NITROGEN STUDIES IN AUTUMN AND SPRING SOWN FIELD BEANS (*Vicia faba* L.)

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ABSTRACT

When two cultivars of field beans were autumn-sown in Canterbury, yield and nitrogen concentration of the grain were higher than in spring sowings of the same cultivars. Time of sowing had little effect upon the grain nitrogen concentration of Daffa (3.55%) but seed from Maris Bead contained 4.15% nitrogen when autumn-sown and 3.69% when spring-sown. Plant population had no effect on grain nitrogen concentration.

Nitrogen was concentrated within the grain at harvest and the nitrogen harvest index for autumn-sown Daffa was 58% while the harvest index was 26%. Up to 17.5g N/m^2 was contained in grain of autumn-sown Maris Bead. Total above-ground nitrogen yield of the plant is also given.

Additional Key Words: *cultivar, nitrogen harvest index, N content, N yield*

INTRODUCTION

Legumes are dual purpose crops. They may be included in crop rotations because they produce protein-containing seeds or because they fix nitrogen symbiotically which may be left in the soil and in crop residues after harvest, boosting soil nitrogen reserves.

Traditionally field beans have been included in cropping rotations in Europe but they have only recently been grown as a grain legume in New Zealand. In Canterbury, they are capable of producing good commercial yields (Newton and Hill, 1978).

Dyke and Slope (1978) reported that field beans left nitrogen residues in the soil equivalent to about 44 kg N/ha. Fertilizer additions of 38 and 75 kg N/ha were required by second and third crops of barley to maintain the yield produced by the first crop of barley after field beans (Slope and Etheridge, 1977).

It is important to understand the distribution of nitrogen within the legume crop so that improvements in grain yields are not made at the expense of the return of nitrogen to the soil. There is little published information on the nitrogen harvest index of field beans - that is, the amount of nitrogen which is harvested in the beans as a proportion of total plant nitrogen at maturity. Sprent and Bradford (1978) reported that 89% of plant nitrogen was concentrated within the seed. The distribution of nitrogen within a field bean crop at harvest was assumed by Dean and Clark (1977) to be 0.6 in seed, 0.2 in straw, 0.2 in roots and nodules. However these authors presented no data to justify this postulated distribution.

Grain nitrogen concentration is generally reported as being higher in spring cultivars than in autumn cultivars of field beans (Smith and Aldrich, 1967; Bond and Toynbee-Clarke, 1968; Carpenter and Johnson, 1968; Eden, 1968). However, when Bond and Toynbee-Clarke (1968) sowed autumn cultivars in spring, they found seed nitrogen concentration of the autumn cultivar little affected by time of sowing. Reciprocal sowings of spring cultivars in autumn were not possible in the United Kingdom because the cultivars lacked winter hardiness.

Winters in Canterbury are apparently milder than those in the United Kingdom and highest yields from field beans were obtained from autumn sowings of a spring cultivar (Newton and Hill, 1977). In this experiment, Maris Bead, a spring cultivar, when sown in autumn yielded up to 430 g/m^2 of seed while yields of up to 250 g/m^2 were obtained from Daffa, an autumn cultivar. When sown in spring, the yields were 218 and 71 g/m^2 respectively. The distribution of nitrogen within the plant at late leaf fall, the concentration of nitrogen within the grain at harvest, the nitrogen harvest index of the crop and its nitrogen yield are reported here.

METHODS

Five plant populations ranging from 20-76 plants/m^2 of Daffa and Maris Bead, were established in rows 15 cm apart on 29 May 1976 in a randomised block design. An identical experiment was established in spring. There were five replicates of all but the autumn-sown Maris Bead, which, because of a shortage of seed, was replicated twice.

All seed was inoculated with a commercial rhizobial inoculant (NZPA 5225). Thimet at 2 kg a.i./ha was incorporated into the soil before sowing and simazine at 1.20 kg a.i./ha and paraquat at 1.0 kg a.i./ha were applied before emergence to control weeds. Honey bees *(Apis mellifera)* were brought into the experimental area during flowering of the crop.

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Three weeks before harvest, at late leaf fall, two samples of 0.1 m² were taken from each plot. Autumn-sown Maris Bead was not sampled at this time because there were only two replicates. Plants were divided into stem, pod and seed fractions, dried at 80 °C and stored for lated chemical analysis.

At final harvest on 14 and 24 February 1977 for the autumn and spring sowings respectively, quadrats of 0.5 m² were taken from two randomly selected positions within the central four rows of each plot. The two samples from each plot were bulked. The dry weight of seed, pod valve, and stem fractions was determined and the seed stored for later chemical analysis. Unfortunately stem and pod valve fractions taken at this harvest were not retained.

Nitrogen concentration of plant components sampled at late leaf fall, and grain sampled at final harvest were determined using micro-Kjeldahl digestion and autoanalyser measurement of ammonia produced.

RESULTS

Agronomic aspects of both experiments have been published previously (Newton and Hill, 1977). The distribution of rainfall and weekly maximum and minimum temperatures over the growing season are outlined in Fig. 1.

Seed size varied with cultivar and difficulties experienced with the drill at sowing meant that the plant populations established were not evenly distributed over the population range. However, at the low population (20-25 plant/m²) and at the high population (59-65 plants/m²), plant number per unit area of both cultivars was similar allowing cultivar comparisons to be made.

Yield per plant was higher when field beans were sown at low populations but grain yield/m² was highest when plants were sown at high plant populations (Fig 2). When both cultivars were sown in autumn, total dry matter yield was higher than when the cultivars were sown in spring. Maris Bead outyielded Daffa at both times of sowing.

Harvest index of the plants was similarly affected by time of sowing and cultivar, and reached a maximum of 40% in Maris Bead sown in autumn at the low population (Table 1).

The nitrogen harvest index of autumn-sown Maris Bead is not available but, in Daffa and spring-sown Maris Bead, it ranged from 43 to 59% (Table 2) suggesting that nitrogen was concentrated in the grain by harvest. The distribution of nitrogen within the plant at late leaf fall supports this conjecture (Table 3).

From the dry matter production per plant (Fig. 2), the nitrogen distribution within plant components (Table 3) and, after accounting for plant population, an estimate of nitrogen yield of the crop can be made. This is presented in Table 4.

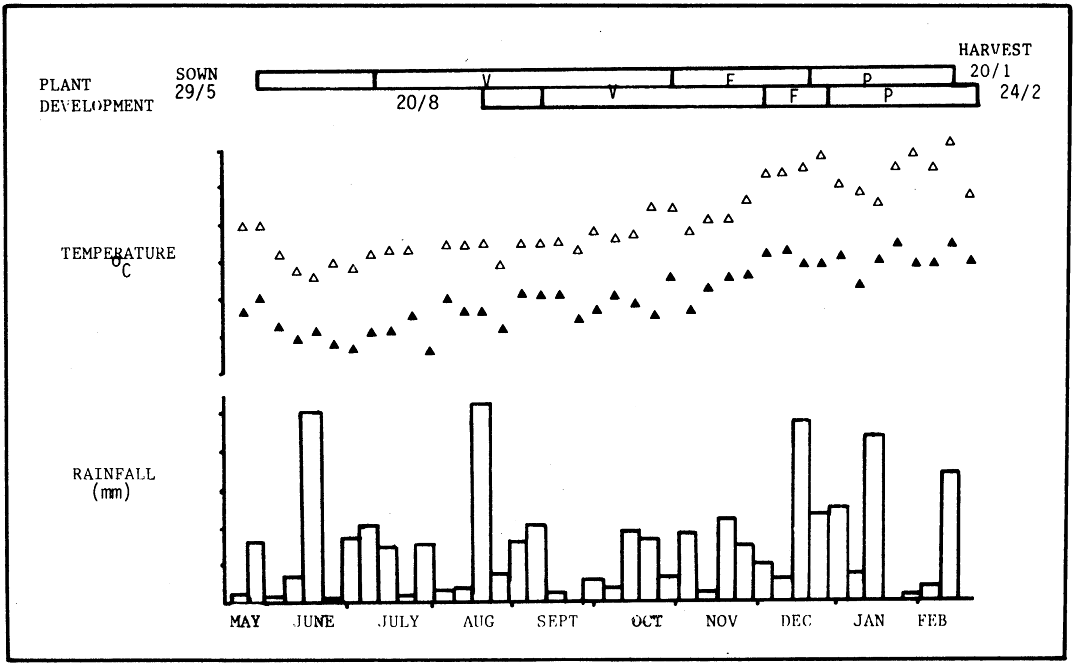

Figure 1: **Weekly distribution of maximum temperature (△), minimum temperature (▲) and rainfall over the growing season 1976-77.**

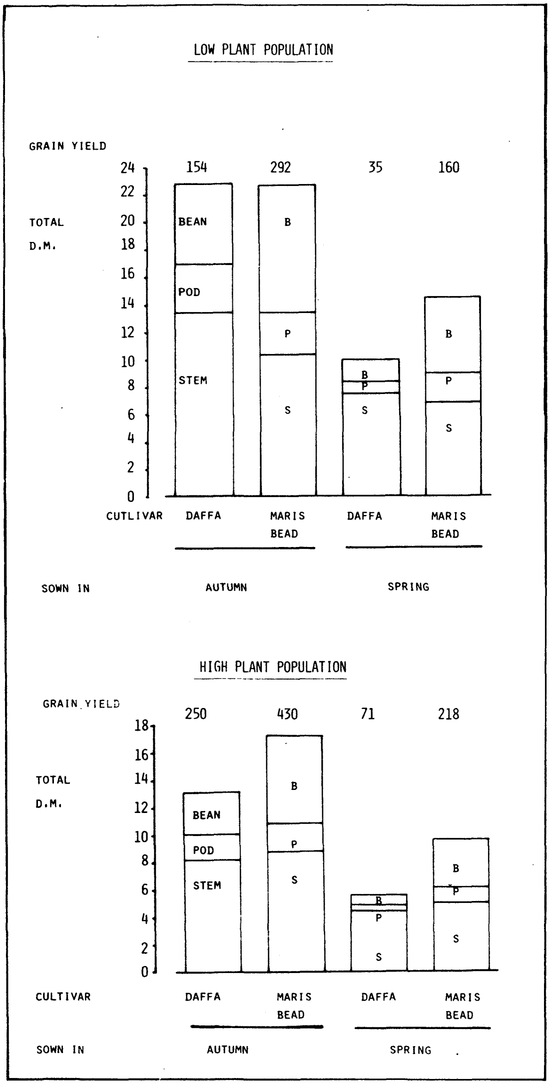

Figure 2: Grain yield (g/m²) and dry matter distribution (g/plant) of two cultivars of field beans sown in autumn and in spring at two populations.

DISCUSSION

Grain nitrogen concentration has previously been reported to be higher in spring cultivars than in autumn cultivars (Smith and Aldrich, 1967; Bond and Toynbee-Clarke, 1968; Carpenter and Johnson, 1968; Eden, 1968), and this was confirmed for field beans grown in Canterbury.

TABLE 1: Dry matter harvest index of (%) of two cultivars of field beans.

Plant Population	Low	High
Autumn-sown		
Daffa	26	25
Maris Bead	40	38
Spring-sown		
Daffa	14	12
Maris Bead	38	35

TABLE 2: Nitrogen harvest index (%) of two cultivars of field beans measured at late leaf fall.

Plant Population	Low	High
Autumn-sown		
Daffa	57	59
Maris Bead	-	-
Spring-sown		
Daffa	48	43
Maris Bead	53	55

It is difficult to attribute these observed differences to genetic or environmental factors because spring cultivars lack winter hardiness and reciprocal sowings can not be made in the United Kingdom. Bond and Toynbee-Clarke (1968) found no difference in the grain nitrogen concentration of an autumn cultivar of field beans when it was grown in autumn and spring. However Sprent and Bradford (1978) reported that the grain nitrogen concentration of Maris Bead and Herz Freya grown in Scotland differed from that reported by the NIAB in England. They suggested that this might be due to environmental differences. No difference in grain nitrogen concentration was found in Daffa, the autumn cultivar, when it was sown in autumn and spring (Table 3) but the grain nitrogen concentration was higher in Maris Bead when this spring cultivar was sown in autumn. This was confirmed when Maris Bead was sown in autumn and spring in the subsequent season (Newton, 1980). Other agronomic treatments such as plant population, pre-floral application of 10 kg N/ha and irrigations had no effect on grain nitrogen concentration. Sprent and Bradford (1977) also reported that plant population had no effect on grain nitrogen concentration, and similar findings were reported for lupins in Canterbury by Herbert (1977). Further work is therefore needed to clarify the effect of environmental factors on grain nitrogen concentration and to elucidate why they affect spring but not autumn cultivars.

Protein concentration of field bean straw reported by Toynbee-Clarke (1970) was low and was equivalent to around 1%N. Stem nitrogen concentration prior to leaf senescence, reported by Sprent and Bradford (1977) was 0.5

TABLE 3: Nitrogen concentration (%) in plant components at late leaf fall and final harvest of two cultivars of field bean sown in Canterbury in autumn and in spring.

	Stem	28 Jan Pod	Bean	14 Feb Bean
Autumn-sown				
Daffa				
Plant population				
Low	1.08	1.47	3.32	3.45
High	1.11	1.32	3.50	3.68
Sx	0.105	0.045	0.105	0.30
Maris Bead				
Low	-	-	-	4.20
High	-	-	-	4.10
Sx	-	-	-	0.42
	Stem	**21 Jan Pod**	**Bean**	**24 Feb Bean**
Spring-sown				
Daffa				
Plant population				
Low	1.22	2.42	3.33	3.53
High	1.25	2.26	3.53	3.61
Maris Bead				
Low	0.86	1.81	3.42	3.66
High	1.08	1.86	3.57	3.72
Sx	0.077	0.109	0.126	0.077

TABLE 4: Nitrogen yield (g/m^2) at late leaf fall and final harvest of two populations of field beans sown in autumn and in spring.

	Total plant 28 Jan	Grain 14 Feb
Autumn-sown		
Daffa		
Plant population		
Low	16.2	5.3
High	18.7	7.1
Sx	2.75	0.96
Maris bead		
Low	—	12.2
High	—	17.5
Sx	—	1.52
	Total Plant 21 Jan	**Grain 14 Feb**
Spring-sown		
Daffa		
Plant population		
Low	4.2	1.3
High	7.3	1.9
Maris Bead		
Low	5.2	5.9
High	11.8	7.6
Sx	1.0	0.41

- 0.6% - which is less than half that of the Canterbury-grown plants (Table 3). Conversely the pods on these plants contained up to 2.7%N. This difference in nitrogen concentration of plant components may be partly due to cultivar differences. The nitrogen in plant components of Maris Bead and Herz Freya reported by Sprent and Bradford, (1977) differed, as did that of Maris Bead and Daffa in this experiment (Table 3).

Symbiotic nitrogen fixation had almost ceased by late leaf fall (Newton, unpublished data) so total nitrogen within the plant would not have increased appreciably before final harvest although, translocation of nitrogen to the seed was still occurring. In all cases, grain nitrogen concentration measured at final harvest was higher than that measured at late leaf fall (Table 3). This may explain why the nitrogen harvest index values in Table 2 are less than the 89% reported by Sprent and Bradford, (1977) or the 75% (above-ground plant nitrogen) reported by Dean and Clarke (1977). Calculation of nitrogen harvest index as N concentration in the grain as a proportion of total plant nitrogen (Table 3) increases the estimates to 50-62%.

The nitrogen yield of autumn and spring-sown field beans indicate that a considerable amount of nitrogen may be harvested in the grain or returned to the soil through decomposition of above-ground crop debris after harvest. As indicated in Table 4, up to 17.5 g N/m^2 was harvested in the grain of autumn-sown Maris Bead. In a further experiment in the subsequent season, up to 22.3 g N/m^2 was obtained in the seed of autumn-sown Maris Bead, and 11.4 g N/m^2 when the cultivar was sown in spring. (Newton, 1980).

Spring sowing of six grain legumes in Canterbury showed that although the grain nitrogen concentration in field beans was lower than in lupins and soyabeans, it was higher than in peas and dwarf beans (Hill *et al.,* 1977). In that experiment, the seed nitrogen yield from the field beans was less than from lupins and peas. However, although a common sowing date may minimise the effect of environmental factors on growth of a number of different species, it does not provide optimum conditions for a single species. Additional work is therefore required to determine the maximum nitrogen yield of grain legumes grown under the optimum conditions for each crop.

CONCLUSIONS

This experiment has shown that, while large amounts of nitrogen may be removed at harvest in the grain of inoculated field beans, decomposition of plant stubbles after harvest may boost soil nitrogen. While field beans may play a valuable role in crop rotations, further work is required with other grain legumes to establish their relative contribution to the nitrogen economy of a cropping system.

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