.

In trials carried out in the East of Scotland during 1982 to 84, seed yield of autumn sown field beans was substantially greater for the winter cultivars Banner Winter and Maris Beagle than for MB (Andrews *et al.*, 1986).

In a trial carried out at Lincoln during 1976-77, seed yield was greater for MB than for the winter cultivar Daffa in both autumn and spring sowings (Newton, 1979; Newton & Hill, 1987). However, greatest TDM production was obtained from autumn sown Daffa.

In the trial described here, seasonal growth and the final yield of autumn sown spring and winter cultivars of *V. faba* obtained from the United Kingdom were compared.

Maris Bead obtained from the United Kingdom and New Zealand was included in the trial.

MATERIALS AND METHODS

Field site, plant material and experimental design: The experiment was carried out during 1988-89 on a Wakanui silt loam at the MAFTech Research Farm, Lincoln. The previous crop was barley. Four winter cultivars, Banner Winter (BW), Bourdon (Bdon), Bulldog (Bdog) and Punch (Pch) and two spring cultivars Puma (Pma) and Maris Bead (MB) obtained from the Plant Breeding Institute, Trumpington Lane, Cambridge, United Kingdom plus MB obtained from Wrightson Dalgety (Christchurch) were used in the trial.

The site was ploughed, Dutch harrowed and rolled on 16 May 1988. Individual seeds were sown by hand on 24 May 1987. A complete block design with four replicates was used. Each plot was 6.05 x 1.33 m. Sowing density was 60 seeds/m². Neither fertilisers nor pesticides were used in the trial. All plots were irrigated on 26 September, 17 November and 9 December; 50 mm of water was applied at each irrigation.

Population counts, plant sampling and yield measurement: In each plot, a 1.0 m x 1.33 m area which originally contained 80 seeds was used to determine plant population, TDM production and seed yield. Plants to determine growth were randomly sampled outside this area. Counts of plant population were carried out on 1 July and 20 September 1988 and 7 January 1989 at final harvest. Plants were cut to ground level on 27 July, 20 September, 2 November and 12 December If no plant was found in the position indicated by random co-ordinates, as was often the case with MB(UK), the closest plant was taken. Two plants from each plot were cut at each harvest.

Plants harvested on 27 July were used for leaflet chlorophyll determination as described in Andrews *et al.* (1985). At the other harvests, plants were separated into leaves and stem plus petioles, dried at 70 °C for 96 h and reweighed on cooling. At harvest, all shoots in the unsampled area of each plot were harvested, spread out on benches in the laboratory and air dried for 3 weeks. Total shoot, pod and seed dry weight were determined.

Mean seed weight was determined from 400 randomly sampled seeds from each plot.

Data analysis: An analysis of variance was carried out on all data. All effects discussed have an F ratio with a probability $P < 0.001$. Means stated as significantly different among cultivars are on the basis of an LSD ($P < 0.05$) test.

RESULTS AND DISCUSSION

Weather: Throughout almost the entire period of study, temperatures were unusually high and rainfall was unusually low (Table 1).

From July to December, monthly mean values for daily temperature ranged from 1.4 to 2.6 °C above long term means. Mean values for daily rainfall were often more than 1 mm/day less than long term means. Irradiance was lower than average from May to September and above average in November and December (Table 1). Possible effects of the low rainfall were to some extent countered by irrigation, but the higher than average temperatures make it likely that any low temperature effects shown by the cultivars would be greater in a more typical year.

Table 1: Monthly mean values for mean daily temperature, solar radiation and rainfall 1987-88 compared with long term means.

	Daily temperature (°C)		Solar radiation (MJ/m²/day)		Rainfall (mm/day)	
Month	Actual	Mean	Actual	Mean	Actual	Mean
May	7.4	8.7	5.3	7.3	1.58	2.29
June	6.6	6.2	4.1	5.5	1.03	2.03
July	7.6	5.7	4.1	6.3	0.80	2.19
August	8.1	6.7	8.5	9.6	1.13	2.00
Septemer	11.2	9.4	12.9	13.6	0.23	1.57
October	14.0	11.7	17.8	18.0	0.22	1.58
November	15.1	13.6	21.2	20.6	1.00	1.77
December	18.0	15.4	25.6	21.0	0.73	1.84
January	18.2	16.4	22.5	21.5	1.92	1.94

Long term means are for period 1967-77 in case of temperature, 1976-86 for solar radiation and 1930-81 for rainfall.

Plant emergence and survival: On 1 July, all cultivars showed greater than 80 % emergence except Bdog (67 %) and MB(UK) (43 %) (Table 2).

Table 2: Plant populations of field bean cultivars in early winter, spring and at harvest.

Date	1 July Emergence (%)	1 July Plants /m^2	20 Sept. Plants /m^2	7 Jan. Plants /m^2
Winter cultivars				
BW	87	52	51	51
Bdon	85	51	52	51
Pch	87	52	51	50
Bdog	67	40	39	36
Spring cultivars				
MB(NZ)	83	50	47	46
Pma	87	52	39	33
MB(UK)	43	26	12	8
SEM	2	1	2	2

At room temperature in the laboratory, all cultivars showed greater than a 90 % germination except Bdog (76 %). In a trial sown in spring 1987; which used seed from the bulk source used in the trial described here, Bdog showed a 74 % emergence while all other cultivars, including MB(UK), showed > 85 % emergence, Thus, a lower seed viability could explain the lower emergence of Bdog but not of MB(UK).

It has been shown that germination/emergence of MB(UK) is very sensitive to low temperatures. At constant 6 °C in the laboratory, MB(UK) showed less than a 10 % emergence while BW showed greater than 90 % emergence (Andrews *et al.*, 1986). As the germination of MB(UK) was high at room temperature in the laboratory and in the spring sowing, it is likely that poor emergence of MB(UK) in this trial was a low temperature effect.

Between 1 July and final harvest, the two imported spring cultivars MB(UK) and Pma showed substantial plant losses. For both cultivars, most plants were lost between 1 July and 20 September This effect could have been related to low temperature sensitivity. Maris Bead(NZ) showed a slight decrease in plant population between 1 July and final harvest. At final harvest, plant density was slightly but significantly less for MB(NZ) than for BW or Bdon.

Chlorosis is a common symptom of low temperature damage in field bean (Fyson, 1982; Andrews *et al.*, 1985). Despite showing substantial losses over winter, neither MB(UK) nor Pma showed marked chlorosis throughout the study. On 27 July, MB(UK) showed slight chlorosis on the leaf margins; all other cultivars appeared healthy. With the exception of MB(UK), chlorophyll concentrations for all cultivars were not significantly different and ranged from 7.2 to 9.4 mg chlorophyll/g dry weight. Chlorophyll concentration for MB(UK) was 5.2 mg/g dry weight, which was significantly lower than those in all other cultivars but one which would be considered more than adequate for light absorption (Heath, 1969).

Plant growth and seed yield: Between sowing and 20 September, all cultivars showed little shoot growth (Table 3). Shoot dry weight for all cultivars increased 3 to 4 times between 20 September and 2 November

Major growth in all cultivars occurred between 2 November and 12 December. For BW, Bdon and Punch, individual shoot dry weight was as great or greater on 12 December than on 7 January For Bdog and all spring cultivars, individual shoot dry weight increased substantially between 12 December and 7 January The general pattern of growth for winter cultivars other than Bdog, is very similar to that shown by the winter cultivar Daffa in a trial carried out at Lincoln 1976-77 (Newton, 1980). Data is not available for MB(NZ) or other spring cultivars.

In the case of the winter cultivars, individual shoot dry weight was greater for BW, Bdon and Pch than for Bdog at all harvests except final harvest (Table 3). At harvests on 20 September, 2 November and 12 December, individual shot dry weight was greater for BW, Bdon and Pch than for MB(NZ). At final harvest, shoot dry weight was still greater for BW than for MB(NZ) but values for MB(NZ), Bdon and Punch were similar. Shoot dry weight for MB(NZ) and Puma were similar throughout most of the trial. In comparison to values for these two cultivars, shoot dry weight for MB(UK) was lower at the first two harvests, similar at the third harvest and greater at the final harvest. At final harvest, shoot dry weight for MB(UK) was as great as that for BW and greater than that for all other cultivars. This high value for MB(UK) may have been related to its low plant density in comparison to the

Table 3: Initial seed dry weight (g) and individual shoot dry weight (g) for field bean cultivars at different harvest times.

	Seed	20 September	2 November	12 December	7 January
Winter cultivars					
Banner Winter	0.70	1.41	4.91	34.95	28.58
Bourdon	0.72	1.49	5.24	29.32	26.44
Punch	0.65	1.76	5.38	24.50	24.84
Bulldog	0.69	0.87	2.88	19.50	28.62
Spring cultivars					
Maris Bead(UK)	0.43	1.09	4.18	18.34	24.41
Puma	0.40	0.91	3.35	20.01	24.16
Maris Bead(NZ)	0.39	0.59	1.92	19.21	30.40
SEM	0.03	0.11	0.44	1.45	1.05

other cultivars (Table 2). A decrease in plant density will result in less inter-plant competition for nutrients, water and light and can result in larger individual plants (Newton & Hill, 1987). However, despite a lower plant density at harvest, shoot dry weight was lower for MB(NZ) than for BW indicating greater growth potential with the winter cultivar.

For the winter cultivars, TDM/m^2 (Table 4) was greater for BW, Bdon and Pch than for Bdog due to a greater plant density at harvest (Table 2). As a result primarily of a greater individual plant size (Table 3) but also partly due to greater plant survival (Table 2), TDM/m^2 at final harvest was substantially greater for BW than for MB(NZ) (Table 4). Total dry matter/m^2 was greater for Bdon than for MB(NZ) due to greater plant density at harvest. For the spring cultivars, TDM/m^2 decreased in the order MB(NZ) > Pma > MB(UK).

The difference between MB(NZ) and MB(UK) was substantial. Seed yield for the winter cultivars was greater for BW and Bdon than for Pch but values for Pch and Bdog were not significantly different (Table 4).

For spring cultivars, seed yield showed a similar ranking as TDM/m^2. As for TDM/m^2, seed yields for Bw, Bdon and Punch were greater than for Pma and MB(UK) but unlike TDM/m^2, seed yield for MB(NZ) was as great as that for any of the winter cultivars due to a greater harvest index (Table 4). The harvest index value for MB(NZ) (38 %) appears high, but even greater values were obtained by Newton & Hill (1987) over a range of plant population, time of sowing and irrigation regimes. Thus, MB(NZ) appears to have a consistently high harvest index. Harvest index for MB(UK) was also higher than for all winter cultivars. Whether MB(UK) would have as high a harvest index at greater plant densities, remains to be tested.

With regard to components of yield (Table 5), the number of pods/plant was greater for Bdog than for Pch but values for BW and Bdon were not significantly different from any of the other winter cultivars. The number of beans/pod was lower for Bdog than for all other winter cultivars.

Mean bean weight was not significantly different among winter cultivars. For spring cultivars, the number of pods/plant was much greater for MB(UK) than for MB(NZ) and Pma. This difference is likely to be related to the lower plant density of MB(UK) in comparison to that of MB(NZ) and Pma (Newton & Hill, 1987). The number of beans/pod did not differ significantly among spring cultivars but mean bean weight was greater for MB(NZ) than for MB(UK) and Pma. The greater harvest index for MB(NZ) in comparison with BW, Bdon and Pch was due to a greater number of pods/plant and beans/pod. Mean bean weight was lower for MB(NZ) than for all winter cultivars. In comparison with winter cultivars, spring cultivars, in general, had a greater number of pods/plant and beans/pod.

Table 4: Total dry matter, seed yield and harvest index of field bean cultivars.

	TDM (g/m^2)	Seed yield (g/m^2)	Harvest index (%)
Winter cultivars			
Banner Winter	1452	438	30.0
Bourdon	1344	388	29.1
Punch	1258	327	26.4
Bulldog	1035	259	24.8
Spring cultivars			
Maris Bead (NZ)	1103	412	37.7
Puma	797	229	28.5
Maris Bead (UK)	240	108	46.1
SEM	71	31	1.9

Table 5: Yield components of field bean cultivars.

	Pods/ plant	Beans/ pod	Mean bean weight (g)
Winter cultivars			
Banner Winter	5.57	2.45	0.59
Bourdon	5.03	2.61	0.58
Punch	4.51	2.43	0.59
Bulldog	6.25	2.04	0.60
Spring cultivars			
Maris Bead (NZ)	7.06	2.94	0.48
Puma	6.93	2.82	0.36
Maris Bead (UK)	11.21	3.06	0.40
SEM	0.47	0.12	0.02

Mean bean weight was lower for all spring cultivars than for all winter cultivars. For seed size at least, the difference between autumn and spring cultivars is a general feature of the two sets of plants (Andrews *et al.*, 1986).

CONCLUSIONS

1. For autumn sown field bean in Canterbury, at least some winter cultivars can give greater dry matter production than locally available seed.
2. Locally available field bean seed is suitable for seed production.
3. Field bean seed sold as Maris Bead in Canterbury has greater cold tolerance than Maris Bead from the United Kingdom.

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