QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

DIVISION OF PLANT INDUSTRY BULLETIN No. 774

EFFECT OF POD REMOVAL ON FLOWER PRODUCTION IN FRENCH BEAN (PHASEOLUS VULGARIS)

by J. F. GAGE, B.Sc., M.Agr.Sc.

SUMMARY

Selective removal of small pods after petal fall had no effect on flower production from pot grown plants of the french bean (*Phaseolus vulgaris*) cv. Redlands pioneer for the period up to the sixteenth day from the start of flowering. After this time flower production was reduced on plants bearing a restricted number of pods, but where no pods were removed flowering ceased. It is suggested that young pods in which cell division was rapid but cell expansion was slow did not significantly compete with flowers for assimilates. However, when rapid pod expansion started assimilate supply to developing flower buds was drastically reduced causing bud abortion. The significance of this in the field is discussed.

I. INTRODUCTION

French beans (*Phaseolus vulgaris*) for market are required to be of uniform maturity (i.e. all pods at a similar stage of development) with small seeds and low fibre. In a once-over harvested crop this may be achieved by ensuring a short flowering period through using appropriate varieties and cultural treatments, and by harvesting at the correct stage of maturity. However, stress during or following flowering, such as is caused by water shortage or high temperature can lead to flower or pod abortion with the possible subsequent resumption or continuation of flowering when the stress is removed. This has the undesirable effect of widening the range of pod maturity at harvest since the pods surviving the stress are more advanced than those from later flowers. Depending on the number of pods surviving the stress it may be desirable to have no further flower production to avoid this maturity problem.

The nature of flower production in french beans allowed to set full pod loads has been recorded by Stobbe, Ormrod and Woolley (1966). They found that when pods were removed at a large green stage a cyclic pattern of flowering resulted, whereas when the pods were allowed to reach the stage of dry maturity only one flowering cycle occured and the plants senesced. Although they did not present supporting evidence, Wein, Sandsted and Wallace (1973) suggested that a small number of pods such as could remain following a period of stress could affect assimilate partitioning sufficiently to affect further pod set and prevent compensation for the loss of pods.

The work described in this paper was carried out to gain a better understanding of the effects of pod removal on subsequent flowering.

II. MATERIALS AND METHODS

The experiment was conducted at Redlands Horticultural Research Station in an evaporatively cooled glasshouse in which the temperature was maintained between 15°C and 25°C.

Individual plants of the determinate cultivar Redlands Pioneer selected for uniformity were grown in 3-1 containers of coarse sand and were watered regularly with Hoaglands No. 1 Solution. They were spaced 40 cm apart on a bench to avoid mutual shading, five replicates of each of five treatments (table 1) being laid out in a randomised block.

TABLE 1

DESCRIPTION OF TREATMENTS

Treatment No.	Description	Days from Flowering to Assigned Pod Number
1	No pods allowed to develop	—
2	One pod allowed to develop	2 to 3
3	Five pods allowed to develop	4 to 5
4	Ten pods allowed to develop	6 to 7
5	No restriction on pod number	—

Records were kept of the number and location of flowers produced on each plant, and when the allotted number of pods for each treatment was reached, further flowers were removed at petal fall. Daily recording was continued for the first 16 days from the start of flowering, then counts of flowers and small pods removed were made on days 19 and 24, by which time the selected pods had reached the fresh market stage of maturity.

III. RESULTS

Mean cumulative flower number for each treatment is plotted in figure 1. When all pods were removed flower production continued at a high rate, and the presence of one pod per plant had no significant effect on final flower number. Plants with five, ten or an unrestricted number of pods produced significantly fewer flowers. Treatment differences for final flower numbers were $1 \gg 3$; $2 > 3$; $1, 2 \gg 4, 5$; $3 > 5$. Pod abortion occurred in the treatment where pod number was unrestricted beginning about 14 days from the commencement of flowering and averaged 9·4 pods per plant. Only one pod aborted on the remaining treatments, from a single plant restricted to ten pods. A mean of 14·2 pods reached green bean maturity on unrestricted plants.

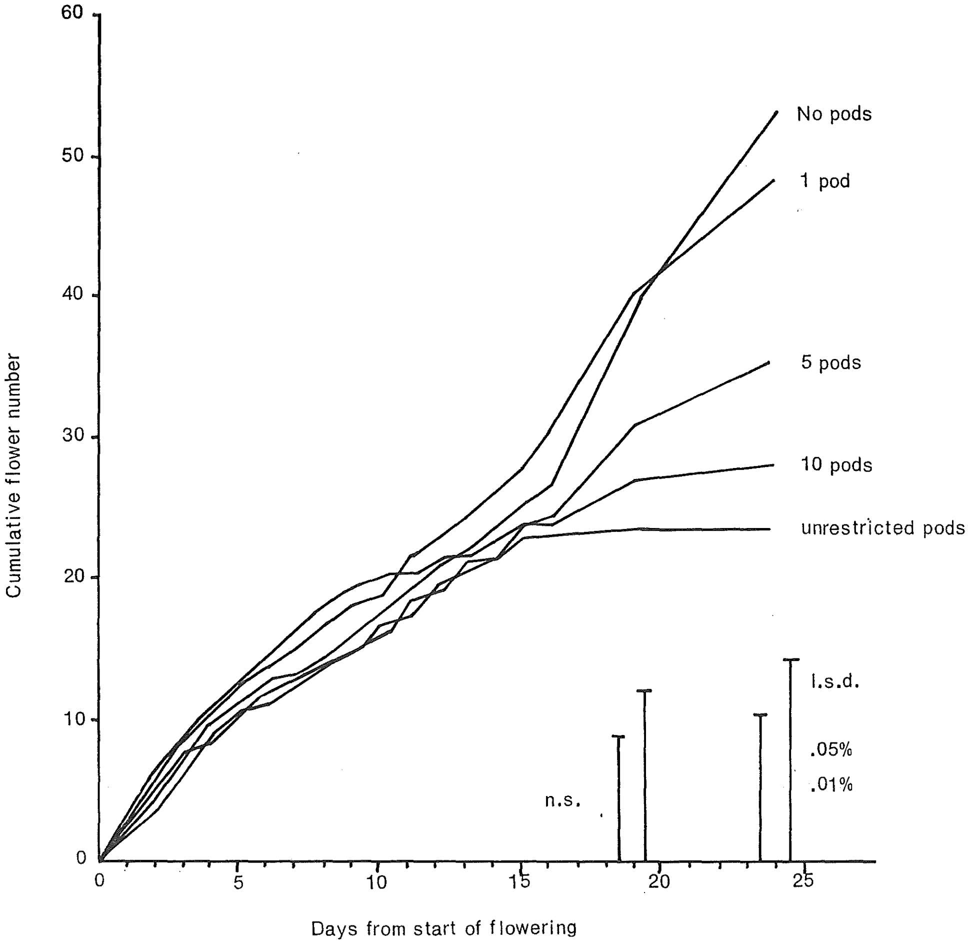

Figure 1.—Effect of pod number on flower production.

There was no significant difference between treatments for flower production during the first 16 days, even though all treatments, including unrestricted, had reached their final pod count early in this period. However, for the last 8 days marked differences in flower numbers were evident between the treatment allowed no pods, and those with varying pod loads. Larger numbers of pods were associated with fewer flowers and unrestrained number of pods with virtually no flower production and abortion of buds at an early stage of development. No shedding of open flowers or buds occurred. Thus in this experiment pods did not significantly influence flower production for about 16 days from the start of flowering, regardless of the pod load of the plant.

Table 2 shows mean leaf number per plant and the mean number of nodes producing inflorescences (flowering nodes). This cultivar characteristically produces only 4 to 5 leaf nodes on the main axis before terminating in an inflorescence, therefore leaf number may be used as a measure of development of axillary branches, which may bear up to four leaves before terminating with an inflorescence.

TABLE 2

PLANT CHARACTERISTICS (MEAN NUMBERS)

Treatment		Leaves per Plant	Flowering Nodes per Plant	Flowers per Flowering Node
1) No pods		13·4	9·4	5·6
2) One pod		13·4	9·2	5·3
3) Five pods		13·8	8·8	4·0
4) Ten pods		12·4	7·8	3·7
5) Unrestricted pods		11·8	7·4	3·2
Necessary difference for significance	0·05	N.S.*	N.S.	0·95
	0·01	N.S.	N.S.	1·31

* N.S. — Not significant

There was no significant difference between the numbers of leaves and flowering nodes produced, but the data suggests a decline for plants with ten pods or unrestrained pod numbers. However, this was not in proportion to the reduced flower production. With the increased pod number, significantly fewer flowers were produced, on average, per node (table 2). Thus in this experiment flower production to compensate for pod removal took place by further production from existing flowering nodes rather than by producing new shoots with more flowering nodes.

IV. DISCUSSION

The main effect of pod removal was to influence the rate of flower production, but only after flowering had been taking place for over 2 weeks. Until then the presence of ten or more pods had little effect, whereas later their effect was inversely related to their number.

The flowering behaviour could therefore be divided into two phases, where flower production was (a) independent of pod load, and (b) affected by pod load. French bean flowers remain open for 2 to 3 days before petal fall, so during the first 2 to 3 days of flowering only very small pods up to 5 mm long would be present. As with many fruits the early stage of growth of beans is primarily by cell division, and the later stage by cell expansion. Loewenberg (1955) showed that with Black Valentine bush beans during the first 3 weeks after flowering a very small increase in seed dry weight occurred as opposed to a large increase in cell numbers. During the next 2 weeks when green bean maturity occurred there was very rapid seed growth but little cell division. Reeve and Brown (1968) found that for a number of bean varieties, pod length at the end of the cell division period of development was about 5 cm. As pods underwent rapid growth to the green bean maturity stage seed size increased rapidly, and starch grains accumulated in the pod parenchyma.

The phases of flower production proposed correspond to these phases of pod development. During the period of cell division, the pods made relatively little growth in size and were a weak assimilate sink and did not restrain flower production. As cell expansion and assimilate accumulation commenced, the effect on flower production could be explained in terms of competition between rapidly growing pods (which were strong sinks with a large potential for growth and a high Relative Growth Rate (Gage 1975)) and flower buds of small mass with limited growth potential.

However, the fact that pod abortion occurred 14 days from the start of flowering in plants with unrestricted pod numbers indicates that strong internal competition for assimilates was occurring at that time. Flowering did not cease for several more days, but flower buds aborted, and although no flower shedding occurred, the small pods aborted soon after petal fall. It is suggested that this inertia in flowering was due to the presence of flower buds at an advanced stage of development which could function as effective sinks or had sufficient reserves to maintain them to flowering.

In another experiment (Gage 1975) the removal of pods led to an increase in leaf number and total leaf area as compared with plants which were allowed to retain their pods. This only became evident when the latter were in the pod development stage, when flowering had ceased. Removal of pods had no significant effect on mean area per leaf. In the experiment reported here there was no significant increase in leaf number in plants with pods removed, so it cannot be argued that differences in assimilate supply accounted for the differences between treatments, nor that the continuation of flowering in some treatments was due to the production of inflorescences from new lateral shoots.

These findings from a glasshouse experiment cannot be quantitatively applied to a field situation, but they could be used to interpret field responses. There appears to be no practical limit to the number of flowers a bean plant of this cultivar may produce providing there is no physiological restraint on their development to the flowering stage. Therefore a plant may compensate for pod loss by producing more flowers. If a number of small beans is lost during the first phase of their development, further flowers still being produced could replace the loss, and as the older pods begin rapid growth, a proportion would abort. This would result in a widened maturity range, but since the latest set pods often abort in preference to those set earlier, this should not be too serious.

If partial pod loss occurred during the later, rapid pod growth stage, the remaining pods could inhibit further flowering, preventing yield compensation, and the result would be a low yield of pods of uniform maturity. If compensation took place through later flowering, the wide spread of maturity of beans produced would be commercially undesirable in a single harvest situation. In this case removal of the beans remaining immediately following partial pod loss would be appropriate to induce a new flowering cycle. Wein, Sandsted and Wallace (1973) did this when they removed all pods from bean plants for a period from the start of flowering in an attempt to increase yields. This treatment resulted in an increased bush size, indicating the limiting effect of pods in further plant development, but did not produce a corresponding increase in yield of pods over plants where the normal flowering and fruiting pattern was allowed. Since pod yield is closely related to photosynthesis during the pod development stage of green beans (Jones 1967), larger plants would be expected to be more productive than smaller ones unless agronomic factors such as plant density, nutrition or water are limiting. This was possibly the case in the experiment of Wein, Sandsted and Wallace (1973).

The relationship between plant size, flowering and fruiting of french beans as it affects harvest efficiency is being investigated further.

V. ACKNOWLEDGEMENTS

Thanks are due to Miss E. A. Goward, Biometry Branch, for statistical analyses, and to Mr J. M. Bain for technical assistance.

REFERENCES

GAGE, J. F. (1975).—Water stress and development of french bean *Phaseolus vulgaris* L. cv. Redlands Pioneer M.Agr.Sc. Thesis Univ. of Queensland.

JONES, L. H. (1967).—Factors affecting the productivity of dwarf french beans. *Agr. Progress* 42: 32-52.

LOEWENEBERG, J. R. (1955).—The development of bean seeds (*Phaseolus vulgaris* L.) *Plant Physiol.* 30: 244-50.

REEVE, R. M. AND BROWN, M. S. (1968).—Histological development of the green bean pod as related to culinary texture. 2. Structure and Composition at Edible Maturity. *J. Food Sci.* 33: 326-331.

STOBBE, E. H., ORMROD, D. P. and WOOLLEY, C. J. (1966).—Blossoming and fruit set patterns in *Phaseolus vulgaris* L. as influenced by temperature. *Canad. J. Bot.* 44: 813-9.

WEIN, H. D., SANDSTED, R. F. and WALLACE, D. H. (1973).—The influence of flower removal on growth and seed yield of *Phaseolus vulgaris* L. *J. Am. Soc. Hort. Sci.* 98: 45-9.

(Received for publication 4 May 1976)

The author is a Horticulturist with Horticulture Branch, Queensland Department of Primary Industries, stationed at the Redlands Horticultural Research Station, at Ormiston.