RESPONSE OF YIELD COMPONENTS TO PLANT DENISTY AND TIME OF SOWING IN TWO CULTIVARS OF FIELD BEANS (*Vicia faba* L.)

S. D. Newton
Plant Science Department
Lincoln College

ABSTRACT

Two cultivars of field beans were sown in Canterbury in autumn and spring. Branch contribution to grain yield was higher, and was less affected by spring sowing in the cultivar Daffa than in Maris Bead and was reduced at high plant populations in both cultivars.

Autumn sowings of both cultivars outyielded sowings made in spring because all components of yield were reduced by spring sowing. When autumn - sown, both cultivars produced pods over more mainstem nodes and each podded node yielded more than when spring sown. Marris Bead outyielded Daffa at both times of sowing because higher yields were produced at each podded node.

Nodes in the middle of the reproductive zone on the mainstream yielded more than the nodes at its extremities. There appeared to be a maximum grain yield obtained from each reproductive node which was dependent on cultivar, plant population and time of sowing.

Increasing the plant population from 20-65 plants/m^2 reduced the number of pods per node, but had little effect upon bean number per pod or weight of the individual bean. Yield per mainstream reproductive node appeared most closely associated with pod number.

INTRODUCTION

There is little published information on the productivity of field beans in New Zealand. Using Daffa and Maris Bead, which are respectively autumn and spring cultivars in the United Kingdom, Newton and Hill (1977) determined that grain yields from autumn sowings (Daffa, 250 g/m^2; Maris Bead 430 g/m^2 DM) were higher than from spring sowings (Daffa, 71 g/m^2; Maris Bead 218 g/m^2 DM). Low yields of spring sown Maris Bead have also been reported in Canterbury (142 g/m^2, Hill *et al.* 1977) and in Palmerston North where yields of this cultivar equivalent to 281 g/m^2 were obtained by Withers (1978).

In previous paper, Newton and Hill (1977) described the effects of time of sowing and plant population upon yield and pod position in Daffa and Maris Bead. When spring-sown, both cultivars began to flower at a higher node and podded over fewer nodes than when sown in autumn. The average number of pods produced by reproductive nodes was presented but yield components were not detailed further. These have since been determined, and the contribution of branches to grain yield and the distribution of yield components at mainstem reproductive nodes are presented for two plant populations of each cultivar.

METHODS

Full agronomic details of this experiment have been given previously (Newton and Hill, 1977). Briefly, an autumn and spring experiment were established on a Wakanui silt loam at Lincoln College. Daffa and Maris Bead, two cultivars of field beans, were sown in 15 cm rows at five plant populations ranging from 20-76 plants/m^2. There were five replicates of all but the autumn-sown Maris Bead, which, because of a shortage of seed was replicated twice.

As there was a possibility that aphids could damage the plants during seedling emergence Thimet, at 2 kg ai/ha, was incorporated into the soil before sowing. Simazine at 1.20 kg/ha and paraquat at 1.0kg/ha were applied before emergence to control weeds. Two hives of honey bees (*Apis mellifera*) were brought to the experimental area when the autumn-sown plants began to flower, and a further ten hives were brought in when flowering of the spring-sown plants began.

At harvest, plants from two quadrats, each of 0.5m^2 were taken from the central four rows of each plot and bulked for each plot. Pods on branches were removed and collected for each sample. Nodes on the mainstem were counted from the base of each plant and pods were removed and collected for each node. Grain yield was then determined for branches and mainstem nodes, and yield components were determined for each reproductive mainstem node.

Because equivalent populations of each cultivar were not obtained at all of the five seeding rates, only results from two populations (20-25; 59-65 plants/m^2). are presented.

RESULTS

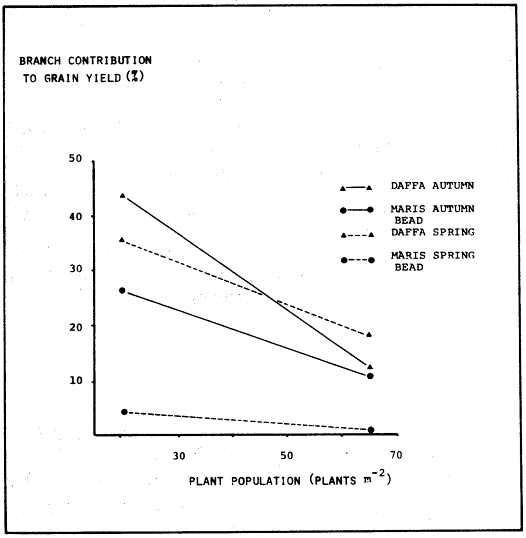
Climatic data for the growing season of the autumn and spring-sown crops have already been given (Newton and Hill, 1977). Considerable rain fell during December and January, hence soil moisture levels (20 cm depth) did not fall below wilting point during crop growth.

Maris Bead produced fewer branches than Daffa when autumn-sown, and even fewer when sown in spring, Daffa branching was only slightly reduced by spring sowing. The contribution of branches to grain yield was reduced at high plant populations and by spring sowing (Fig. 1). Regression equations linking %

branch contribution to grain yield (Y) and plant population (X), were:–

Daffa	Autumn	$y = 57.83 - 0.71x$ ** $r = 0.693$
	Spring	$y = 42.72 - 0.38x$ ** $r = 0.523$
Maris Bead	Autumn	$y = 33.20 - 0.35x$ ** $r = 0.807$
	Spring	$y = 5.36 - 0.07x$ ** $r = 0.522$

Figure 1: The contribution of branches to grain yield of two cultivars of field beans sown in Autumn and Spring.



Although the number of podded nodes on the mainstem was reduced at high plant populations, the reproductive zone extended to the 20th node when Daffa and Maris Bead were sown in autumn, but there were few pods at nodes beyond the 16th node when either cultivar was sown in spring (Fig. 2). As this figure shows, more reproductive nodes produced high yields when the cultivars were sown in autumn. Higher grain yields were therefore obtained from this time of sowing because, not only were there more productive nodes on the mainstem, but high yields were obtained from a greater proportion of them. Maris Bead outyielded Daffa at both times of sowing because each podded node had a greater yield.

For clarity, the number of pods per node is presented for only the high plant population in Fig. 3. This population is closest to those recommended for high yields by Hodgson & Blackman (1956) and those which produced high grain yields in Canterbury (Newton and Hill, 1977).

Plant population had no effect on the number of beans per pod, or the weight of the individual bean. The distribution of these components over mainstem reproductive nodes are presented in Fig. 4 and 5 respectively.

Both components tended to be most stable at the lower reproductive nodes on the mainstem, but decreased at the higher reproductive nodes. (Compare the distribution of grain yield over mainstem nodes of the high plant population shown in Fig. 2 with the distribution over the mainstem nodes of the yield components – Pods per node, Fig. 3; beans per pod, Fig. 4; individual bean weight, Fig. 5). It can be seen that the distribution of grain yield over the mainstem nodes is most closely matched in both cultivars at both times of sowing by the distribution of pods per mainstem node.

Figure 2: Grain yield at mainstem nodes in Daffa and Maris Bead sown at two plant populations in Autumn and Spring.

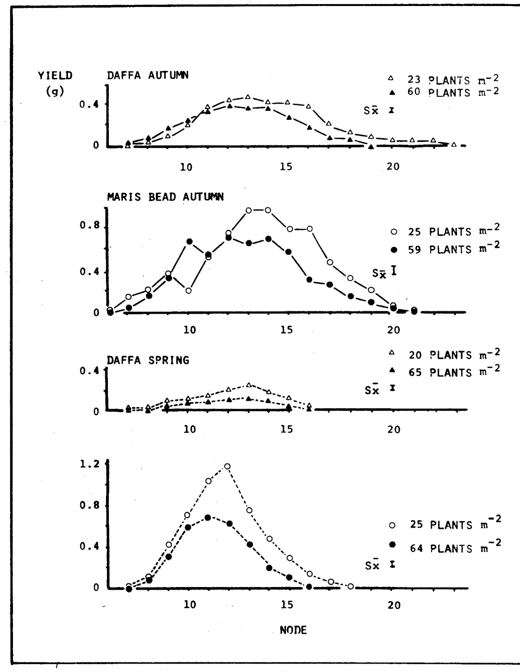
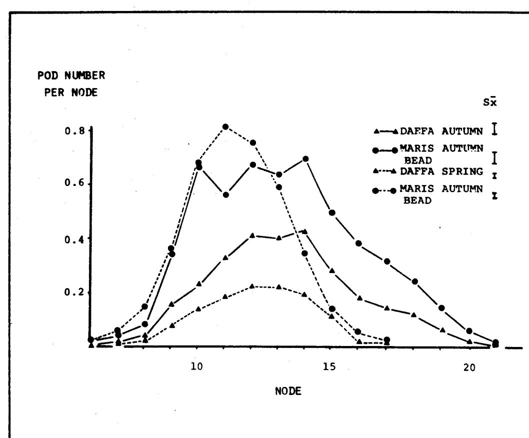


Figure 3: Pod number at mainstem nodes in Autumn and Spring-sown field beans.



DISCUSSION

The contribution of each yield component to total grain yield was reduced by spring-sowing so that grain yields were lower than when the cultivars were sown

Figure 4: Bean number per pod at mainstem nodes of Autumn and Spring-sown field beans.

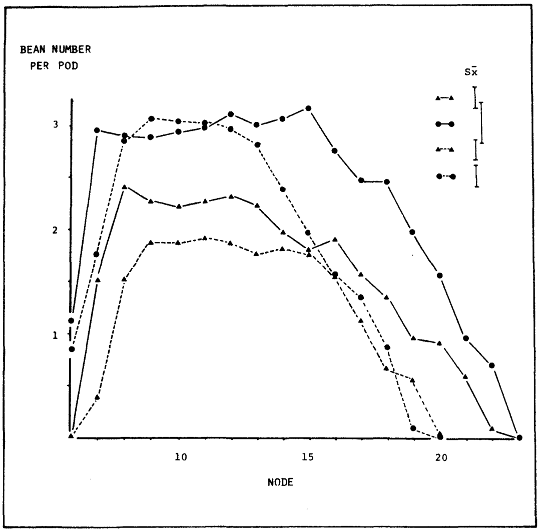
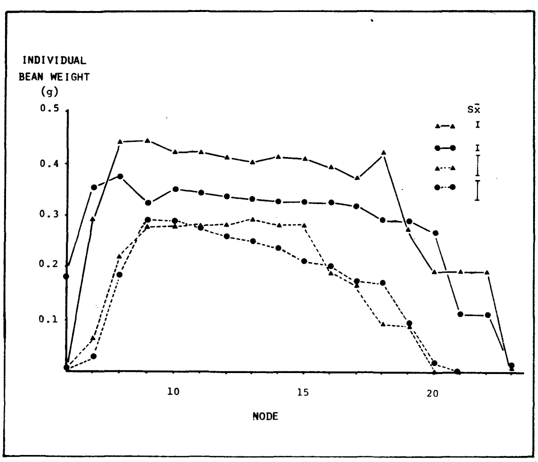


Figure 5: Weight of the individual bean (g) at mainstem nodes in Autumn and Spring-sown field beans.



in autumn. Maris Bead outyielded Daffa because higher yields were obtained from each podded mainstem node. When spring-sown, the number of podded nodes was similar in Daffa and Maris Bead, but nodal yields of Daffa were lower. This suggests that pod filling was limited in Daffa.

It is unlikely that the soil incorporated insecticide provided protection against aphids beyond early seedling establishment, but, as Newton and Hill (1977) noted, the autumn-sown plants were protected until after the last flight of *Acythosiphon (Aulacorthum) solani* Kltb. in autumn and plants were well grown before the first flight of aphids in the spring so that they were less affected by the bean leaf roll virus that these aphids may transmit. More alates of this aphid were trapped at Lincoln during the spring than the autumn of this season and 18 percent of them were infected with subterranean clover red leaf virus (Synonym bean leaf roll virus in field beans) (Ashby *et al.,* 1979) and, as previously noted (Newton and Hill, 1977) spring-sown plants were more affected by the virus than those sown in autumn.

Newton and Hill (1977) also suggested that Daffa appeared more susceptible to B.L.R.V. than Maris Bead and it appears that because yields of all reproductive mainstem nodes were reduced regardless of plant population, infection with bean leaf roll virus may have been largely responsible for low yields in spring-sown Daffa.

Branch yields

Hodgson and Blackman (1956) and Ishag (1973) cited evidence which suggested that spring cultivars of field beans produce few branches so that the bulk of their yield is produced on the mainstem. Fig 1. indicated that branch contribution to grain yield of Daffa, the 'autumn' cultivar was less affected by time of sowing than the 'spring' cultivar Maris Bead.

The distribution of grain yields over mainstem reproductive nodes was generally similar at both plant populations (Fig. 2) however, there was some indication that grain yields at basal mainstem nodes were lower at the low plant population. Branch contribution to grain yield was highest in this plant population and it appears that some competition occurred during pod development of the basal mainstem reproductive nodes.

Mainstem yields

Nodes in the middle of the mainstem reproductive zone yielded more than nodes at the extremities (Fig. 2). This has been reported previously by Hodgson and Blackman (1956) and Ishag (1973).

Williams and Free (1975) found that pod set at early flowering nodes of runner beans *(Phaseolus coccineus* L.) was lower than from mid-season flowers but was increased by cross pollination. They suggested that this might occur because numbers of pollinating insects were influenced by the weather, because the flowers were less attractive to bees, or because there were too few flowers open for adequate cross pollination to occur.

Cross pollination has been observed more frequently at lower reproductive nodes than those further up the mainstem in field beans (Hanna and Lawes, 1967). However, honey bee (*Apis mellifera*) and long tongue bumble bee *(Bombus hortorum, B. ruderatus)* populations could have been insufficient after winter hibernation to ensure adequate cross pollination of autumn-sown field beans which began to flower in early spring.

Yields of the upper reproductive nodes were considered by Newton and Hill (1977) to be limited by an environmental factor, possibly photoperiod. However as grain yields of later forming mainstem nodes were reduced at high plant populations it is more probable that yield of these nodes was limited by soil moisture. Measured soil moisture (20 cm depth) did not fall below wilting point during growth of autumn or spring sown crops, but the figures were lowest under high plant populations. Yield reductions have been reported in *Lupinus angustifolius* as soil moisture during flowering and podding approached wilting point (Stoker, 1978) and it seems likely that yields of upper reproductive mainstem nodes of field beans were limited by soil moisture levels which approached, but did not reach wilting point.

Yield components

The number of pods per plant is generally considered to be the component of yield which, in the unstressed plant, is the major determinant of grain yield (Hodgson and Blackman, 1956; Kambal, 1969; Ishag, 1973; Magyarosi and Sjodin, 1976). Ishag (1973) determined that the number of pods per node influenced grain yield more than the number of nodes which produced pods.

In both cultivars, at both times of sowing, the distribution of grain yield over the mainstem reproductive nodes (Fig. 2) was most closely approximated by that of pods per node (Fig. 3) and there was little variation in the number of beans per pod (Fig. 4) or individual bean weight at the majority of reproductive nodes although means for each cultivar differed. Similar results have been reported by Ishag (1973).

As bean weight and bean number per pod appear to be relatively stable components of grain yield at mainstem reproductive nodes, and were not affected by plant population, it would seem that higher plant yields are most likely to result from increases in the number of podded nodes or pods per node in the reproductive zone.

There appears to be a maximum grain yield which can be produced at each node within the mainstem reproductive zone (Fig. 2). Ishag (1973) contended that potential yield from each node was finite, and dependent on photosynthetic area of the subtending leaf. Field bean pods may also contribute to grain yields (Kipps and Boulter, 1974) as may other leaves on the plant (Kipps and Boulter, 1973, Newton and Field, unpublished data). When Maris Bead was sown in spring, fewer podded nodes were produced, but nodal yields were higher than when autumn sown (Fig. 2), which suggests that nodal yields were augmented by assimilate transported from unpodded nodes.

It has been suggested that grain yields of field beans could be increased if plants had a determinate growth habit. However decapitation of the plant has not increased seed yields (Hodgson and Blackman, 1957, Chapman and Peat, 1978, Chapman *et al.*, 1978). Knowledge of the contribution of nodes beyond the reproductive zone to grain yield is still required.

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