Effect of Growth Habit on Agronomic Characters in Faba Bean

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SUMMARY

A change in growth habit in order to concentrate the harvest of green pods at the same date will allow for mechanical harvesting of both green pods and seeds. The *ti* (terminal inflorescence) gene was incorporated into horticultural *major* type genotypes by backcrossing. These new lines show shorter periods of both flowering and maturity, allowing for an early production of green pods. The dry seed yield observed is greater for the best indeterminate cultivars than those of determinate habit.

KEY WORDS

Growth habit, terminal inflorescence, horticultural crops, *Vicia faba* L.

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INTRODUCTION

Vicia faba has been widely used as a vegetable crop for the fresh market and for processing (canning or freezing). The cultivars used as vegetable crop have an indeterminate growth, usually being of *major* type, with a high cost of manual harvesting and with many logistic problems at harvesting time. A possible solution could be to change the growth habit from indeterminate to determinate. A change in the plant architecture would permit a mechanical harvesting, decreasing the harvesting cost. A desirable ideotype would be a plant with determinate habit in order to concentrate the fresh pods production in the same date, maintaining the seed size and the cooking quality of the best traditional indeterminate habit cultivars. Besides, the insertion-position of pods on stem should be erect, helping in harvesting. Additional advantage is that they could be used to stabilise seed yield as in determinate habit cultivars the vegetative growth stops after flower initiation (De Costa et al., 1997).

Our breeding programme has incorporated the terminal inflorescence (*ti*-gene Sjødin, 1971) into horticultural *major* varieties of excellent quality by backcrossing. We have obtained three new cultivars, suitable for mechanical harvesting.

OBJECTIVES

A preliminary characterisation and evaluation of some agronomical characters, comparing the yield with standard varieties seems necessary.

Thus, the objectives of the present study are: 1) to evaluate the new determinate cultivars from the agronomical point of view and 2) to compare them to indeterminate (traditional) cultivars of faba bean.

MATERIALS AND METHODS

Plant material and management

Six cultivars (3 indeterminate and 3 determinate) were used. The determinate cultivars were the new faba bean cultivar “Retaca” and two experimental lines “CD16-12” and “CD-38-1”, especially developed for purpose of human consumption and mechanical harvesting (type *major-equina* seed). The indeterminate cultivars were “Reina Blanca” (*major* type), used commonly for fresh consumption (Fitó Seeds), “Alameda” (*equina-major* type) and “Baraca” (*equina* type), both generally used for dry seed.

The material was sown in two seasons, 1998 and 1999, in Córdoba (Southern Spain) following a randomised complete block design with three replications. The plot unit consisted of 6 rows 5 m long with 0.7 m between rows, 1 m between plots and 0.1 m between plants.

Weeds were controlled after sowing with Terbutilazina 15% + Terbutrina 35% p/v. Two treatments with glyphosate were performed to prevent *Orobanche crenata* attack. Broad-leafed weeds were scarce and removed by hand when required. Aphids were controlled with Pirimicarb (non-toxic for bees).

The characters studied were grouped in (a): *characters related to the flowering period* taken on the whole plot, as days to flowering from sowing (FCF), days to 50% open flowers (F50FA), days to the end of flowering (FTF), days to first mature pod (F1VM); (b) *characters related to the plant structure*: taken on the main stem, as the lowest node bearing flowers (PNF), number of nodes with flowers (NNF), number of total flowers (NFT), number of nodes bearing mature pods (NNVM) (only in the first year) and (c) *yield characters*: number of mature pods (NVM) on main stem (only in the first year) and seed yield (G), scored on 20 central plants.

Statistical analysis

The combined analysis of variance for 2 years was applied to the data according to the following model:

$$X_{ijk} = m + Y_i + G_j + B_{k(i)} + GY_{ij} + e_{ijk}$$

where x_{ijk} is the individual datum, m the population mean, Y_i the effect of *i*th year, G_j the genotypic effect for the *j*th line, $B_{k(i)}$ the *k*th block effect within the *i*th year, GY the effect resulting from interaction between *j*th line and *i*th year and e_{ijk} is the experimental error. Years were considered a random effect whereas genotypes were considered fixed (McIntosh, 1983).

An orthogonal decomposition of the sums of squares and degrees of freedom of the genotypic effect in indeterminate habit (IH), determinate (DH) and indeterminate *vs* determinate habit was carried out (SS genotype= SS indeterminate + SS determinate + SS indeterminate *vs* determinate). The same procedure was followed for the genotype x year interaction (GY) sums of squares when it was significant.

One-way ANOVA and comparison of means (LSD, 0.05) were performed for number of nodes bearing mature pods (NNVM) and for number of mature pods (NVM), analysed in the first year only.

RESULTS

Characters related to flowering period

Table 1 shows the mean values of the characters studied. Combined analyses of variance are presented in Table 4. Significant differences existed between years for all characters. No significant differences existed among genotypes in term of days to flowering (FCF), 50% flowering (F50FA) and days to first mature

Table 1. Flowering period characters (mean ± SE)*

Genotype	FCF	F50FA	FTF	F1VM
"Reina Blanca"	92±2	102.5±4	159.3±2 (A)	111.17±4
"Baraca"	90±3	97.6±3	148.8±10 (A)	110.3±4
"Alameda"	92.6±2	98.8±3	138.3±13 (A)	111.6±5
CD-16-12	92.3±2	97.8±3	109±2 (B)	109±3
CD-38-1	92±2	98.1±3	108.6±2 (B)	107±4
"Retaca"	91.3±2	97.6±3	108.3±2 (B)	107.8±4

* FCF: days to flowering from sowing; F50FA: 50% open flowering; FTF: days to end of flowering; F1VM: days to first mature pod. Letters in common per column indicate that differences are not statistically significant (LSD, $P<0.05$).

Table 2. Characters related with the plant structure (mean ± SE)*

Genotype	PNF	NNF	NFT	NNVM
"Reina Blanca"	6.2±0.2 (ABC)	12.7±0.7 (C)	31.5±1.5 (C)	2.8±0.5 (C)
"Baraca"	5.5±0.4 (C)	18.7±0.4(A)	62.6±4.3 (A)	7.5±0.9 (A)
"Alameda"	6.9±0.2 (A)	15.7±0.5 (B)	56.2±0.4 (B)	6±0.6 (B)
CD-16-12	6.6±0.3 (AB)	4.18±0.2 (D)	12±1.2 (D)	2.8±0.2 (C)
CD-38-1	7±0.3 (A)	4±0.2 (D)	13.5±1.8 (D)	2.3±0.1 (C)
"Retaca"	5.8±0.4 (BC)	3.64±0.2 (D)	9±0.7 (D)	2.9±0.3 (C)

*PNF: lowest node bearing flowers; NNF: numbers of nodes with flowers; NFT: number of total flowers; NNVM: number of nodes bearing mature pods. LSD (0.05) in parenthesis. Letters in common per column indicate that differences are not statistically significant (LSD, $P<0.05$).

pod (F1VM); however, differences in days to the end of flowering were statistically significant (FTF), a fact explained by the differences between indeterminate and determinate habits (Table 1: the indeterminate habit lines show greater FTF values).

The Year x IH interaction was significant for F50FA, suggesting that indeterminate habit genotypes differed in their sensitivity to the "Year" effect.

Characters related to the plant structure

Differences between years were not statistically significant for the number of nodes bearing flowers (NNF). On the contrary, they were significant for PNF and NFT; these results were also explained by the differences between indeterminate and determinate habits.

Differences among genotypes in nodes bearing mature pods were statistically significant (Table 2). When the interaction was significant, its variation was explained principally by the interaction with indeterminate habit.

Yield characters

Seed yield (G) showed significant differences among varieties, but this effect is also explained by the differences between indeterminate and determinate habit. The effect of the GxY interaction was not significant for production. Differences among genotypes were found for mature pods (NVM) (Table 3).

Table 3. Yield characters (mean ± SE)*

Genotype	NVM	G
"Reina Blanca"	2.9±0.5 (D)	0.73±0.05 (A)
"Baraca"	8.8±0.8 (A)	0.63±0.05 (AB)
"Alameda"	7.1±0.4 (B)	0.66±0.06 (AB)
CD-16-12	4.2±0.2 (C)	0.53±0.06 (BC)
CD-38-1	3.2±0.5(D)	0.54±0.06 (BC)
"Retaca"	3.8±0.4 (CD)	0.44±0.03 (C)

* NVM: numbers of mature pods; G: seed yield. LSD (0.05) in parenthesis. Letters in common per column indicate that differences are not statistically significant (LSD, $P<0.05$).

DISCUSSION

Major effects of change of plant architecture were detected for: 1) end of flowering period; 2) nodes bearing flowers and 3) nodes bearing mature pods.

Flowering period

"Indeterminates" often produce excessive vegetative growth and the flowering period is larger than that of "determinate" ones. Rowland et al. (1986) considered internal plant competition as an important yield component; lines with a short flowering period were suggested to reduce intra-plant competition in young pod nutrition (Duc and Picard, 1981). Our results show that the flowering period was longer for "indeterminate" than for "determinate" cultivars (Figure 1). An early production of determinate growth

4. Means squares form the combinated analysis of variance to test significance among years, blocks, genotypes, and year genotype interaction, for all the characters studied*

Source	D.F	FCF	F50FA	FTF	F1VM	PNF	NNF	NFT	G
Year (A)	1	1272.11***	2368.44***	3344.69***	3364***	11.32***	3.78	250.3***	0.20903***
Block (B)	2	0.77	1.44	300.25	1.75	0.03	1.59	31.6	0.00929
Gen. (C)	5	5.44	21.11	3168.92*	20.93	2.14	271.5***	3338.9***	0.06673*
IH	2			661.5			53.3***	1613.5	0.01608
DH	2			0.66			0.47	32.01	0.01706
IH vs DH	1			14520.27**			1249.9***	13403.5**	0.26739**
A*C	5	2.24	9.11***	343.89	7.13	0.91**	1.12	44.5*	0.01284
A*IH	2		21.5***			1.66***		103.4**	
A*DH	2		0.38			0.18		7.73	
A*Habit	1		1.78			0.87*		0.3	
A*B*C	22	1.141	0.71	198.614	2.78	0.16	0.98	12.41	0.01424

* FCF: days to flowering from sowing; F50FA: 50% open flowering; FTF: days to end of flowering; F1VM: days to first mature pod; *PNF: lowest node bearing flowers; NNF: numbers of nodes with flowers; NFT: number of total flowers; G: seed yield.
*: significant at 5%. **: significant at 1%. ***: significant at 0.1%.

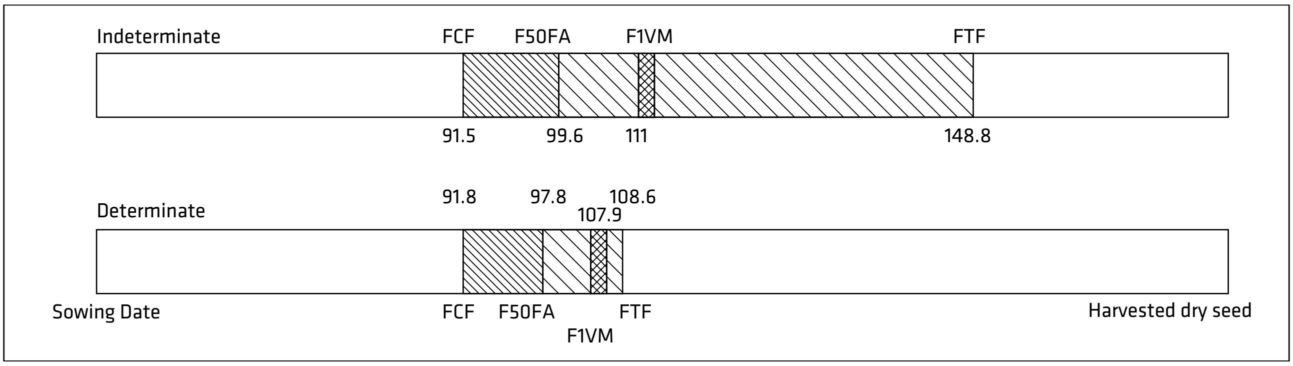

Figure 1. Dates for flowering characters of indeterminate and determinates lines (FCF: days from sowing to flowering; F50FA: 50% flowering; FTF: days to end of flowering; F1VM: days to first mature pod)

cultivars, harvesting at February (green young pods), will have the additional advantage of allowing for a second crop in our conditions.

Nodes bearing flowers.

In general the number of flowers on indeterminate plants largely exceeds the number of pods produced (Lawes, 1973). In our study, there were marked differences for both the number of flower-bearing nodes and the number of flowers. Indeterminate habit lines showed a larger number of nodes with flowers and more flowers than the determinate habit lines. It will be necessary to know the autofertility levels of different genotypes as well as to study the transition from "flowers to mature pods" in different pollination conditions (absence-presence of pollinators insects).

Yield

Yield in field beans is closely correlated with the number of pods produced per unit area (Rowlands, 1955; Kambal, 1969; Lawes, 1973; Cubero y Martín, 1981). The number of pods was larger in *equina* lines than in *major* (horticultural) varieties (i. e. "Reina Blanca", CD16-12, CD38-1 and "Retaca"). This result can be explained by the fact that the number of nodes bearing mature pods is usually lower for *major* types (Suso et al., 1993) traditionally used in horticulture.

The dry seed yield was higher for the indeterminate habit lines than for the determinate ones, but in spite of existing statistically significant differences between habit types, the determinate cultivars showed a considerable seed yield potential in our environment, although additional studies are required.

Austin et al. (1981) found the determinate type not to be inherently inferior to the indeterminate one and suggested that the future breeding programs should concentrate on selection for increased production of tillers developing synchronously with the main shoot and against production of infertile branches. We also suggest a cultural complementary approach by modifying the sowing density to increase the number of plants per unit area in order to increase the number of pods and obviously the yield.

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