FABIS

Faba Bean Information Service

NEWSLETTER

No. 15

August 1986

INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS

(ICARDA)

ICARDA and CGIAR

The overall objective of the International Center for Agricultural Research in the Dry Areas (ICARDA) is to increase agricultural productivity and food availability in both rural and urban areas, thus improving the economic and social well-being of people in developing countries, particularly in North Africa and West Asia. The center focuses mainly on winter rainfall areas with 200-600 mm annual precipitation. When appropriate, research also covers environments with monsoon rainfall or irrigation.

ICARDA is a world center for the improvement of barley, lentil, and faba bean, and a regional center for improving wheat, chickpea, farming systems, livestock, and pasture and forage crops. The training of agricultural researchers from developing countries and the communication of research results are an important part of ICARDA's activities.

ICARDA is a non-profit research center established in 1977 by the Consultative Group on International Agricultural Research (CGIAR), The CGIAR, an informal association of donors including governments, organizations, and private foundations, supports agricultural research worldwide to improve food production in developing countries, through a network of 13 international research institutions, including ICARDA. The network covers crop and livestock systems that supply three-quarters of the food of the developing world.

FABIS

FABIS Newsletter is produced three times a year at ICARDA with the financial support of the International Development Research Center (IDRC), Ottawa, Canada. FABIS, the newsletter of the Faba Bean Information Service, is a forum for communicating faba bean research results. Short research articles provide rapid information exchange, and comprehensive reviews are invited regularly on specific areas of faba bean research. The newsletter also includes announcements. The Faba Bean Information Service provides information on faba bean research free of charge through a question and answer service, photocopies, and searches of a faba bean document collection.

DEADLINE: Contributions must reach FABIS for No. 17 by 28 February, for No. 18 by 30 June, and for No. 19 by 31 October 1987.

SUBSCRIPTIONS: FABIS Newsletter is available free to faba bean researchers under an IDRC grant. To subscribe, write: FABIS/Documentation Unit/ICARDA/P.O. Box 5466/Aleppo, Syria.

COVER PHOTO: An Egyptian farmer in the Nile Valley harvests green faba beans for human consumption.

FABIS

Faba Bean Information Service

NEWSLETTER No. 15 August 1986

CONTENTS

Agronomy and Mechanization

Pests and Diseases

Seed Quality and Nutrition

REVIEW ARTICLE

Recent Studies of Nitrate Assimilation in Vicia faba L.

M. Andrews
Department of Plant Science,
Lincoln College,
Canterbury,
NEW ZEALAND

Abstract

This article discusses recent publications on nitrate assimilation in *Vicia faba*. Particular reference is made to partitioning of nitrate assimilation between root and shoot, nitrate reductase activity as a measure of nitrate uptake and assimilation, and the benefits of nitrate application in the field.

Introduction

Although *Vicia faba* commonly obtains much of its nitrogen from N_2 fixation, it can develop normally with nitrate as the sole N source (Andrews *et al.* 1985). Except at the pre-nodulation stage and at low temperatures, which can completely inhibit N_2 fixation, it is likely that N_2 fixation and nitrate assimilation occur simultaneously in *V. faba* in the field. The relative importance of each will depend on environmental conditions, e.g. external nitrate concentration and temperature.

The partitioning of nitrate assimilation between root and shoot

The two most common sets of measurements used to determine the partitioning of nitrate assimilation between the root and shoot of higher plants are the relative proportions of total plant nitrate reductase activity (NRA) in the two plant parts, and the relative concentrations of nitrate and reduced N in the xylem sap. When both sets of measurements indicate similar partitioning of nitrate assimilation

between root and shoot, it is strong evidence that they are a true reflection of what is occurring in the intact plant *in situ* (Andrews 1986a). Recent work has shown that for uninoculated *V. faba*, the partitioning of nitrate assimilation between root and shoot is dependent on the external nitrate concentration and the cultivar (Sutherland *et al.* 1985). For example, NRA distribution between root and shoot, and xylem sap nitrate: Kjeldahl N ratio indicate that, for both the winter cultivar Banner Winter (BW) and the spring cultivar Herz Freya (HF), the root is the major site of nitrate assimilation at an applied nitrate concentration of 1 mol/m^3. As external nitrate concentration is increased, shoot assimilation becomes increasingly important (Sutherland *et al.* 1985). Both sets of data also indicate that at any one external nitrate concentration, the proportion of nitrate assimilation carried out in the shoot is greater for HF than BW. NRA studies indicate that, depending on external nitrate concentration, lateral roots, tap root, stem, and leaves can all play a substantial role in total plant nitrate assimilation (Andrews *et al.* 1984; Sutherland *et al.* 1985). If well nodulated plants from the field are potted and flushed with 20 mol/m^3 nitrate every 2 days for about a week, root activity (including nodules) per gram fresh weight (fw) can be up to four times as great as the highest activity measured for uninoculated roots in the laboratory (M. Andrews unpublished). This indicates that nodules are also capable of assimilating nitrate.

NRA as a measure of nitrate uptake and assimilation

In a growth cabinet with fixed photoperiod, light intensity, and temperature, leaf and stem *in vivo* + NO_3^- NRA (NRA + NO_3^-), and N content of nitrate-fed plants can show a close correlation, with both parameters increasing per g fw and per organ as applied nitrate concentration is increased from 1 to 20 mol/m^3. NRA + NO_3^- per g fw root changes little with nitrate concentration over this range (Andrews *et al.* 1985; Sutherland *et al.* 1985). Thus, under these conditions, it may be possible to obtain a relationship between NRA + NO_3^- of leaf or stem and rates of nitrate uptake and/or assimilation. It has

also been shown in the laboratory that NRA + NO_3^- need not necessarily be related to rates of nitrate uptake or assimilation. For example, under otherwise similar conditions, BW and HF had lower growth rates at 6°C than at 15°C but their nitrate content per gram dry weight (dw) of leaf and stem was similar, while their NRA + NO_3^- per g fw leaf and stem was substantially greater at the lower temperature (Andrews et al. 1985; Sutherland et al. 1985). Under field conditions, N_2 fixation, NH_4^+ assimilation, and NO_3^- assimilation are likely to be occurring simultaneously and attempts to correlate NRA with rates of nitrate uptake and assimilation can be complicated (Andrews 1986b). However, the finding that NRA + NO_3^- per g fw shoot can be high at a time when the N content of plants is not increasing and shoot NO_3^- concentrations are low (Andrews 1986b), indicates that this assay cannot be used as a reliable measure of nitrate assimilation in the field. In vivo - NO_3^- NRA (NRA - NO_3^-) for shoot, and NRA + NO_3^- and NRA - NO_3^- for roots appear to show a much closer correlation with rates of nitrate uptake and assimilation in the field (Andrews 1986b). It is possible that one, or more likely a combination, of these three measurements could prove useful as an indication of rates of nitrate uptake and/or assimilation under these conditions. However, the ever-present possibility of different interpretations of the activities obtained (Andrews 1986b) means that at best it is a qualitative rather than quantitative estimate.

The benefits of nitrate application in the field

At 6°C in the laboratory, a temperature at which fully functional nodules will not form and previously formed nodules show low rates of N_2 fixation, a range of V. faba cultivars can grow with nitrate as sole N source (Andrews et al. 1985). At higher temperatures in a greenhouse, additional nitrate increased the growth rate of nodulated plants (Hill-Cottingham and Lloyd-Jones 1980). Such findings suggest that increased growth rates may be achieved by both autumn- and spring-sown V. faba if nitrate is applied at low temperatures in the spring or at higher temperatures in the summer.

Few data are available for autumn-sown V. faba. In a preliminary field trial carried out in Scotland in 1983/84, overwinter and spring applications of nitrate increased g dw seed/m^2 and increased mg N/g dw seed for plants sown on 26 October 1983 (Andrews et al. 1986). There was no effect of nitrate on growth (dry weight and C and N content) up to 8 May 1984. Therefore, the response must have occurred after this date. In a study carried out in 1982/83, KNO_3 application (100 kg N/ha approx.) during April and May gave greater growth and yield per plant for HF sown the previous October (M. Andrews unpublished), but no controls were run to test the effect of additional potassium. Many studies have been carried out to assess the effects of nitrate application on spring-sown V. faba. On the basis of results from trials carried out between 1960 and 1980, Hebblethwaite et al. (1983) and Roughley et al. (1983) concluded that V. faba rarely responds to additional nitrate and there is little or no increase in yields. Roughley et al. (1983) suggest that V. faba has a "poor fertilizer utilization efficiency in the field". However, many recent reports (Faba Bean Abstracts 1981-85) indicate that, in the field, positive responses to additional N are not uncommon for spring-sown V. faba. Also, Dekhuijzen and Verkerke (1984) have shown that V. faba can take up over 50% of applied nitrate. Possible causes of these differences are manifold, but three are especially worthy of mention.

1. Soil N levels before N application. In the overwinter study of Andrews et al. (1986), in which additional nitrate gave greater yield, soil N levels were low before application. In many of the earlier studies on spring-sown plants, a predressing of 20-35 t/ha farmyard manure was applied (Day et al. 1979). Thus, it is possible that the soil contained high levels of N initially and additional nitrate was superfluous to plant requirements.

2. Time of application. Andrews et al. (1986) applied nitrate from plant emergence to the onset of flowering. In the study of Dekhuijzen and Verkerke (1984), in which over 50% of the applied nitrate was recovered in plants, treatments were given at early flowering and early pod fill. In many of the earlier experiments, additional nitrate was applied to the seedbed only. If the effects of nitrate are more pronounced at later stages of growth then, in these early studies, additional nitrate could have been diluted or leached before it could have an effect. In earlier work where large predressings of farmyard manure were given, positive responses to additional nitrate usually occurred when application was later in the season (Day et al. 1979). This suggests that nitrate applied to the seedbed was lost before it could have an effect.

3. Measurement of response. In many early studies on *V. faba*, yield (dry weight seed per unit area) was the only parameter measured to test for effects of additional nitrate (Day *et al.* 1979). In cases where yield was unaffected, vegetative growth may have been increased as the two measurements need not be directly correlated. For example, Richards and Soper (1982) working in nine locations in Manitoba, Canada, found that 50% of a range of NH_4NO_3 treatments (30-300 kg/ha) increased the protein concentration in the forage. Indeed, almost all high N applications evoked this response. Despite this, yield was rarely affected. Measured maximum yield trials for *V. faba* highlight this non-correlation between vegetative growth and seed production as, in such studies, application of nutrients can dramatically increase growth without affecting yield (Thompson and Taylor 1982). In addition, *V. faba* can show increased seed N concentration without an increase in seed dry weight (Andrews *et al.* 1986). Therefore, in experiments where yield alone has been measured, responses to additional nitrate may have been overlooked.

Comparisons between nitrate, ammonium, and urea as N source

The three most common forms of combined N given to crop plants are nitrate, ammonium, and urea. *V. faba*, like most plant species studied, is able to achieve growth on all three (Andrews *et al.* 1985) but the relative growth rates on each are dependent on growth conditions. For example, at 6°C in the laboratory, urea can give greater growth than nitrate at comparable applied N concentrations, but at 15°C the opposite is the case (Andrews *et al.* 1985). At concentrations above 4 mol/m^3, ammonium as sole N source can cause toxicity effects at 6°C in the laboratory (Andrews *et al.* 1985). In a preliminary study under field conditions (Andrews *et al.* 1986), overwinter and spring applications of ammonium and urea increased spring growth of autumn-sown *V. faba*. These increases in early growth rate plus any residual effect of the additional N were reflected in increased yield and increased N concentration in the seed. Overwinter and spring applications of nitrate had no effect on growth up to 5 May 1984 but did affect yield and seed N concentration. Further studies are necessary to determine whether these results are repeatable year to year and whether similar effects can be obtained with spring-sown *V. faba*.

The involvement of nitrate in low temperature chlorosis

Andrews *et al.* (1984) describe preliminary experiments to determine whether increased external nitrate concentration can overcome low temperature chlorosis, a phenomenon shown by some cultivars of *V. faba*. On completion of this work, it was concluded (Andrews 1986a; Andrews *et al.* 1986) that in both the laboratory and field, additional N as nitrate, ammonium, or urea cannot overcome low temperature chlorosis. Indeed, high external nitrate concentrations can increase low temperature chlorosis in the cold-sensitive HF and cause it in the cold tolerant cultivar BW (Andrews 1986a). This appears to be a direct effect of the NO_3^- ion, as substitution of KNO_3 with KCl at the same concentration does not induce low temperature chlorosis. In view of these responses and the finding that, at a given external nitrate concentration, HF carries out a greater proportion of its nitrate assimilation in the shoot compared to BW, it has been proposed that low temperature tolerance in *V. faba* involves decreased transport of nitrate to the shoot (Andrews 1986a).

Conclusions

Recent studies of nitrate assimilation in *V. faba* indicate that

1. the partitioning of nitrate assimilation between root and shoot is dependent on external nitrate concentration and cultivar.

2. leaves, stem, lateral roots, tap root, and nodules are all capable of assimilating nitrate.

3. NRA need not be correlated with rates of nitrate assimilation.

4. application of nitrate to established plants will commonly give greater vegetative growth if soil N levels are initially low.

5. greater vegetative growth may not give greater yield.

6. at low temperatures, additional ammonium and urea can give greater growth than additional nitrate but none can overcome low temperature chlorosis.

7. nitrate transport to the shoot is a factor in low temperature sensitivity.

References

Andrews, M. 1986a. The partitioning of nitrate assimilation between root and shoot of higher plants. Plant, Cell and Environment 9. In press.

Andrews, M. 1986b. Seasonal nitrate reductase activity of autumn sown *Vicia faba* L. FABIS Newsletter 15. In press.

Andrews, M., MacFarlane, J.J. and Sprent, J.I. 1985. Carbon and nitrogen assimilation by *Vicia faba* L. at low temperature: the importance of concentration and form of applied N. Annals of Botany 56:651-658.

Andrews, M., Sutherland, J.M. and Sprent, J.I. 1984. Nitrate reduction in *Vicia faba* grown at different temperatures. Pages 29-36 *in Vicia faba*: Agronomy, Physiology and Breeding (Hebblethwaite, P.D., Heath, M., Dawkins, T.C.K. and Lockwood, C. eds). Martinus Nijhoff, The Hague, The Netherlands.

Andrews, M., Taylor, H., McInroy, S. and Sprent, J.I. 1986. Early growth and final yield of autumn sown *Vicia faba* L. cultivars given different forms of fertiliser N over winter. Plant and Soil. In press.

Day, J.M., Roughley, R.J. and Witty, J.F. 1979. The effect of planting density, inorganic nitrogen fertiliser and supplementary carbon dioxide on yield of *Vicia faba* L. Journal of Agricultural Science, Cambridge 93:629-633.

Dekhuijzen, H.M. and Verkerke, D.R. 1984. Uptake, distribution and redistribution of [15]Nitrogen by *Vicia faba* under field conditions. Field Crops Research 8:93-104.

Faba Bean Abstracts 1981-85. Commonwealth Agricultural Bureaux, Slough, England.

Hebblethwaite, P.D., Hawtin, G.C. and Lutman, P.S.W. 1983. The husbandry of establishment and maintenance. Pages 271-312 *in* The Faba Bean (Hebblethwaite, P.D. ed.). Butterworths, London, England.

Hill-Cottingham, D.G. and Lloyd-Jones, C.P. 1980. The influence of nitrate supply on nitrogen fixation during growth of the field bean *Vicia faba* in sand. Physiologia Plantarum 48:116-120.

Richards, J.E. and Soper, R.J. 1982. N fertilization of field grown faba beans in Manitoba. Canadian Journal of Soil Science 62:21-30.

Roughley, R.J., Sprent, J.I. and Day, J.M. 1983. Nitrogen fixation. Pages 233-260 *in* The Faba Bean (Hebblethwaite, P.D. ed.). Butterworths, London, England.

Sutherland, J.M., Andrews, M., McInroy, S. and Sprent, J.I. 1985. The distribution of nitrate assimilation between root and shoot in *Vicia faba* L. Annals of Botany 56:259-263.

Thompson, R. and Taylor, H. 1982. Prospects for *Vicia faba* L. in Northern Europe. Outlook on Agriculture 2:127-133.

SHORT COMMUNICATIONS

Breeding and Genetics

A Recurrent Breeding Scheme for Faba Bean Improvement

J. Le Guen and P. Berthelem
Station d'Amelioration des Plantes,
35650 Le Rheu,
FRANCE

Abstract

In *Vicia faba,* yield improvement through breeding can be achieved by adopting several breeding schemes appropriate for the partly out-crossing nature of the plant. This paper discusses problems and suggests methods of obtaining synthetic varieties. These methods are currently under study at INRA, France.

Introduction

Theoretically, improving yields of *Vicia faba* through breeding can be achieved in different ways. For breeding purposes, several schemes have been drawn up to suit the floral biology of this crop, which is partly autogamous and partly allogamous.

In the first of these schemes, pure line breeding has proved, until now, to be unsuccessful because of the high inbreeding depression exhibited by faba bean in successive selfing generations. Nevertheless, we are presently investigating the use of F_4 or F_5 material, with self fertility maintained by single seed descent (SSD) in a large bulk. We have no experimental evidence for this as yet but we think that it would be possible to obtain high-yielding types this way. We are currently doing comparative trials of such varieties at Rennes and Dijon.

The second improvement scheme, which resulted in good yields, was the creation of F_1 or three-way hybrids. Unfortunately, the instability of the cytoplasmic male sterility, in both the English 447 and French 350 sources, caused the failure of this scheme.

So, until we find new, stable, male sterility or improve the varieties we possess at present, the creation of synthetic varieties is restricted. This paper discusses the problem and suggests methods of obtaining synthetic varieties. So far, there are no definitive results and experiments are continuing. However, we think that the methodology may be of some interest to breeders.

Selection for yield components

The fundamental basis of this recurrent scheme is the improvement of yield components. From experiments we have done elsewhere, it has been shown that the additive component of genetic variance is high for most characters compared to nonadditive variance in *V. faba* (Table 1), and generally higher than that for yield alone. Therefore, theoretically it would be more appropriate to alter yield components than

Table 1. Expected mean squares of yield and yield components (Griffing's Model I, Griffing 1956).

Characters	Expected mean squares	
	EGCA*	ESCA**
Yield	367.60	879.60
Number of tillers/plant	0.471	0.917
Number of pod-setting nodes	5.56	3.06
Number of pods/setting node	0.109	0.074
Number of seeds/pod	0.245	0.360
1000-seed weight	0.099	0.024
Seeds/plant	12.252	3.138
Pods/plant	3.607	538.0

$$* \quad EGCA = \sigma^2 + 2p \left(\frac{1}{p-1} \right) \sum_i gi^2$$

$$\text{with} \quad gi = \frac{1}{2p} (X_{i.} + X_{.i}) - \frac{1}{p^2} X_{..}$$

$$** \quad ESCA = \sigma^2 + \frac{2}{p(p-1)} \sum_i \sum_j sij^2$$

$$\text{with} \quad sij = \frac{1}{2} (xij + xji) - \frac{1}{2p} (X_{i.} + X_{.i} + X_{j.} + X_{.j}) + \frac{1}{p^2} X_{..}$$

yield. However, it must be said that some of these yield characters are only slightly variable and thus may reduce the efficiency with which they can be improved. These characters include the number of tillers per plant and the number of seeds per pod. Attempts have been made to improve the former through crosses with *paucijua* types, and the latter through crosses with *major* types which increase the number of ovules/ovary.

Recurrent scheme

When this program was started, the first operation was to create a source population, Po. As we wanted information about the efficiency of our method quickly, the variability in different yield components we used was not as high as can be found in the various subspecies of *V. faba*. So our Po population was created from crosses between English synthetic varieties (Maris Beagle and Throw's) and the French synthetic varieties Soravi and Avrissot.

The scheme used is shown in Fig. 1. For Po creation, crosses were made by hand, after emasculation, between the synthetic varieties. All the F_1 obtained from these crosses were gathered under an insect-proof cage and allowed to intercross with the help of a bumblebee colony placed inside the cage. At harvesting, each plant was kept separate and their progenies sown the following season in individual rows replicated six times in a randomized block experiment. Observations were made during growth and, at harvest, yield components were computed and analyzed. These components included numbers of tillers, pod-setting nodes, pods per setting node, and seeds per pod, 1000-seed weight, and mean number of seeds per plant or mean number of pods per plant. More recently, selections for total biomass have also been made.

Two methods have been developed to estimate these characters:

(i) Family selection in which the best family is selected for each of the yield components. In this case, one family corresponds to a line or single plant progeny.

(ii) Individual within-family selection in which the best individuals for each trait within the best families for that trait are selected.

Table 2 shows the behavior of some within-yield characters for family selection and for individual
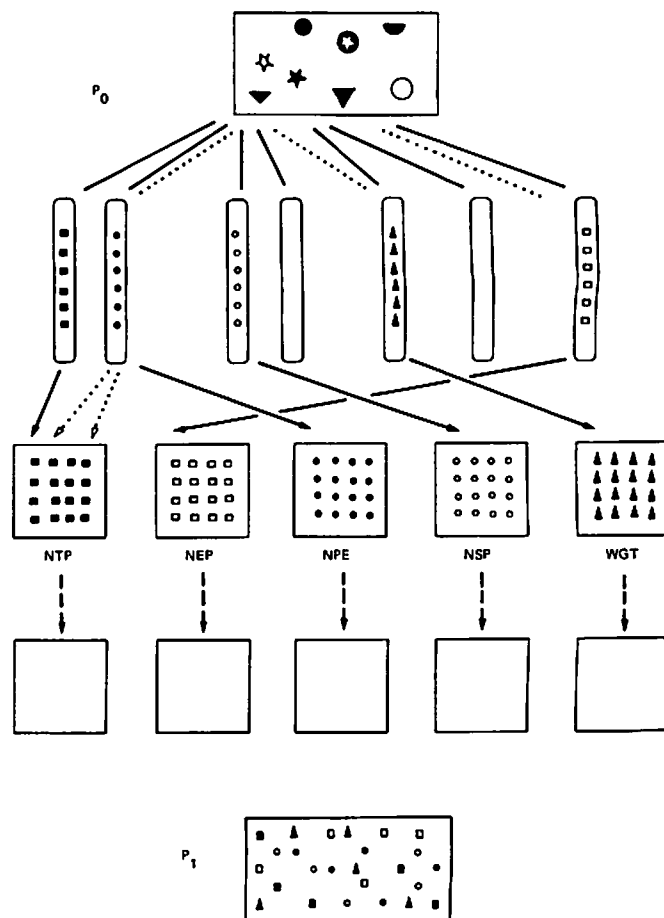
Fig. 1. Recurrent selection for yield components.

within-family selection. Note that in most cases, family selection gives the best results for the mean and standard deviation of each character. As we have a greater facility to select whole families according to their mean values rather than individuals within families, we have used the former method in all subsequent breeding actions.

Using the results from the above, subpopulations were created (Fig. 2), each subpopulation representing one of the selected traits, and containing about 20% of the progenies of the best families for each character. The subpopulations are further tested using three methods.

In the first method, (selection model 1) all the selected progenies for all characters are bulked into the improved Po population. These progenies are allowed to intercross in an isolated field for 3 or 4 years, each successive generation arising from the previous one by single seed descent (SSD).

Table 2. Comparison of a family selection versus an individual within-family selection on yield components after one cycle of a recurrent scheme. Mean values and standard deviations after one 3-year selection cycle.

Yield component and yield	Selected components							
	Tiller		Seeds/pod		Number of seeds/plant		Yield	
	I**	F*	I	F	I	F	I	F
Tiller	2.83	3.19	2.21	2.76	2.26	2.80	2.25	2.91
	(0.87)[a]	(0.86)	(1.29)	(0.91)	(0.79)	(0.90)	(0.69)	(0.74)
Pod-setting nodes	15.60	14.50	16.20	16.10	13.70	17.70	14.10	18.30
	(6.80)	(6.90)	(3.40)	(6.90)	(6.80)	(8.20)	(6.60)	(8.50)
Pods/node	1.38	1.17	1.12	1.20	1.22	1.22	1.21	1.24
	(0.71)	(0.20)	(0.15)	(0.15)	(0.24)	(0.20)	(0.22)	(0.18)
Seeds/pod	2.84	2.88	3.17	3.36	2.87	2.94	2.87	2.87
	(0.46)	(0.49)	(0.63)	(0.40)	(0.51)	(0.49)	(0.50)	(0.47)
Pods/plant	19.00	17.00	7.00	19.60	16.60	21.60	17.10	22.60
	(9.00)	(9.10)	(4.10)	(10.40)	(8.90)	(11.10)	(8.90)	(10.90)
Seeds/plant		46.80	22.30	61.00	36.00	61.30	34.60	61.00
		(25.10)	(12.40)	(32.40)	(21.40)	(33.50)	(17.80)	(33.10)
Yield	28.40	26.30	10.50	31.70	19.20	32.40	17.30	32.40
	(6.80)	(16.80)	(7.30)	(17.10)	(12.80)	(18.40)	(10.10)	(17.20)

* F = Family selection
** I = Individual within-family selection
[a] Values in parentheses are standard deviations

RECURRENT SELECTION (2)

Fig. 2. Methods for varietal creation using different selection schemes.

Table 3. Yield and primary and secondary yield component variability in relation to the type of selection applied in the course of a recurrent cycle. Values are expressed as mean per plant (issuing from selection model 2).

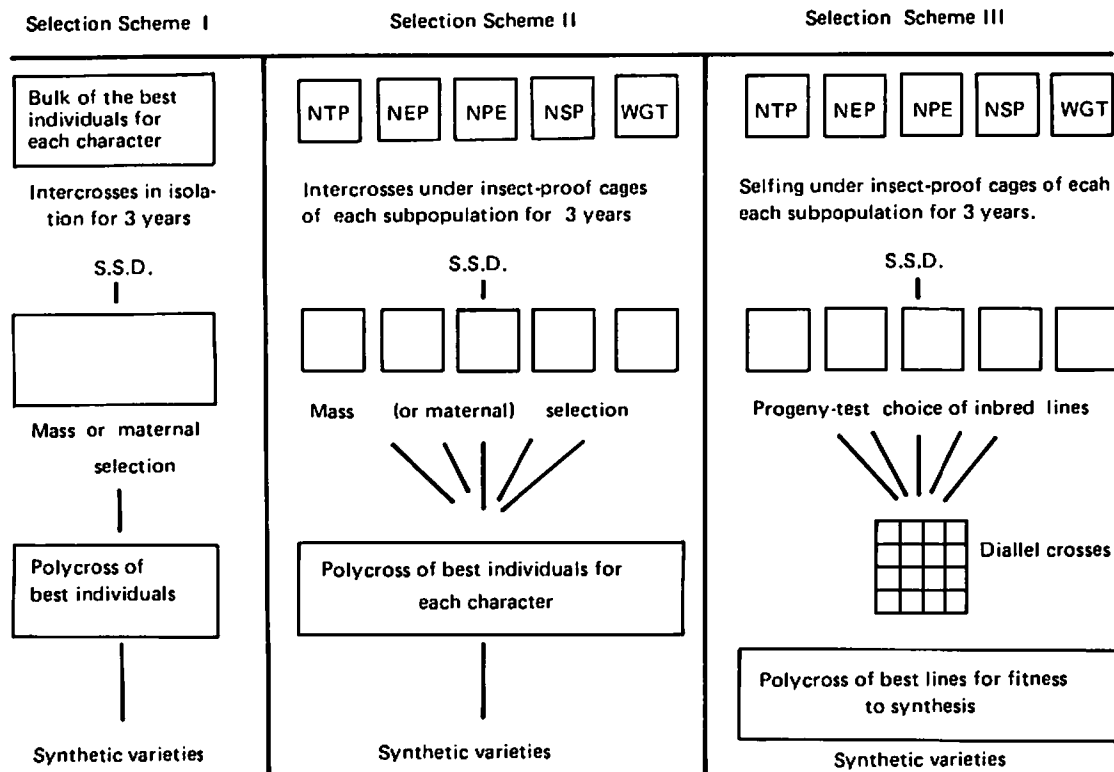| Familial selection for	Mean values of yield and its components (percent of the lowest value in each case)*							
	Tiller	Pod-setting nodes	Pods/node	Seed/pod	Seed weight	Pods/plant	Seeds/plant	Yield
Tiller	145.6	104.7	102.2	102.4	111.0	100.0	100.0	102.8
Pods/node	159.3	135.9	111.0	100.0	102.4	140.9	141.5	129.6
Seeds/pod	135.1	109.2	104.4	109.4	108.0	106.5	118.3	111.5
Seed weight (high level)	134.3	107.9	100.0	109.8	111.0	102.3	112.0	110.1
Seed weight (low level)	146.0	118.9	114.7	102.8	105.2	126.4	133.3	124.4
Seeds/plant	100.0	100.0	117.7	104.2	100.0	107.8	111.0	100.0
Pods/plant	156.0	135.9	109.6	101.7	109.4	137.2	141.9	135.6
Yield	154.8	128.6	105.9	106.6	107.3	126.4	137.3	130.2

*Each value represents the mean of families: 12 x 15 plants = 180 plants

In the second method (selection model 2), each subpopulation is maintained in isolation under a 3 x 3 m insect-proof cage (one cage per selected trait). A bumblebee colony in a little hive is placed inside the cage and plants are left to intercross for 3 or 4 years to increase the number of eventual recombinations. As in the first method, each successive generation arises from the previous one by SSD.

In the third method (selection model 3), each subpopulation selected for one trait is put into an insect-proof cage and each plant under isolation is selfed by hand tripping. This selfing is done for 3 or 4 years and successive generations carried by SSD as before.

So, at the end of a 3 or 4 year recurrent cycle we have three types of selected material. The first type issues from a large intercross of selected plants after nursery test (we have called this the S_1 test). It is expected that during these 3 or 4 year cycles, recombinations have occurred between the different traits selected. The second type of material constitutes what we hope are optimized recombinations within a selected trait, and we have at the issue of this cycle optimized various subpopulations for each of the yield components. With the third type of methodology, we have created more fixed material--equivalent to F_4 families--than with the other two methods. These individuals are multiplied by brother x sister crosses in isolation. We hope that this method of maintenance prevents high inbreeding depression and leads to homogeneous material for the main traits under selection.

Table 3 gives some results from one cycle of family selection for various characters. Differences appear for various traits in relation to the nature of the subpopulation. Also, tillering ability seems to be a very important character to increase yield. Unfortunately, this trait is very sensitive to competition so we are developing research to explore the competitive ability of various types of plants with Dr Poulain of the Agronomy Station at Rennes.

Use of selected material

Methodology of varietal creation

The material created in the previous cycle is being used partly to constitute the next population and also in a varietal creation scheme.

In connection with the various subpopulations from the different selection models, we are also testing different methods of creating commercial synthetic varieties. Our aim is to define the method that gives the best genetic gain per unit time (= year or cycle) in the most economic way. For that, three methods are presently under test (Fig. 2).

The first method (varietal creation model 1) uses the bulk in which, by mass or maternal selection, we choose the best individuals, which are then mixed and allowed to intercross for 3 years in an isolated field. The resulting intermixture constitutes a commercial synthetic variety. This method has the great advantage of being simple to implement and quick. Also, it is not rigorous; in particular, the bulk may drift during maintenance and the choice of the best individuals by mass selection may change, leading to variable varieties from cycle to cycle.

In the second method (varietal creation model 2), we make a mass or a maternal selection within each of

the subpopulations selected for one of the yield components. The individuals retained, in equal proportions for each trait, are intermixed as before for 3 years in an isolated field. The resulting intercrossed population constitutes a commercial synthetic variety. The main advantage of this method is that it is relatively easy. Manipulations are reduced and the time consumed is similar to the previous method. However, the cost of production is higher than in the first method because different subpopulations must be maintained under insect-proof cages for several years.

In the third method (varietal creation model 3), after selfing generations, the best parents are chosen in a progeny test. The different subpopulations are tested for general combining ability in partial diallel crosses. Parents exhibiting the best values for general combining ability are then mixed and allowed to intercross for 3 years, the resulting intermixture being a synthetic variety.

This method is very time-consuming and expensive. Moreover, the diallel and progeny tests increase the time required to create varieties compared to the two other methods. However, this method leads to a more stable and homogeneous synthetic variety and recombinations between selected material are optimized.

At present, we have experimental varieties created by the first two methods. Lines from the third method are to be tested. When partial diallel crosses are achieved, we will test the different varieties obtained in comparative trials, to compare the genetic progress for each in relation to the difficulty of implementation.

Evolution of the breeding scheme

As shown here, this breeding scheme has some disadvantages, which are essentially of three types.

First, some of the yield components show very limited variability, in particular the number of seeds per pod and the number of tillers per plant. So, even through a recurrent scheme, it is difficult to increase these components. This is the reason why crosses have been made between *V. faba major* and *V. faba minor* to increase the ovules per pod. Similarily, crosses have been made between *V. faba paucijuga* and *V. faba minor* to increase the number of tillers per plant.

The second point is that we are limited by the narrow genetic base of our source population. We are presently improving this by using different source populations that are to be maintained independently from each other. In fact we are creating different types of source populations:

(i) the French-type population, containing small-seeded and winter-hardy genotypes,

(ii) the English type which has larger seeds than the French type and matures later,

(iii) the southern population arising originally from Spanish varieties (TALO and ALTO in particular) and into which we are going to introduce North African cultivars and progenies of crosses between Spanish varieties and winter-hardy lines, and

(iv) the exotic population which includes very heterogeneous material with special characteristics such as tillering ability, high number of seeds/pod, independent vascular supply, self fertility, seed size, and resistance or tolerance to disease. For this population, we are not interested in agronomic adaptation to our agricultural conditions.

All these populations are to be developed in the general scheme previously described. We hope that in selecting parents of the synthetic varieties from quite different genetic pools we should increase heterosis in the created varieties.

The third disadvantage of our breeding scheme is the irregular and generally low intercrossing rate between plants. This reduces the number of efficient recombinations between characters and makes the recurrent cycle longer. We have considerably improved this factor by introducing into our populations a dominant gene for male sterility. This gene has been obtained from mutagenic treatment at the Dijon Plant Breeding Station as part of a cooperative program between INRA (Dijon and Rennes) and the private breeding sector. We have introduced this gene into various winter-type cultivars which are used as the female parent when we establish our source population. Moreover, if we put this gene into the parents of synthetic varieties, we increase the intercrossing rate in the synthetic constitutive generations and the level of heterosis.

Conclusion

The scheme presented here is just part of a larger program developed at Rennes' which includes genetic, agronomic, pathologic, and physiological research in cooperation with our colleagues of other INRA and University laboratories. We are particularly interested in all traits related to yield constitution, such as

- Competition and complementation events within homogeneous and heterogeneous populations.

- Factors affecting yield expression and fluctuations in yield components.

- Variability of physiological metabolism related to yield constitution, especially photosynthesis and light interception, and efficiency of translocation in plants.

New aspects arising from these studies may be integrated into our recurrent breeding scheme as a criterion of selection.

Reference

Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Australian Journal of Biological Sciences 9:465-493.

Inheritance of Determinate Growth Habit Induced in <u>Vicia faba major</u> by Ethyl Methane Sulphonate (EMS)

A. Filippetti
Institute of Plant Breeding,
University of Bari,
Bari, ITALY

Abstract

The inheritance of determinate growth habit was studied in *Vicia faba* L. The original variety (Aquadulce, major type, 100-seed weight = 200 g), the determinate mutant, and their F_1 and F_2 generations were grown at Valenzano (Bari, Italy) in the 1983-85 seasons. Determinate growth was found to be monogenic and recessive.

In earlier studies with *V. faba* L. (Sjodin 1971), experimental mutagenesis proved to be a useful tool to increase genetic variability and induce mutations of morphological traits of immediate use in breeding work. Later, Abdalla and Hussein (1977) and Filippetti and de Pace (1982; 1983) showed that for a specific variety, gamma rays are effective in inducing useful morphological variants, and both gamma-rays and ethyl methane sulphonate (EMS) are effective in broadening quantitative variation.

Chapman (1981) reviewed the new variants induced in *V. faba minor* for simple inherited characters. However, the variety *major* is mainly grown in the Mediterranean region. Transfer of the useful mutations from one botanical group to the other using conventional breeding methodology is a long process. Therefore, a breeding program was started in 1981 to induce in *major* types the same spectrum of genetic variability available in *minor* types and to identify variants which could be used to get determinate growth habit, new leaf characteristics, etc.).

Materials and Methods

Faba bean cultivar Aquadulce has indeterminate growth habit; stem elongation and leaf production continue for a long while after flowering. Seeds of this *major* type faba bean cultivar (average seed weight 2 g) were soaked for 24 hours in a 1.7% solution of the mutagen ethyl methane sulphonate (EMS) at 20 $\pm$ 1°C. The 2500 treated seeds were thoroughly washed under running water for 2 hours. The M_1 plants were grown in a 2 m high pollinating insect-proof cage. The progeny from each M_1 plant was sown in separate rows with 20 cm between seeds and 50 cm between rows. When the 15000 M_2 plants were large enough to distinguish variation in plant size and plant habit, the mutants directly visible as aberrant types were selected. One of these mutants showed terminal inflorescence and determinate growth (Fig. 1).
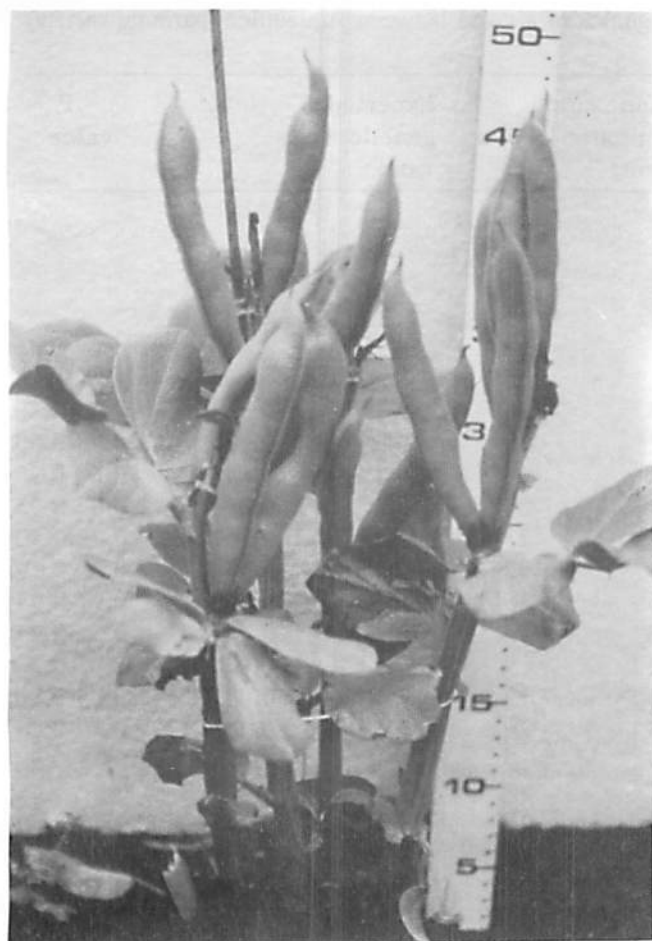
Fig. 1. Mutant showed terminal inflorescence and determinate growth.

Two determinate mutants have previously been isolated in *V. faba minor* by Sjodin: one of the mutants was induced in 1962 (neutrons, 35 rad) and the other in 1968 (MMS, 0.015%). The character displayed monofactorial inheritance, in which the F_1 was normal and the F_2 segregated into three normal phenotypes to one mutant. The genes were designated ti-1 and ti-2 (Sjodin 1971).

Table 1 shows the fertility parameters of the M_2 determinate plant progeny in our experiment. The parental plants (Aquadulce and the M_2 determinate mutant) were grown in the field at Valenzano, Bari, Italy in 1982/83 and crossed using the technique described by Bond *et al.* (1980). The F_1 plants were grown in the 1983/84 season. The F_2 plants were grown in 1984/85 and used to estimate the segregation ratio for determinate growth.

All material (parents, F_1, and F_2) was protected from outcrossing. The F_1 plants showed indeterminate growth habit: dominance of indeterminate over determinate growth habit was confirmed.

The segregation of terminal inflorescence in the F_2 generation is shown in Table 2. A significant 3:1 ratio of segregation was established in the determinate growth and was found to be monogenic and recessive.

Table 1. Performance of determinate M_2 plant progeny and the standard indeterminate check (Aquadulce) in preliminary evaluation at Valenzano, Italy 1983.

Mutant plants	Number of stems*	Number of flowering nodes	Number of flowers	Number of pods/plant	Number of seeds/plant	Number of seeds/pod	Seed yield/ plant (g)	Seed weight (g)
1	5	50	165	11	39	3.5	72	1.84
2	4	40	115	6	18	3.0	45	2.50
3	4	33	100	7	18	2.6	31	1.72
4	4	40	120	8	24	3.0	39	1.62
5	3	50	170	10	29	2.9	47	1.62
6	3	30	90	5	16	3.2	29	1.81
7	3	35	105	5	20	4.0	43	2.15
8	4	38	115	6	20	3.3	43	2.15
9	3	50	160	9	30	3.3	48	1.60
10	3	38	120	7	24	3.4	41	1.70
X	3.3	40.4	126.0	7.4	23.8	3.2	43.8	1.87
Aquadulce test X	2.5	24.0	75.0	10.5	42.0	4.0	82.5	1.96

*Axis + secondary stems

Table 2. Segregation for determinate grown habit in F_2 progenies of a cross between Aquadulce (parental variety) and the determinate mutant.

Parent/ F_1 and F_2	Field number of segregating families	Observed segregation Indeterminate (normal)	Observed segregation Determinate (mutant)	Total	Expected genetic ratio	X^2	P value
1. Determinate mutant		10		10			
2. Aquadulce x Determinate mutant							
F_1 (1984)		15		15			
F_2 (1985)	1	13	3	16	3:1	0.333	0.75-0.50
	2	8	2	10	3:1	0.133	0.75-0.50
	3	11	2	13	3:1	0.640	0.50-0.25
	4	22	8	30	3:1	0.044	0.97-0.95
	5	16	7	23	3:1	0.361	0.75-0.50
	6	19	3	22	3:1	1.514	0.25-0.10
	7	20	6	26	3:1	0.050	0.97-0.95
	8	31	13	44	3:1	0.484	0.50-0.25
	9	7	2	9	3:1	0.036	0.95-0.90
	10	10	3	13	3:1	0.025	0.95-0.90
	11	21	5	26	3:1	0.461	0.50-0.25
	12	21	9	30	3:1	0.400	0.75-0.50
	13	17	5	22	3:1	0.060	0.97-0.95
	14	15	6	21	3:1	0.142	0.75-0.50
	15	8	2	10	3:1	0.133	0.75-0.50
Overall F_2		239	76	315	3:1	0.128	0.75-0.50

We assume that this determinate mutant will be valuable in future breeding programs on *V. faba* var *major* due to the large number of flowering nodes/plant and flowers/plant, and more uniform and earlier ripening compared with the indeterminate types.

This research was carried out within the CNR/IPRA-Plant Breeding Institute, University of Bari.

References

Abdalla, M.M.F. and Hussein, H.A.S. 1977. Effects of single and combined treatments of gamma rays and EMS on M_2-quantitative variation in *Vicia faba* L. Zeitschrift fur Pflanzenzuchtung 78:57-64.

Bond, D.A., Lawes, D.A. and Poulsen, M.H. 1980. Broad bean (Faba bean). Pages 203-213 *in* Hybridization of Crop Plants. ASA-CSSA Publication.

Chapman, C.P. 1981. Genetic variation within *Vicia faba* L. *In* Genetic Variation Within *Vicia faba* L. FABIS Newsletter, ICARDA, June 1981. ICARDA, Aleppo, Syria.

Filippetti, A. and De Pace, C. 1982. Mutagenesi sperimentale e miglioramento genetico della fava da granella secca (*Vicia faba* L.). Annali della Facolta di Agraria, Universita di Bari XXXII:197-211.

Filippetti, A. and De Pace, C. 1983. Improvement of grain yield in *Vicia faba* L. by using experimental mutagenesis. I. Frequency and types of mutations induced by gamma-radiation. Genetica Agraria XXXVII:53-68.

Sjodin, J. 1971. Induced morphological variation in *Vicia faba* L. Hereditas 67:155-180.

Association of Closed Flowers and Non-Perforation of Corollas by Bees in Vicia faba L.

D. A. Bond
Plant Breeding Institute,
Cambridge,
UNITED KINGDOM

Abstract

Corolla-biting bees do not usually perforate flowers of the closed-flower mutant of faba beans because, it is assumed, these flowers lack nectar. Six closed-flower plants were discovered with as many perforated flowers as open-flower plants, but they did not pass this characteristic on to their offspring. Thus, the closed-flower character continues to be regarded as pleiotropic with absence of nectar and may still be useful in controlling outcrossing. In fields of mixed flower types, certain bumblebees probably become so habituated at biting nectar-containing flowers that they occasionally continue to do so for some time on nectar-free flowers.

Introduction

The possible use of the closed-flower character (Poulsen 1977) in allowing pedigree selection under open pollination, in screening for autofertility, or eventually in changing the species to complete autogamy, depends on a lack of nectar as well as on only limited unfurling of the petals. In central and northern Europe, the presence of nectar in normal open-flowered plants is nearly always indicated by perforations made by corolla-biting bumblebees (*Bombus terrestris* and *B. lucorum*). It was assumed, as a result of very strong correlations between the closed-flower habit and lack of perforations of the corolla tube (Knudsen and Poulsen 1983; Bond 1984), that closed-flower habit and lack of nectar are controlled by the same gene. However, it is important that this assumption is checked because any change in this association, such as might be expected from a break in close genetic linkage, could render closed-flower genotypes less useful in breeding for a high level of self pollination. Even though the petals might be only partly unfurled, the presence of nectar would attract bees, some of which might attempt to reach it from the front of the flower and thereby bring about cross pollination.

Materials and Methods

In a replicated trial conducted in 1983 comprising three normal, open-flowered and 22 closed-flowered families each with over 400 plants, six closed-flowered plants were found with over 70% of their flowers perforated, a proportion similar to that on open-flowered plants in the same trial. The six contrasted with all other closed-flower plants in the trial, which averaged about 5% and did not exceed 10% of perforated flowers, as had been previously reported by Bond (1984). Moreover, five of the six plants were all members of the same family. It was necessary to determine whether the apparent attractiveness of these six plants to corolla-biting bees was heritable.

Offspring of the six plants were grown in progeny-rows in 1984. Two progenies were large enough to be replicated while a closed-flower control population and the cultivar Maris Bead were planted three times in rows at fixed intervals among the progeny rows. All surrounding faba beans were normal open-flowered types.

Flowers were observed for perforations on two dates (Table 1). All flowers on all plants were inspected on 18 June 1984, but on 28 June 1984 only the first 10 closed-flower plants in each row were examined.

Results and Discussion

On 18 June, an average of six flowers per plant were old enough to be classified as perforated or unperforated. Only 2 out of 894 closed-flowers (Table 1) were perforated compared with 19.4% on Maris Bead. By 28 June, an average of 16.8 flowers per plant could be classified and the range among progenies was now much less, from 13.8 to 20.1 closed-flowers per plant.

None of the closed-flower progenies were significantly different from the closed-flower standard population in the ratio of perforated to unperforated flowers. The ratio for the progeny of plant 35/1 approached significance ($X^2 = 3.67$; $0.1 > P > 0.05$; Table 1) and perhaps should be retested. However, its mean number of flowers per plant was greater than any other entry in the test and the 16 perforated flowers were distributed fairly evenly over the 20 plants observed in the progeny, suggesting no simple genetic segregation.

Table 1. Perforated (P) and non-perforated (NP) flowers on closed-flower progeny derived from perforated closed-flower parents.

	Observed 18.6.84		Observed 28.6.84			Mean no. flowers/ plant
	No. of flowers		No. of flowers			
	P	NP	P	NP	X^2_v Control	
Closed-flower, single-plant progenies						
38/1	0	181	6	315	0.01	16.1
38/2	1	79	3	135	0	13.8
38/3	1	115	4	189	0	19.3
38/4	0	136	3	145	0	14.8
38/5	0	170	3	137	0	14.0
35/1	0	70	16	385	3.67	20.1
Closed-flower population (control)	0	143	9	516		17.5
Maris Bead	82	341	691	74	981.5	19.1

The proportion of perforated flowers on Maris Bead on 28 June was 90.3% compared with 1.7% on the closed-flower control. Thus, even if the progeny of 35/1, with 4.0% flowers perforated, differed significantly from other closed-flower entries in the test, it was less perforated than the normal, open-flowered, Maris Bead.

There were nine open-flowered plants among closed-flower progenies (due to pollination of incompletely closed flowers by pollen-gathering honeybees in 1983), and on 18 June these had a significantly higher proportion (34.8%) of perforated flowers than Maris Bead. However, on that date more of their flowers were classifiable than those of Maris Bead.

It was concluded that five of the closed-flower plants selected in 1983 for high proportions of perforated flowers did not, despite belonging to the same family, pass on this characteristic to their offspring. Neither was there a significantly greater proportion of perforated flowers detected in the progeny of the sixth plant, No 35/1, though this test should be repeated. The most likely explanation of the perforations observed on the six closed-flower plants in 1983 is that, in a field of mainly open-flowered plants certain bumblebees may become so habituated at corolla biting of nectar-containing, normal open-flowers that they continue to bite

nectar-free closed flowers for some time before detecting that nectar is absent.

The closed-flower character can therefore continue to be regarded as pleiotropic with absence of nectar and probably of scent, and its possible use in controlling outcrossing should still be considered.

Acknowledgements

References

Bond, D.A. 1984. Behaviour of bees visiting a type of *Vicia faba* with closed-flowers. Pages 141 - 145 *in* Proceedings of Veme Symposium International sur la Polinisation, Versailles, France.

Knudsen, J.C.N. and Poulsen, M.H. 1983. Pollination studies on the closed-flower mutant of *Vicia faba* L. Zeitschrift fuer Pflanzenzuechtung 90:106-115.

Poulsen, M.H. 1977. Obligate autogamy in *Vicia faba* L. Journal of Agricultural Science, Cambridge 88:253-256.

Physiology and Microbiology

Estimation of Leaf Area in Faba Bean Using Leaf Area to Leaf Dry Weight Ratio

M.E. Habib Ibrahim and M.C. Saxena
ICARDA,
P.O. Box 5466, Aleppo,
SYRIA

Abstract

Determination of leaf area in faba bean is time consuming because of the large number of leaves of various sizes and shapes. Therefore, a method was devised to predict the total leaf area (LE) of a plant from the total leaf dry weight (LW) and the ratio of area (A) to dry weight (W) of a sample of leaves. The LE correlated well with the measured leaf area (LA) at various stages of growth. The correlation coefficient, however, decreased at the podding stage, particularly when the estimation was made using a ratio determined from a smaller sample. Leaf sampling from specific nodes (every second or third node, depending on the treatment) was better than random leaf sampling from various nodes. To obtain a precise estimate of total leaf area per plant at podding, the size of the leaf sample should be increased from a third to a half of the total leaves, and the leaves sampled from specific nodes.

Introduction

The leaves are the main source of photosynthate in most green plants. Because of this, and its direct bearing on crop productivity, measurement of leaf area is important in evaluating crop performance. Various other leaf attributes such as dry weight, thickness, and chlorophyll content have also been used as an index of the photosynthetic capacity of green plants, but leaf area continues to be the one most widely used.

Many methods are used to measure leaf area in crops. These range from actual measurement of the area of all leaves to those methods in which an indirect estimate is made using measurements of only a small sample of the total leaves. A comprehensive review of different methods has been carried out by Marshall (1968). In many crops, measurement of total leaf area can be very laborious and time consuming because of one or more of the following reasons; very small or very large leaves or leaflets, a large number of leaves, uneven leaf surface, and rapid loss of leaf turgidity after dissecting for leaf area measurement. This has led researchers to look for methods which overcome these difficulties.

Robinson and Massengale (1967) observed that the leaf weight of alfalfa plants can be used to obtain a fair estimate of leaf area because of the close association between leaf area and weight at various stages of crop growth. Several other workers have also found a high correlation between leaf area and dry weight (Watson 1937; Rhoads and Bloodworth 1964; Ashley *et al.* 1965; Pearce *et al.* 1965; Zrust *et al.* 1974; Ase 1978).

The objective of this study was to investigate the relationship between leaf area and dry weight in faba bean (*Vicia faba* L.) and to find out whether or not this relationship can be used to estimate leaf area at different growth stages.

Materials and Methods

A large-seeded faba bean landrace (ILB 1814) from Syria was sown, using standard agronomic practices, at the ICARDA research station at Tel Hadya, Syria during the autumn season of 1981/82. The crop was sampled at the early vegetative phase, 100% flowering, and early pod-set. At each stage, 15 plants were harvested to study the relationship between leaf area and weight using two sample sizes, i.e., half or a third of the total number of leaves. These are designated later in the text as Method 1 and Method 2, respectively. Within each method, leaf sampling was done in two ways: (1) sampling specific nodes, as per sample size (every second or third node), starting from ground level, and (ii) sampling randomly from an equivalent number of nodes (half or a third) as per sample size.

Leaf area (A) and leaf dry weight (W) of the sampled leaves were measured. In addition, total leaf area (LA) and total dry weight of leaves (LW) and stem were also measured. The leaf area was measured using a LICOR leaf area meter.

Estimates of total area (LE) per plant were calculated using the equation LE=AWR X LW, where AWR is the leaf area to leaf weight ratio. AWR was calculated using the equation,

$$AWR = \frac{A}{W}$$

Simple correlation was studied among measured total leaf area (LA), estimated leaf area (LE), total leaf dry weight (LW), stem dry weight, and total plant dry weight. Stem weight included the weight of reproductive bodies when they were present.

Results

Average values for actual total leaf area (LA) and estimated total leaf area (LE) for the two sampling methods at various stages are presented in Table 1. LE was very close to LA irrespective of growth stage, sampling method, and position of the sampled node. The deviation in LE from LA, although small in both methods, was larger with sampling method 2, where only a third of the total leaves was sampled to determine AWR.

Correlations among the various characters studied are shown in Table 2. There was close association between LA and LE. Leaf area was also highly correlated with leaf weight.

When correlated separately at the three growth stages, for different sampling methods and nodal sampling positions, many correlation coefficients were significant (Table 3). However, the correlation coefficients tended to decrease at the podding stage compared to earlier stages and when the sample size was reduced from half to a third of the total leaves.

Discussion

Leaf area was highly correlated to leaf weight and total plant weight at various growth stages (Tables 2 and 3). Leaf area (cm^2), when regressed on leaf dry weight (g), resulted in the linear regression equation, Y = 186.46 + 361.08 X, where Y is leaf area and X is leaf dry weight. This accounted for about 97% of the total variance in leaf area. Such an association has already been established for several crops. The hypothesis that the leaf area of a sample of the total leaves of a faba bean plant can be used to obtain an accurate estimate of total leaf area of the plant is proved in this study because the mean LA and mean LE were very close (Table 1). Ase (1978) was able to reliably estimate the leaf area indices of winter wheat because of very high correlation between leaf area and leaf dry weight.

Although the correlation values for the various parameters were high (Table 3), they tended to decrease and, in some instances, were not significant at the podding stage when only a third of the leaves was sampled. This might be attributed to leaf senescence and associated changes in leaf thickness. Blackman (1956) suggested that, in winter wheat, the association between leaf area and leaf dry weight might change during plant growth. The trend in this

Table 1. Measured (LA) and estimated (LE) leaf area at the various stages of development in Syrian local large faba bean (ILB 1814).

Stage of crop		Method I			Method II		
		Leaf area/plant (cm^2)		LE as % of	Leaf area/plant (cm^2)		LE as % of
		LA	LE	LA	LA	LE	LA
Vegetative	S	167.87	155.99	93	145.46	154.00	106
	R	142.90	141.05	99	128.97	129.36	100
Flowering	S	527.31	531.86	101	489.79	477.51	97
	R	455.08	456.24	100	364.63	318.97	87
Podding	S	4041.27	4075.15	101	4034.96	3974.30	98
	R	3295.62	3577.52	108	3907.18	4763.94	122
Mean		1438.34	1489.63	104	1511.83	1636.35	108

S = specific nodes sampled; R = random nodes sampled

Table 2. Simple correlation coefficients among means of morphological characters in Syrian local large faba bean (ILB 1814).

	Estimated leaf area (cm^2)	Leaf weight (g)	Total plant weight (g)	Stem weight (g)
Measured leaf area, LA (cm^2)	0.991**	0.986**	0.986**	0.981**
Estimated leaf area, LE (cm^2)		0.996**	0.997**	0.995**
Leaf weight (g)			0.996**	0.993**
Total plant weight (g)			0.996**	0.993**
				0.999**

**Significant at P < 0.01

Table 3. Simple correlation for different morphological characters at the vegetative (V), flowering (F), and podding (P) stages in Syrian local large faba bean (ILB 1814).

	Measured leaf area (cm^2)		Estimated leaf area (cm^2)		Leaf weight (g)		Total plant dry weight (g)	
	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2
Measured leaf area (cm^2)								
V			0.99**	0.78**	0.95**	0.58*	0.95**	0.54*
F			0.97**	0.93**	0.93**	0.69**	0.93**	0.79**
P			0.93**	0.77**	0.86**	0.77**	0.83**	0.08
Estimated leaf area (cm^2)								
V	0.89**	0.95**			0.97**	0.41	0.97**	0.96**
F	0.98**	0.96**			0.88**	0.51	0.90**	0.66*
P	0.99**	0.61*			0.75**	0.82**	0.77**	0.40
Leaf weight (g)								
V	0.84**	0.94**	0.93**	0.81**			0.98**	0.93**
F	0.96**	0.95**	0.95**	0.95**			0.94**	0.95**
P	0.82**	0.85**	0.97**	0.77**			0.90*ⁿ	0.46
Total plant weight (g)								
V	0.82**	0.95**	0.94**	0.83**	0.98**	0.99**		
F	0.94**	0.97**	0.95**	0.97**	0.98**	0.99**		
P	0.83**	0.55*	0.79**	0.27	0.93**	0.70**		

*P < 0.05; **P < 0.01

The upper, right-hand portion of the table represents random sampling of leaves while the lower, left-hand portion represents sampling of specific nodes.

experiment indicated a rapid increase in A/W at the podding stage (352 cm^2/g) compared to the flowering and vegetative stages (213 and 212 cm^2/g, respectively). Koller (1972) studied leaf area-weight relationships in the soybean canopy and found that A/W increased rapidly during leaf abscission.

In conclusion, it was apparent that leaf area estimates could be obtained using A/W ratios. However, care should be taken to increase the number of leaves sampled at the podding stage. As the accuracy of estimated leaf area is dependent upon the accuracy of the A/W ratio, the relationship of leaf area to leaf weight in various parts of a faba bean canopy should be analyzed in the future.

References

Ase, J.L. 1978. Relationship between leaf area and dry matter in winter wheat. Agronomy Journal 70: 563-565.

Ashley, D.A., Doss, B.D. and Bennett, O.L. 1965. Relation of cotton leaf area index to plant growth and fruiting. Agronomy Journal 57:61-64.

Blackman, G.E. 1956. Influence of light and temperature on leaf growth. Pages 151-167 in The Growth of Leaves. (Milthrope, F.L. ed.). Butterworths, London, England.

Koller, M.R. 1972. Leaf area-leaf weight relationships in the soybean canopy. Crop Science 12:180-183.

Marshall, J.K. 1968. Methods for leaf area measurement of large and small leaf samples. Photosynthetica (Prague) 2:41-47.

Pearce, R.B., Brown, R.H. and Blaser, R.E. 1965. Relationships between leaf area index, light interception and net photosynthesis in orchardgrass. Crop Science 5:553-556.

Rhoads, F.M. and Bloodworth, M.E. 1964. Area measurement of cotton leaves by a dry weight method. Agronomy Journal 56:520-522.

Robinson, D.R. and Massengale, M.A. 1967. Use of area-weight relationship to estimate leaf area in alfalfa (Medicago sativa L. cultivar Moapa). Crop Science 7:394-395.

Watson, D.J. 1937. The estimation of leaf area in field crops. Journal of Agricultural Science 27:479-483.

Zrust, J.E., Partykova, J. and Necas, J. 1974. Relationships of leaf area to leaf weight and length in potato plants. Photosynthetica (Prague) 8:118-124.

Seasonal Nitrate Reductase Activity of Autumn-Sown Vicia faba

M. Andrews
Department of Plant Science,
Lincoln College,
Canterbury,
NEW ZEALAND

Abstract

Using field grown plants of autumn-sown faba bean cultivar Banner Winter the seasonal pattern of nitrate reductase activity (NRA) was assayed *in vivo* with and without added nitrate as substrate. The results suggested that the assay with added nitrate would not provide a reliable estimate of rates of nitrate uptake and/or assimilation by *Vicia faba* under field conditions. NRA without added nitrate was a better estimate of nitrate assimilation although at best it is only a qualitative measure.

Introduction

For uninoculated soybeans given nitrate under laboratory conditions, an *in vivo* + NO_3^- nitrate reductase assay (NRA + NO_3^-) for leaves could be adapted such that rates of nitrate reduction estimated from activity agreed closely with actual nitrate reduction estimated from increases in total plant nitrogen (Hatam and Hume 1976). Hatam and Hume (1976) reported that this assay can be used under field conditions to determine seasonal patterns of nitrate uptake and the amount of total plant N derived from soil nitrate in nodulated plants.

Dekhuijzen *et al.* (1981) measured NRA + NO_3^- of the youngest developing leaf of spring-sown *Vicia faba* and assumed activity was related to nitrate assimilation *in situ*. Recent work on uninoculated *V. faba* grown at 6 and 15°C under laboratory conditions indicates that this assumption is correct. Shoot (leaf and stem) NRA + NO_3^- and reduced N were closely correlated. Both parameters increased per gram fresh weight (fw) and per organ as applied nitrate concentration was increased over the range 1 - 20 mol/m^3 (Andrews *et al.* 1985; Sutherland *et al.* 1985). Although at comparable applied nitrate concentrations growth rates were substantially greater at 15°C that at 6°C, NRA + NO_3^-per g fw was substantially less,

indicating that growth temperature can be a major factor affecting shoot NRA + NO_3^-.

This report gives details of seasonal NRA, with and without added NO_3^-, in shoots and roots of autumn-sown *V. faba* and an assessment is made of the usefulness of these measurements in determining seasonal patterns of nitrate assimilation.

Materials and Methods

Plants analyzed in this experiment were obtained from the field plots described by Andrews *et al.* (1986). NRA was determined using the *in vivo* assay described previously (Andrews *et al.* 1984). Two estimates were obtained by assaying with or without added nitrate as substrate and are termed NRA + NO_3^- and NRA - NO_3^-, respectively. Tissue nitrate levels were determined in aqueous extracts using the method of Mackereth *et al.* (1976). Variability quoted in text is SD.

Fig. 1. Overwinter, spring, and summer nitrate reductase activity (NRA) in shoot (●, o) and root (■,□) of autumn sown *Vicia faba* cv Banner Winter. Closed and open symbols represent NRA + NO_3^- and NRA − NO_3^- respectively. Vertical lines indicate SD, n = 6.

Results and Discussion

In the laboratory, experimental design can ensure that almost all reduced N accumulation in *V. faba* is a result of nitrate assimilation. However, under field conditions, plants are likely to be fixing substantial amounts of atmospheric N_2 and carrying out at least some ammonium assimilation in addition to assimilating nitrate. In the experiment described by Andrews *et al.* (1986), four cultivars were given each of four N treatments. Regardless of cultivar or N treatment, nodules were absent between 15 December 1983 and 9 April 1984. Therefore, during this period, comparisons of NRA and N accumulation can be made without considering N_2 fixation. Figure 1 shows seasonal NRA of cv Banner Winter (BW) without additional nitrogen. Although activity decreased significantly between 20 December 1983 and 22 February 1984, in this case highest NRA + NO_3^- per g fw occurred during the winter. Values throughout this period were as great as for plants given 20 mol/m³ nitrate at 6°C and 8 mol/m³ nitrate at 15°C under laboratory conditions (Andrews *et al.* 1985; Sutherland *et al.* 1985). On the basis of the correlation between NRA + NO_3^- and N accumulation at 6 or 15°C in the laboratory, there should have been substantial growth of BW overwinter. However, there were no detectable increases in total plant dry weight, carbon content, or nitrogen content during this period (Andrews *et al.* 1986). Regardless of N treatment, all cultivars showed highest NRA + NO_3^-

per g fw shoot during the winter but no growth at this time. There were similar high values for NRA + NO_3^- per g fw shoot in overwintering BW, cv Herz Freya (HF), and cv Maris Beagle (MBg) in 1982/83 and also in spring-sown (April 1982 and 1983) BW, HF, and MBg before measurable increases in total plant dry weight, carbon content, or nitrogen content. High NRA + NO_3^- per g fw shoot was not associated with high concentrations of tissue nitrate. For example, on 20 December 1983, nitrate was undetectable in BW shoots, while on 22 February 1984, concentrations in BW leaves and stem were 8.2 ± 2.1 and 2.9 ± 1.4 µ mol NO_3^-/g dw, respectively, where n=6 in both cases. Such low levels associated with no growth suggest that high flux of nitrate to the shoot is not the cause of high NRA + NO_3^- (Shaner and Boyer 1976). Even if high overwinter NRA + NO_3^- per g fw shoot is a low temperature response alone, it seems highly unlikely that this assay could provide a reliable estimate of rates of nitrate uptake and/or assimilation by *V. faba* under field conditions.

NRA - NO_3^- gave substantially lower overwinter activity per g fw shoot than NRA + NO_3^- and thus was a better estimate of the rate of nitrate assimilation as indicated by N accumulation in the plants. In this case, activity increased between 20 December and 24 March, as would be expected on the basis of N accumulation. Also, throughout most of the study, activity per g fw was lower in shoots than in roots,

as is likely for BW under unfertilized conditions (Sutherland *et al.* 1985). Root NRA + NO_3^- and NRA - NO_3^- per g fw also increased between 20 December and 24 March. However, both root activities were extremely low on 20 December 1983, but were higher on 22 February 1984, when growth was undetectable. In the case of NRA - NO_3^-, this indicates the presence of nitrate in the tissue. This was shown to be the case, with levels of 40.2 ± 5.3 μ mol NO_3^-/g dw (n=6) in the roots at that time. This highlights a weakness of NRA - NO_3^- as a measure of nitrate assimilation: under conditions where nitrate is being taken up but not assimilated, activity will be measured. Conversely, if flux of nitrate to a tissue is high but little nitrate is stored, NRA - NO_3^- will indicate low rates of nitrate assimilation. This could have been the case for BW shoots in the summer when NRA + NO_3^- was substantially greater than NRA - NO_3^-. This seems unlikely, as soil nitrate levels were low and the root is likely to be the major site of nitrate assimilation (Sutherland *et al.* 1985). However, the possibility of different interpretations of NRA - NO_3^- data emphasises that even this assay is limited in its use under field conditions. At best, it can only give a qualitative measure of nitrate uptake and assimilation.

Acknowledgement

References

Andrews, M. 1986. Recent studies of nitrate assimilation in *Vicia faba* L. FABIS Newsletter 15. In press.

Andrews, M., Sutherland, J.M., Thomas, R.J. and Sprent, J.I. 1984. Distribution of nitrate reductase activity in six legumes: the importance of the stem. The New Phytologist 98:301-310.

Andrews, M., Taylor, H., McInroy, S. and Sprent, J.I. 1986. Early growth and final yield of autumn sown *Vicia faba* L. cultivars given different forms of fertilizer N overwinter. Plant and Soil. In press.

Dekhuijzen, H.M., Verkerke, D.R. and Hauwers, A. 1981. Physiological aspects of growth and development of *Vicia faba*. Pages 7-30 *in Vicia faba*: Physiology and Breeding (Thompson, R. ed.). Martinus Nijhoff, The Hague, The Netherlands.

Hatam, M. and Hume, D.J. 1976. Relations between nitrate reductase activity and nitrogen accumulation in soybeans. Canadian Journal of Plant Science 56:377-384.

Mackereth, F.J.H., Heron, J. and Talling, J.F. 1976. Water analysis: some revised methods for limnologists. Scientific Publications of the Freshwater Biological Association 27. 139 pp.

Shaner, D.L. and Boyer, J.S. 1976. Nitrate reductase activity in maize (*Zea mays* L.) leaves. II. Regulation by nitrate flux at low leaf water potential. Plant Physiology 58:505-509.

Sutherland, J.M., Andrews, M., McInroy, S. and Sprent, J.I. 1985. The distribution of nitrate assimilation between root and shoot in *Vicia faba* L. Annals of Botany 56:259-263.

Effects of Drought on Autofertility in Faba Beans

F. L. Stoddard
Agronomy Department,
Waite Agricultural Research Institute,
Glen Osmond, SA 5064, AUSTRALIA

Abstract

Autofertility was determined by examining flowers from plants enclosed in nylon net bags and grown in well irrigated and in water-stressed conditions. While autofertility showed the expected increase with time in the irrigated plots, drought considerably reduced autofertility, which decreased with time. Possible mechanisms for these differences are proposed.

Introduction

Pollination of faba beans is partly bee-mediated and partly spontaneous. When it leads to fertilization, the latter is termed autofertility (Drayner 1959) and its expression increases with plant age under normal field conditions (Hanna and Lawes 1967; Poulsen 1975; Porceddu *et al.* 1980; Stoddard 1986a). Temperature, day length, and water stress may all contribute to this change, but environmental effects on autofertility have not been extensively studied.

Lord and Heslop-Harrison (1984) postulated that water stress should impede autofertility by preventing spontaneous rupture of the stigmatic cuticle, but Stoddard (1986b) found no significant effect of water stress on overall fertilization in spring faba beans.

The effects of environment on autofertility are being investigated in the Mediterranean environment of South Australia. This paper is a preliminary account of the effects of water stress on autofertility. Water stress was achieved by growing plants during the dry summer instead of during the wet winter which is the normal practice.

Materials and Methods

Faba beans, cv Fiord, were sown on 21 January 1986 in eight 10-row plots each 5 m long, with 25 cm between rows and 10 cm between plants within rows. The entire trial was watered to field capacity on alternate days from sowing until flower buds were colored. Thereafter, only the central four rows of each plot were trickle irrigated and most of the non-irrigated border rows eventually died. Four plots were irrigated daily with 48 mm equivalent of rain and the other four with 9-12 mm daily. These irrigation levels were empirically determined as the maximum before run-off occurred or the minimum commensurate with the maintenance of plant growth. The plots were called wet and dry, respectively.

On 11 March, 1 week after the onset of flowering, two or three adjacent plants were enclosed within a nylon net bag, eight of which were used in each plot. On 19 March, 4-6 flowers which were near the end of their anthesis, were collected from each bag. At dawn on the same day, four leaves per plot were collected from the corresponding flowering node of unenclosed plants and their water status determined in a pressure bomb. A similar collection of flowers was made on 2 April.

Flowers were preserved in boiling ethanol, hydrolyzed in hot lactic acid, stained with aniline blue, and examined using epifluorescence microscopy (Stoddard 1986c). Stigmas were scored for pollen deposition, pollen germination, and pollen tube growth. An ovule was scored as fertilized when a pollen tube was seen within its micropyle. From 205 to 245 ovaries were sampled on each date from each level of irrigation.

When most of the pods were black, all of the enclosed plants were collected together with 20 unenclosed ones from each plot. Each ovule was scored as a matured seed, an aborted ovule, or an unfertilized ovule. From 739 to 872 pods were examined from each level of irrigation and enclosure. Only 405 were available from the dry, enclosed treatment.

Results were analyzed by generalized linear model-fitting (Snedecor and Cochran 1980) as adapted by Stoddard (1986c).

Results and Discussion

The number of ovules per ovary declined as flowering progressed (Table 1) and was fewer in the dry plots. Although no data were collected on flower numbers, dry plants clearly bore fewer flowers, and observations on bee activity indicated that a very high proportion of unenclosed flowers were visited by honeybees and probably pollinated.

Table 1. Basic characteristics of faba bean plants in wet and dry plots.

Variate	Water supply	Enclosed flowers			Pods Mean
		19 Mar	2 Apr	Mean	
Number of	Wet	3.16	2.99	3.07	3.09
ovules/ovary	Dry	3.08	2.83	2.97[+]	2.96[+]
	Mean	3.12 ***	2.92	3.02	3.03
Water deficit	Wet		1.9		
of leaves	Dry		5.2[++]		
(bars)	Mean		3.6		

+.++ Wet and dry significantly different at P < 0.05 and 0.01, respectively.
*** Dates significantly different at P < 0.001.

The incidences of pollination and fertilization as a consequence of autofertility increased with time in the wet plots (Table 2), as expected. Drought, however, reduced self-pollination, which declined with time. Several possible mechanisms may be involved: (1) anthers failed to dehisce as a result of the stress, making the flowers functionally male-sterile, (2) reduced water availability resulted in reduced pliability of the pollen mass so preventing its deposition, (3) the petals were too flaccid to force the pollen mass onto the stigma, or (4) a changed characteristic of the stigmatic cuticle prevented pollen retention during preparation of the flowers for microscopy.

The fertilized proportion of pollinated flowers (effectiveness of pollination) did not change significantly with time, but was lower in the dry than the wet plots. This effect of drought was probably due to an effect on the stigmatic cuticle and/or stigmatic exudate, as postulated by Lord and Heslop-Harrison (1984).

The fertilized proportion of ovules within fertilized ovaries i.e., the index of fertilization, was not significantly affected by either date or water stress but was significantly greater when plants were not enclosed. This difference was found in all three ovular positions but was significant only at ovule 3 (Fig. 1). Similarly, the number of fertilized ovules per fertilized ovary was greater in unenclosed than in enclosed pods but otherwise did not vary significantly.

At maturity, pods from the dry treatments had slightly fewer seeds than those from the wet plots, but the proportion of mature seeds was similar for both treatments (Table 3). Enclosed pods matured fewer seeds and a lower proportion of seeds than unenclosed pods, especially at the second and third ovular positions (Fig. 1). In Fiord, as in cv Deiniol but unlike cv Cockfield (Stoddard 1986b), water stress did not significantly affect abortion of fertilized ovules. In this cultivar, heterosis and any attendant autofertility are therefore unlikely to

Table 2. Pollination and fertilization in wet and dry plots.

Variate	Water supply	Enclosed flowers				Pods		
		19 Mar	2 Apr	Mean		Enclosed	Unenclosed	Mean
Incidence of	Wet	28	40	34				
pollination (%)	Dry	18 *	10	14 +++				
	Mean	23	26	24				
Effectiveness	Wet			80				
of pollination (%)	Dry			56 +				
	Mean			68				
Incidence of	Wet	21	33	27				
floral	Dry	11 *	3.9	7.8 ++				
fertilization (%)	Mean	16	20	18				
Incidence of	Wet	14	25	19				
ovular	Dry	8.1 *	2.4	5.5 ++				
fertilization (%)	Mean	11	15	12				
Index of fertilization (%)	Mean			69		77 ##	86	82
Fertilized ovules/ fertilized ovary	Mean			2.12		2.35 ##	2.60	2.50

+, ++ Wet and dry significantly different at P < 0.05 and 0.01, respectively.
##, ### Unenclosed and enclosed significantly different at P < 0.01 and 0.001, respectively.
* Irrigation x date interaction significant at P < 0.05.

Table 3. Seed development in wet and dry plots.

Variate	Water supply	Pods Enclosed		Pods Unenclosed	Mean
Number of	Wet	1.88		2.10	2.00
seeds/pod	Dry	1.76		1.86	1.83 [+]
	Mean	1.84	*	1.99	1.93
Ovules in pods forming seeds (%)	Mean	60	**	66	63
Number of abortions/pod (% of fertilized	Mean	0.51	*	0.62	0.57
ovules)	Mean				23
Number of	Wet	7.6		10.9	9.1
pods/plant	Dry	4.3		10.0	6.9 [+]
	Mean	6.0	**	10.4	8.0
Number of	Wet	14.4		22.9	18.2
seeds/plant	Dry	7.5		18.6	12.6 [+]
	Mean	11.0	**	20.8	15.4

+ Wet and dry significantly different at $P < 0.05$.
*,** Enclosed and unenclosed significantly different at $P < 0.05$ and 0.01, respectively.
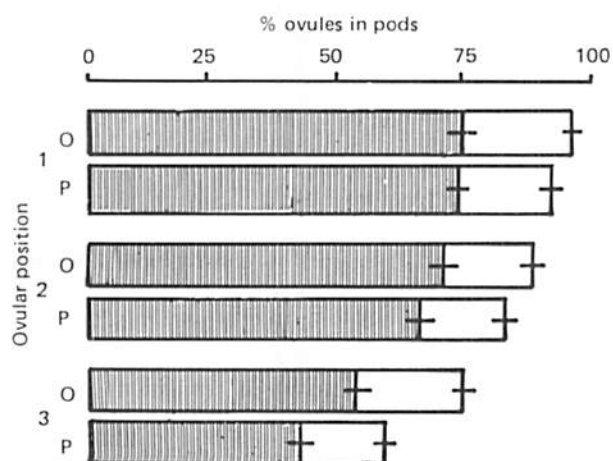
Fig. 1. Fertilization (clear) and seed maturation (shaded) in enclosed (P) and non-enclosed (O) pods of faba beans, cv Fiord. Bars represent 2 x standard error.

be maintained by abortion of inbred embryos in favor of retaining hybrid ones.

The numbers of pods per plant and seeds per plant show that the yield capacity of dry plants was slightly less than that of wet ones when not enclosed. The dry plants were very much more strongly affected by enclosure than wet ones.

Further experiments are planned to elucidate the mechanism of autofertility reduction by drought, as the results have obvious importance for regions where flowering occurs in dry weather.

References

Drayner, J.M. 1959. Self- and cross-fertility in field beans (*Vicia faba* L.). Journal of Agricultural Science, Cambridge 53:387-403.

Hanna, A.S. and Lawes, D.A. 1967. Studies on pollination and fertilization in the field bean (*Vicia faba* L.). Annals of Applied Biology 59:289-295.

Lord, E.M. and Heslop-Harrison, Y. 1984. Pollen-stigma interaction in the Leguminosae: stigma organization and the breeding system in *Vicia faba* L. Annals of Botany 54:827-836.

Porceddu, E., Monti, L., Frusciante, L. and Volpe, N. 1980. Analysis of cross-pollination in *Vicia faba* L. Zeitschrift fur Pflanzenzuchtung 84:313-322.

Poulsen, M.H. 1975. Pollination, seed setting, cross-fertilization and inbreeding in *Vicia faba* L. Zeitschrift fur Pflanzenzuchtung 74:97-118.

Snedecor, G.W. and Cochran, W.G. 1980. Statistical Methods, 7th edition. Iowa State University Press, Ames, Iowa, USA.

Stoddard, F.L. 1986a. Autofertility and bee visitation in winter and spring genotypes of faba beans (*Vicia faba* L.). Zeitschrift fur Pflanzenzuchtung. In press.

Stoddard, F.L. 1986b. Effects of irrigation, plant density and genotype on pollination, fertilization and seed development in spring field beans (*Vicia faba* L.). Journal of Agricultural Science, Cambridge. In press.

Stoddard, F.L. 1986c. Floral viability and pollen tube growth in *Vicia faba* L. Journal of Plant Physiology 123:249-262.

The Practice of Irrigating Faba Beans

C. F. Green, P. D. Hebblethwaite and Helen E. Ricketts

Department of Agriculture and Horticulture,
School of Agriculture,
University of Nottingham,
Sutton Bonington,
Loughborough, Leicestershire, LE12 5RD,
UNITED KINGDOM

Abstract

Spring-sown faba beans were grown at Sutton Bonington during two growing seasons (1983, 1984) to compare the effect of irrigation before flowering, during and after flowering, and throughout the season with a droughted (unwatered) control. Irrigation was adjusted to keep soil moisture deficits between the limiting deficit of 30 mm and field capacity. Increases in seed yield due to irrigation were directly proportional to increases in biomass production, while biomass partition was not systematically affected. Watering during and after flowering increased seed yield to levels similar to the fully irrigated treatment as the potential for overall biomass accumulation was greater at this time. Pre-floral irrigation gave modest but consistent increases in seed yield.

Introduction

Moisture stress at any ontogenetic stage during the development of faba bean crops (*Vicia faba* L.) can reduce biomass and seed yield (Talha *et al.* 1978;

Krogman *et al.* 1980; Farah 1981; Skjelvag 1981). Spring-sown cultivars are especially susceptible to soil moisture deficits as their root system is less developed than their winter-sown counterparts (Day and Legg 1983). While Karamanos (1978) established that water deficits can be a major limitation to growth, Dantuma *et al.* (1983) concluded that moisture supply imposed the main constraint to seed yield.

Krogman *et al.* (1980) demonstrated a close linear relationship between seed yield and water use. Following these observations, Hebblethwaite (1982) compiled records from various sources and, using a linear interpolation, demonstrated a yield increase of 0.66 g/m^2 for every mm of water used. However, the linear relationship between seed yield and cumulative transpiration has a positive intercept around 1 t/ha at zero water use, which makes the imposition of linearity questionable.

Influence of water stress on physiological variables

Monteith and Elston (1983) postulated that biomass accumulation was dependent on the amount of radiation absorbed, and that the value for the efficiency of conversion of radiation into biomass (ϵ) was fairly conservative. While Fasheun and Dennett (1982) found no ontogenetic change in ϵ, they found that its value varied with sowing date. Further, ϵ declines with increasing moisture limitation in both pigeon peas (Hughes and Keatinge 1983) and faba beans (Green *et al.* 1985). Green *et al.* (1985) also found that drought reduced the amount of radiation absorbed to 60-70% of an undroughted stand.

Moisture stress reduces chlorophyll content (Moursi *et al.* 1978), induces stomatal closure (Nerkar *et al.* 1981), and inhibits primary electrochemical photosynthetic reactions (Mohanty and Boyer 1976). These physiological limitations account for reduced photosynthetic efficiency.

Drought limits stem extension so reducing stem area (Tamaki and Naka 1971) and induces wilting which reduces the projected foliage area (Day and Legg 1983). Further, water stress reduces laminar area (Farah 1981; Green *et al.* 1985) by slowing the rate of leaf appearance (Farah 1981) and leaf expansion (Karamanos 1978). Drought also reduces the duration of leaf expansion (Elston *et al.* 1978). Later in the crop's ontogeny, moisture stress advances the onset of canopy senescence, increases the rate of leaf death (Finch-Savage and Elston 1982), and accelerates leaf abscision (El-Beltagy and Hall 1974).

Green *et al.* (1985) showed that the net effect of drought-imposed reductions in canopy area and t was a slower, mid-season, linear growth rate. This caused the mean crop growth rate to decline in proportion to water stress. In terms of yield components Hebblethwaite (1982) concluded that all components can be affected depending on the severity and timing of the stress.

Irrigation response

Tawadros (1981) suggests that the requirement for irrigation is maximal during flower and pod development as this is the period of maximum dry matter accumulation. Sammler *et al.* (1982) found that moisture deficits during full flowering imposed a more severe restraint on seed yield than deficits at the end of flowering, while drought during early flowering had little effect on yield due to yield component compensation. Other workers have established a particularly favorable response to irrigation during flowering (Salter and Goode 1967; Sprent *et al.* 1977).

Contrasting results from those reported above have demonstrated that there is no sensitive stage at which to irrigate (Stock 1977; Husain *et al.* 1983). Krogman *et al.* (1981) showed that both seed yield and total biomass varied with irrigation but the harvest index remained constant, which agreed with studies by Kogbe (1972). In a review, Day and Legg (1983) concluded that the majority of evidence indicated no specific stage for irrigation.

Materials and Methods

Irrigation studies were conducted on spring-sown faba beans during two growing seasons (1983 and 1984) at the School of Agriculture of the University of Nottingham. In 1983, four cultivars were sown, two of *V. faba* var *major* (Minica and Optica), one of var *minor* (Kristall), and one of var *equina* (Alfred). In 1984, only Minica was used.

All plots (2.6 m wide and 18 m long) were covered between the rows with black polythene sheeting which was fastened between plants within rows with wooden clothes pegs. This prevented precipitation water entering the plots. Under the polythene, trickle irrigation pipes traversed the rows 0.5 m apart. There were four treatments.

1. Fully irrigated: Water was applied throughout

growth to keep soil moisture levels between the 30 mm limiting deficit (Hebblethwaite 1982) and field capacity.

2. Irrigated before flowering: Water was applied before the onset of flowering but withheld during and after flowering.

3. Irrigated during and after flowering: Irrigation began at the onset of flowering and continued throughout growth.

4. Droughted: No precipitation or irrigation water.

No fertilizer was applied in either season, and *Botrytis fabae* was controlled successfully using carbendazim. Pirimicarb was applied when aphids were present.

Results and Discussion

In all cases, drought reduced seed yield to 46-77% of the fully irrigated treatment, where the level of depression depended on cultivar and season (Table 1). While irrigation before flowering had a positive influence on yield, applying water during and after flowering in many cases produced seed yields similar to the unstressed crop. However, for Minica grown during 1983, withholding water before flowering produced significantly (P $\leq$ 0.01) lower yields than when moisture levels were optimized; the treatment irrigated during and after flowering yielded 1 t/ha less than a fully irrigated stand.

Fig. 1 shows that variations in seed yield imposed by different water regimes were strongly related to the total quantity of assimilate produced, implying a constant harvest index or at least only small deviations in its value that were not systematically related to seed yield. It follows that, where water stress limits biomass accumulation, whether through reduced light absorption or conversion efficiency, irrigation increases biomass production and therefore seed yield. This response is irrespective of the ontogenetic state at watering (Fig. 1).

Many workers have attributed increases in seed yield with post-floral irrigation to increases in biomass partitioning into reproductive growth. Table 2 shows harvest indices for Minica grown in both seasons. Irrigation during and after flowering

Table 1. Seed yields (t/ha, dry matter) of faba bean crops grown under different irrigation regimes.

| Season | Cultivar | Irrigation regime | | | | | |
		Fully irrigated	Irrigated before flowering	Irrigated during and after flowering	Droughted	S.E.D.	d.f.
1983	Minica	6.22	3.44	5.21	2.86		
1983	Optica	3.28	3.11	3.70	2.52		
1983	Alfred	4.62	3.20	4.37	2.59	0.18	4
1983	Kristall	4.62	3.28	4.45	2.60		
1984	Minica	7.40	5.25	7.63	5.19	0.319	8
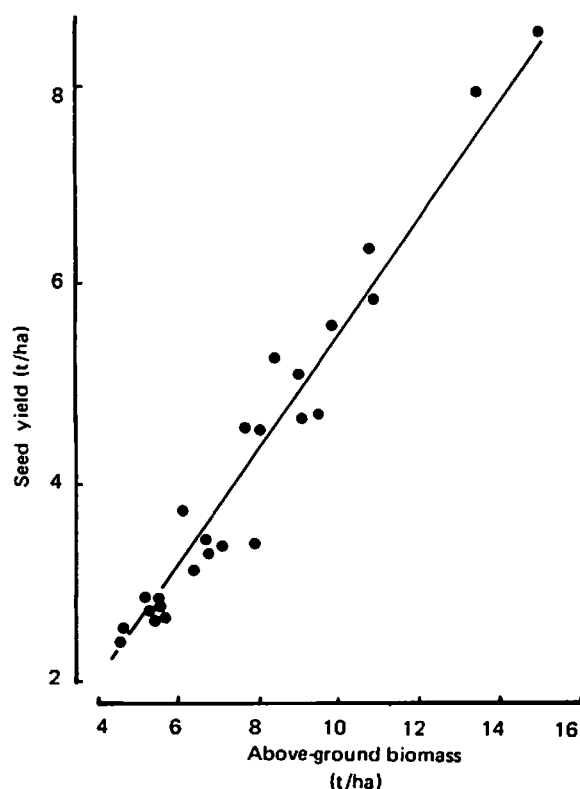
Fig. 1. Relationship between seed yield and total biomass for faba bean crops grown under different irrigation regimes during 1983 and 1984. Mean harvest index is 0.55. Observations include measurements for an untreated control.

increased the harvest index in 1983, while in 1984, treatment did not affect biomass partitioning. The increase in harvest index with post-floral watering in 1983 may have been due to plant compensation in response to a constrained yield potential (Table 1) rather than the presence of any sensitive developmental stage for water use.

The question remains concerning why flowering and pod filling periods have often been associated with critical timings for irrigation (Salter and Goode 1967; Sprent et al. 1977; Tawadros 1981; Sammler et al. 1982). While the data presented demonstrate fairly large yield increases from irrigation during and after flowering, this can be explained by considering biomass production rather than partition. There are three possibilities.

i. At the onset of flowering, there is rapid canopy expansion and commensurately greater light absorption (Green et al. 1985). The influence of drought on biomass accumulation at high levels of radiation interception i.e., during flowering and early pod filling, will be greater than at the beginning of the season when foliage areas are small.

ii. Studies on potatoes (Moorby and Milthorpe 1975), sugar beet (Green et al. 1986), and cereals (Hodges and Kanemasu 1977; Green and

Table 2. Harvest indices for *V. faba* var *major* (cv Minica) grown under different irrigation regimes during two growing seasons.

Season	Irrigation regime					
	Fully irrigated	Irrigated before flowering	Irrigated during and after flowering	Droughted	S.E.D.	d.f.
1983	0.60	0.53	0.64	0.55	0.011	4
1984	0.58	0.54	0.56	0.60	0.04	8

Vaidyanathan 1986) indicated increases in radiation conversion efficiency when sink demand is high. Further, Acock *et al.* (1985) have shown that the rate of soybean photosynthesis rose in response to the flowering stimulus. Fig. 2 shows that the efficiency of conversion of absorbed radiation into biomass ε increased at flowering for a crop of Minica grown at Sutton Bonington, to a level approximately 60% higher than that measured before flowering. It follows that reductions in ε imposed by moisture stress will be of more consequence for growth if they occur after anthesis.

iii. Greater light absorption is correlated with increased energy availability for transpiration (Monteith 1966). Thus, the likelihood of moisture deficits will increase through development, especially after flowering. Further, both the level of incident power flux and mean temperature increase during the growing season, enhancing the possibility of water stress at later developmental stages.

Table 3 shows the influence of irrigation regimes on crop height. Effects of irrigation timings on plant height were dissimilar to the influence of watering on yield and biomass production. Irrigation before flowering increased final crop height to a level similar to the fully irrigated treatment. However, the height attained by a stand irrigated during and after flowering was similar to that of the droughted stand. Tamaki and Naka (1971) have shown that moisture stress decreases stem extension. The data presented in Table 3 suggest that this depends on the timing of stress, the sensitive phase being before flowering.

Much of the past work on scheduling irrigation with regard to stage of development has indicated
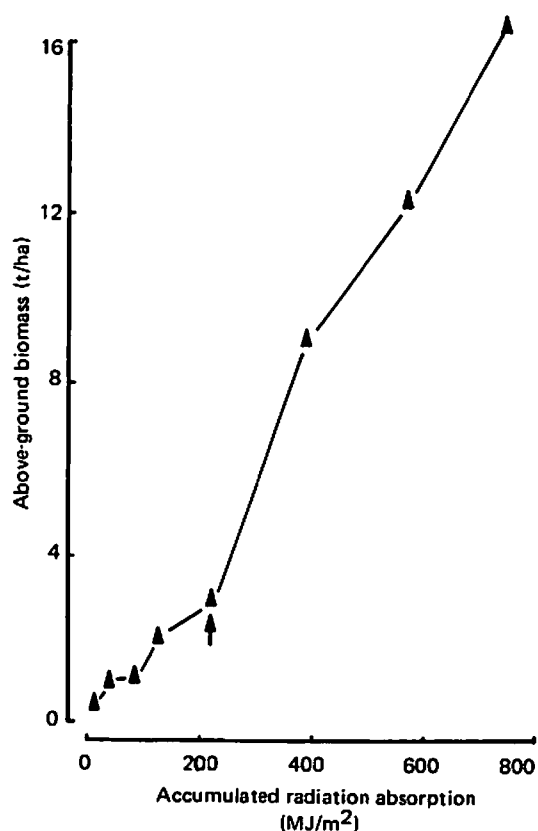
Fig. 2. Dependence of dry matter production on the absorption of solar radiation in *Vicia faba major* cv Minica. The arrow marks the onset of flowering.

that the flowering and pod filling stages are particularly sensitive to moisture stress. The rational behind this is that watering during reproductive growth favors assimilate partitioning to the developing pods and may therefore increase assimilate partitioning in favor of seeds.

Ostensibly, the data presented here support the practice of post-anthesis irrigation. However, the

Table 3. Plant height (mm) for faba bean crops grown under different irrigation regimes.

Season	Cultivar	Irrigation regime				S.E.D.	d.f.
		Fully irrigated	Irrigated before flowering	Irrigated during and after flowering	Droughted		
1983	Minica	108	108	75	73		
1983	Optica	99	100	81	78		
1983	Alfred	145	135	104	101	2.4	4
1983	Kristall	151	149	118	116		
1984	Minica	116	115	98	88	12.7	8

mechanism behind yield increases is overall biomass production, with little influence of irrigation scheduling on partition (Fig. 1). During and after flowering, canopy area and thus light absorption are relatively large. Further, the onset of flowering provides a photosynthetic stimulus which increases the light conversion efficiency (Fig. 2). It follows that any moisture limitation after the beginning of flowering is more likely to reduce assimilation and thus seed yield. This effect is enhanced by the influence of increased accumulated transpiration leading to an increased likelihood of limiting soil moisture deficits later during the growing season i.e, during flowering and pod fill.

In conclusion, scheduling of irrigation should be determined by the attainment of limiting soil moisture deficits particular to the soil type under consideration (Hebblethwaite 1982; Day and Legg 1983) rather than with regard to the crop's developmental stage. However, when considering the culture of long-stemmed cultivars, alleviation of pre-anthesis soil moisture deficits may induce maximum crop height and increase the risk of lodging.

References

Acock, B., Reddy, V.R., Hodges, H.F., Baker, D.N. and McKinnon, J.M. 1985. Photosynthetic response of soybean canopies to full-season carbon dioxide enrichment. Agronomy Journal 77:942-947.

Dantuma, G., von Kittlitz, E., Frauen, M. and Bond, D.A. 1983. Yield, yield stability and measurements of morphological and phenological characters of faba bean (Vicia faba L.) varieties grown in a wide range of environments in Western Europe. Results of the EC joint faba bean trials. Zeitschrift fur Pflanzenzuchtung 90:85-105.

Day, W. and Legg, B.J. 1983. Water relations and irrigation response. Pages 217-232 in The Faba Bean: A Basis for Improvement. (Hebblethwaite, P.D. ed.). Butterworths, London, England.

El-Beltagy, A.D. and Hall, M.A. 1974. Effect of water stress upon endogenous ethylene levels in Vicia faba. New Phytologist 73:47-59.

Elston, J., Karamanos, A.J., Kassam, A.H. and Wadsworth, R.M. 1978. The water relations of the field bean crop. Philosophical Transactions of the Royal Society of London B 273:581-591.

Farah, S.M. 1981. An examination of the effects of water stress on leaf growth of crops of field beans (Vicia faba L.). 1. Crop growth and yield. Journal of Agricultural Science, Cambridge 96:327-336.

Fasheun, A. and Dennett, M.D. 1982. Interception of radiation and growth efficiency in field beans. Agricultural Meteorology 26:221-224.

Finch-Savage, W.E. and Elston, J. 1982. The effect of temperature and water stress on the timing of leaf death in Vicia faba. Annals of Applied Biology 100:567-579.

Green, C.F., Hebblethwaite, P.D. and Ison, D.A. 1985. A quantitative analysis of varietal and moisture status effects on the growth of *Vicia faba* in relation to radiation absorption. Annals of Applied Biology 106:143-155.

Green, C.F. and Vaidyanathan, L.V. 1986. A reappraisal of biomass accumulation by temperate cereal crops. Speculations in Science and Technology. In press.

Green, C.F., Vaidyanathan, L.V. and Ivins, J.D. 1986. The growth of sugar beet crops including the influence of synthetic plant growth regulators. Journal of Agricultural Science, Cambridge. In press.

Hebblethwaite, P.D. 1982. The effects of water stress on the growth, development and yield of *Vicia faba* L. Pages 165-175 *in* Faba Bean Improvement. (Hawtin, G. and Webb, C. eds). Martinus Nijhoff, The Hague, The Netherlands.

Hodges, T. and Kanemasu, E.T. 1977. Modelling daily dry matter production in winter wheat. Agronomy Journal 69:974-978.

Hughes, G. and Keatinge, J.D.H. 1983. Solar radiation interception, dry matter production and yield in pigeon pea (*Cajanus cajan* (L.) Millspaugh). Field Crops Research 6:171-178.

Husain, M.M., Gallagher, J.N., Hill, G.D. and Othman, M. 1983. The non-existence of moisture sensitive phases in *Vicia faba* L. grown under irrigation in Canterbury. Proceedings of the Agronomy Society of New Zealand 13:82-94.

Karamanos, A.J. 1978. Water stress and leaf growth in field beans (*Vicia faba* L.) in the field: leaf number and total leaf area. Annals of Botany 42:1393-1402.

Kogbe, J.O.S. 1972. Factors influencing yield variation of field beans (*Vicia faba* L.). Ph.D. thesis, University of Nottingham, Nottingham, England.

Krogman, K.K., McKenzie, R.C. and Hobbs, E.H. 1980. Response of faba bean yield, protein production and water use to irrigation. Canadian Journal of Plant Sciences 60:91-96.

Mohanty, P. and Boyer, J.S. 1976. Chloroplast response to low leaf water potentials. IV. Quantum yield is reduced. Plant Physiology 57:704-709.

Monteith, J.L. 1966. The photosynthesis and transpiration of crops. Experimental Agriculture 2:1-14.

Monteith, J.L. and Elston, J. 1983. Performance and productivity of foliage in the field. Pages 449-518 *in* The Growth and Functioning of Leaves. (Dale, J.E. and Milthorpe, F.L. eds). Cambridge University Press, London, UK.

Moorby, J. and Milthorpe, F.L. 1975. Potato. *In* Crop Physiology, Some Case Histories. (Evans, L.T. ed.). Cambridge University Press, London, UK.

Moursi, M.A., El-Habbasha, K.M. and Shaheen, A.M. 1978. Photosynthetic efficiency, water and nitrogen contents of *Vicia faba* plant as influenced by water deficit. Egyptian Journal of Agronomy 1:223-246.

Nerkar, Y.S., Wilson, D. and Lawes, D.A. 1981. Genetic variation in stomatal characteristics and behaviour, water use and growth in five *Vicia faba* L. genotypes under contrasting soil moisture regimes. Euphytica 30:335-345.

Salter, P.J. and Goode, J.F. 1967. Crop responses to water at different stages of growth. Commonwealth Bureau of Horticulture, East Malling, Research Review No. 2.

Sammler, P., Egel, G., Schmidt, A. and Bergman, H. 1982. The influence of water stress on reproductive development and the abcission of reproductive organs in *Vicia faba* L. Archiv fur Acker- und Pflanzenbau und Bodenkunde 26:227-236.

Sprent, J.I., Bradford, A.M. and Norton, C. 1977. Seasonal growth patterns in field beans (*Vicia faba*) as affected by population density, shading and its relationship with soil moisture. Journal of Agricultural Science, Cambridge 88: 293-301.

Skjelvag, A.O. 1981. Effects of climatic factors on the growth and development of field bean (*Vicia faba* L. var minor). III. Yield and its components. Acta Agriculturae Scandinavica 31:382-394.

Stock, H.G. 1977. Preliminary results obtained from studies into temporally differentiated, water supply to field bean and its effects in terms of yield formation. Tagungsbericht der deutschen Akademie der landwirtschaftlichen Wissenschaft, Berlin 158 S:229-241.

Talha, M., Hamdi, H. and Semaik, M. 1978. Evapotranspiration and yield of onion and beans as affected by soil texture and available soil moisture depletion. Egyptian Journal of Soil Science 18:1-10.

Tamaki, K. and Naka, J. 1971. Physiological studies of the growing process of broad bean plants. III. Effects of soil moisture on the growth and the various chemical components in the various organs. Technical Bulletin of the Faculty of Agriculture, Kagawa University 22:73-82.

Tawadros, H.W. 1981. Response of faba beans to soil water regime. FABIS Newsletter 3:38.

Agronomy and Mechanization

Effect of Phosphorus Application and Time of Harvest on the Seed Yield and Quality of Faba Bean

Farouk A. Salih[1] and Abdalla El Mubarak Ali[2]

1. Shambat Research Station,
   P.O. Box 30, Khartoum North,
   SUDAN
2. Food Research Centre,
   Shambat, Khartoum North,
   SUDAN

Abstract

The effect of harvest date and phosphorus application on faba bean (cv BF 2/2) grain yield and seed quality was studied in the 1985/86 season. The optimum time to harvest for maximum yield is about 100 days from sowing. Delaying harvest to 110 and 120 days from sowing resulted in a 6.8 and 16.8% reduction in grain yield, respectively. Phosphorus fertilization had no significant effect on grain yield, but it significantly increased (P=0.01) 1000-seed weight. A high percentage of hard seeds (non-soaker) is the major factor limiting the quality of seed for human consumption. Generally, the hard seed percentage decreased with delay in harvest. Phosphorus application increased the percentage of non-soakers, but not significantly. This also applied to the percentages of total defects, hydration coefficient, and cookability.

Introduction

Faba beans are grown as a winter crop on smallholdings along the Nile and in the Northern Region of Sudan. They are an important cash crop in the area and the major grain legume in the Sudan. Farmers tend to harvest the crop before full maturity to benefit from the relatively high prices at a time when supplies are short. Harvesting the crop at full maturity might result in increased yield and better seed quality.

Rowland (1978) reported that swathing faba beans could be safely carried out at 99 days from planting, when 30% of the plants in a plot had the lowest pods blackened. At this point, yield, seed protein content, and 1000-seed weight were stabilized. Swathing before or after this point would affect seed quality.

Ageeb (1980) and Salih (1983) reported that the optimum time to harvest for maximum grain yield is 110 - 120 days after sowing. Delaying harvest to 130 and 140 days after sowing could result in appreciable losses in grain yield. This is due to pod shattering which is estimated to be about 10%.

Salih (1979), studied the effects on faba bean yield of different application rates of nitrogen and phosphorus when broadcast, banded, or placed in holes with the seed, either separately or in combination at Hudeiba Research Station. The results showed that none of the treatments or methods of application had an effect on seed yield or any of the yield components.

Ibrahim and Ali (1984) found that phosphorus application increased faba bean seed yield at two sites at Aliab and at all the sites at Zeidab, but not significantly. Increasing the phosphorus application rate produced seeds with high 1000-seed weight, having a higher percentage of non-soakers and total defects.

In Sudan, faba bean is primarily grown for human consumption, so the incidence of hard seed not only reduces germination but also adversely affects cooking quality and, therefore, the market price of the product. Hard seededness is a type of seed dormancy resulting from an impermeable seed coat. Seed coat impermeability is most widespread in the Leguminosae and a comprehensive review of the literature on this subject has been published by Barton (1965). The present work studied the effects of phosphorus fertilization and time of harvest on faba bean grain yield and quality.

Materials and Methods

Faba bean variety BF 2/2 was planted by hand on 27 October 1985 at Shambat Research Farm. Seeds were planted 20 cm apart with two seeds per hole (33.3 plants/m^2) on both sides of a ridge. Ridges were 60

cm apart. The crop was grown under furrow irrigation, the trial receiving 10 irrigations at 10 - 12 day intervals. Treatments were arranged in a split plot design with three replicates, phosphorus fertilizer as the main treatment and time of harvesting as sub-plots.

The crop was fertilized with three levels of superphosphate (0, 43, and 86 kg P_2O_5/ha) at sowing and nitrogen was applied as urea at 43 kg N/ha as a basal treatment to all treatment combinations at sowing. Harvesting was at 90, 100, 110, and 120 days after sowing.

Total seed yield was recorded for each plot. Pods per plant and seeds per pod were determined from 20 randomly selected plants per plot. The seed quality characteristics studied were:

Physical quality of the seed

For each treatment, 1000 seeds (in triplicate) were selected at random and weighed before and after soaking for 16 hrs at ambient temperature. The hydration coefficient (H.C.) was calculated from the equation,

$$H.C.(\%) = \frac{\text{Weight of soaked beans} \times 100}{\text{Initial weight}}$$

The percentage of total defects including unimbibed, under-sized, and insect-damaged seeds was recorded.

Cooking quality

Seeds were soaked, drained, blanched in boiling water for 6 minutes, packed with brine (2%) into cans, and shaken for 60 minutes at 110°C. The increase in weight after processing (I.W.P.) was determined 7 days later using the equation,

$$I.W.P.(\%) = \frac{\text{(Drain weight - Filling weight)} \times 100}{\text{Filling weight}}$$

Results and Discussion

Grain yield was increased significantly (P=0.01) by delaying harvest from 90 to 120 days from sowing (Table 1). The highest grain yield/ha was obtained from 100-day old plants, which was not significantly (P=0.01) different from the yield at 110 days. There was a gradual decline in yield between harvesting at 100 and 120 days after sowing. The grain yield of 100 day old plants was greater than the yield at 120, 110, and 90 days after sowing by 16.8, 6.8, and 74.2%, respectively. The yield at 110 days after sowing exceeded the yield at 120 and 90 days by 9.4 and 63.1%, respectively. Harvesting at 120 days resulted in a seed yield 49% greater than that obtained at 90 days.

There were no significant differences between harvesting dates for number of plants/m² (Table 1). However, differences between harvesting dates for

Table 1. Mean effect of plant age at harvesting and phosphorus fertilizer rates on faba bean seed yield, yield components, and seed quality.

		Seed yield (kg/ha)	No. of plants/m²	No. of pods/ plant	No. of seeds/ pod	Non-soaker (%)	Total defects (%)	Hydration coefficient (%)	I.W.P. (%)
Plant age at	90	1389	25.2	15.6	2.21	53.01	72.55	202.6	46.83
harvesting	100	2420	26.0	17.0	2.28	24.93	49.87	192.8	53.82
(days)	110	2266	22.3	20.4	2.56	17.52	37.49	199.5	52.76
	120	2071	24.0	23.2	2.64	14.37	37.08	202.8	57.61
S.E. (±)		94	1.72	1.02	0.06	1.35	1.87	1.63	0.86
Phosphorus	0	1941	24.5	18.6	2.46	26.50	44.88	204.9	52.59
fertilizer	43	2017	24.4	19.8	2.52	25.85	48.57	196.8	54.26
rates (kg/ha)	86	2152	24.4	18.8	2.47	30.03	54.29	196.6	51.42
S.E. (±)		41	0.84	0.69	0.06	1.17	1.62	1.41	0.75

number of seeds per pod were highly significant (P=0.01). The number of seeds per pod increased as harvesting date increased from 90 to 120 days from sowing (Table 1).

The number of pods per plant increased significantly (P=0.01) as harvest was delayed from 90 to 120 days after sowing. Plants at 120 days had 48.7 and 36.5% more pods than 90- and 100-day old plants (Table 1).

No significant effect was detected on seed yield/ha, number of plants/m^2, number of pods/plant, or number of seeds per pod due to phosphorus application. However, both 43 and 86 kg P$_2$O$_5$/ha increased seed yield by 11 and 4%, respectively over the control (Table 1).

Salih (1981) studied the effect of different nitrogen and phosphorus application rates on faba bean when applied separately or in combination at Shambat. None of the treatments had an effect on seed yield. However, 1000-seed weight was increased significantly (P=0.01) and progressively with increasing phosphorus (Table 2).

Seed size, as indicated by 1000-seed weight, was very small when the plants were harvested at 90 days old (Table 2). There was a significant (P=0.01) increase in seed size when harvest was delayed from 90 to 100 days after sowing, followed by a slight gradual increase between 100 and 120 days from sowing. The largest seed size was obtained when the plants were 120 days old. The interaction between

phosphorus levels and plant age for 1000-seed weight was highly significant (Table 2). For each harvesting age, there was a gradual increase in seed weight with increasing phosphorus rate.

The hard seed percentage increased significantly (P=0.05) with increasing levels of phosphorus (Table 1). Hard seed percentages decreased progressively from 90 to 120 days from sowing and the differences between the different harvest dates were highly significant. These results are in agreement with those obtained by El Bagoury and Niyazi (1975) in Egyptian clover (*Trifolium alexandrinum*), and Ageeb (1980) and Salih (1983) in faba bean. El Bagoury (1975) found the reverse in faba beans in which the hard seed percentages increased markedly with maturity. Baciu Mielans (1970) showed that the incidence of hard seededness was correlated with air humidity and this in turn caused increased or decreased hard seed percentage during development.

The effect of phosphorus application and stage of harvesting on the percentage of total defects, hydration coefficient, and increase in weight after cooking was similar to that on hard seededness (Table 1). Ibrahim and Ali (1984) reported that phosphorus application at Aliab, Zeidab, and Hudeiba might have given a positive effect if the land preparation had been better and the sites selected were deficient in available soil phosphorus.

Our investigation clearly showed that the time of harvest is very critical for faba beans. Cultivar BF 2/2 matures 110 days after sowing and must be harvested within 10 days from this period otherwise a certain percentage of the crop will be lost through shattering.

Where farmers harvest their crop before full maturity to get a better price, yield losses amounting to 50% or more may result if harvesting is 10 to 20 days earlier than full maturity. The losses in yield may not be offset by the increased price the farmer gets by harvesting before full maturity. In addition, the hard seed percentage will be high before the plants reach full maturity.

Table 2. Mean effects of plant age at harvesting and phosphorus fertilizer rates on 1000-seed weight (g) of faba bean.

Plant age at harvesting (days)	Phosphorus rates (kg/ha)			Mean
	0	43	86	
90	266.7	(±3.55) 258.7	289.3	(±2.05) 271.5
100	345.0	352.7	356.0	351.2
110	346.7	357.3	364.0	356.0
120	346.0	362.7	372.7	360.4
Mean	326.1	(±1.77) 332.8	345.5	334.8

References

Ageeb, O.A.A. 1980. Effect of harvest on the grain yield and percentage of hard seed of broad beans. FABIS Newsletter 2:38-39.

Baciu Mielans, D. 1970. Contribution to the study of

hard seed and coat properties of soya bean. Proceedings of the International Seed Testing Association 35:599-617.

Barton, L.V. 1965. Dormancy in seeds imposed by the seed coat. Pages 727-745 in Encyclopaedia of Plant Physiology XV (2) (Ruhland, W. ed.). Springer-Verlag, Berlin.

El Bagoury, O.H. 1975. Effect of different fertilizers on the germination and hard seed percentage of broad bean seeds (Vicia faba). Seed Science and Technology 3:569-574.

El Bagoury, O.H. and Niyazi, M.A. 1973. Effect of different fertilizers on the germination and hard seed percentage of Egyptian clover seeds (Trifolium alexandrinum L.). Seed Science and Technology 1:773-779.

Ibrahim, H.S. and Ali, A. El M. 1984. Effect of phosphorus application on the yield, phosphorus up-take and quality of faba bean. The Fifth Annual Coordination Meeting, ICARDA/IFAD Nile Valley Project. Cairo, 13-17 September 1984. ICARDA, Aleppo, Syria.

Rowland, G.G. 1978. Effects of planting and swathing dates on yield, quality and other characters of faba beans (Vicia faba) in Central Saskatchewan. Canadian Journal of Plant Science 58:1-11.

Salih, F.A. 1979. Effect of different nitrogen and phosphorus fertilizer levels and different methods of application on faba bean yield and its components. Annual Report, Hudeiba Research Station, Hudeiba, Sudan.

Salih, F.A. 1981. Effect of nitrogen and phosphorus on the yield of faba bean. Annual Report, Shambat Research Station, Shambat, Sudan.

Salih, F.A. 1983. Broad bean (Vicia faba L.) grain yield and percentage of hard seed as affected by time of harvest. Zeitschrift fur Acker und Pflanzenbau 152:394-398.

Effect of Several Growth Regulators on Growth, Lodging, and Yield of Faba Bean (Vicia faba minor)

J. Bochniarz, S. Kukula and M. Pleskacz
Institute of Soil Science and Plant Cultivation,
Pulawy,
POLAND

Abstract

Field experiments with faba bean cultivar Nadwislanski were conducted at Pulawy during 1977-84. Four growth regulators were applied at the beginning of flowering to study their effect on growth, lodging, and yield. Alar 85 at 0.25-16.0 kg/ha and Antywylegacz (CCC) at 2-16 kg/ha did not alter plant growth. Antyrost (MH-30) at 5-15 kg/ha damaged the crop while at 0.05-0.2 kg/ha it had no effect on plant growth but decreased seed yield. Camposan (Etafon) at 0.25-2 l/ha did not affect the plants but at the higher rates of 4 or 8 l/ha, inhibited growth and decreased seed yield. None of the chemicals at any application rate caused clear effects on plant development and 1000-seed weight.

Introduction

In Poland, faba beans are mainly grown on soils with high moisture. In such conditions, the plants often grow too tall, which results in increased lodging, harvesting problems, and reduced yield. When faba beans become overgrown this can limit and sometimes prevent insect and disease control with spraying equipment during the growing season. Spraying when the plants are 130-200 cm tall causes high yield losses. An undesirable feature of faba bean is a long vegetation season of 130-180 days. Removal of the tops of plants increases lodging resistance and forces maturity but significantly reduces seed yield. Therefore, this practice cannot be recommended (Bochniarz and Pleskacz 1986).

To shorten the stem and make it stiff, the lodging protector CCC has been used with good effect in wheat (Gorecki 1976) and some grasses (Bochniarz et al. 1983). Alar has been similarily used in red clover (Fojtik et al. 1976), Ethrel in rye and winter barley (Gorecki 1976), and Antyrost in lawngrasses (Gorecki 1976).

Some evidence suggests an increase in seed yield and protein content of faba bean with the use of

Table 1. Effect of growth regulators on faba bean height and lodging.

Treatments	Application rates (kg/ha)	Height (cm)					Lodging (1-9 scale)*				
		1977	1978	1979	1980	1981	1977	1978	1979	1980	1981
Control		136	135	93	141	127	5.7	7.3	8.5	4.5	7.0
Alar 85	0.25			100	135				8.4	4.0	
	0.5			94	130	124			7.9	4.1	7.5
	1.0			92	131	128			8.4	2.7	7.0
	2.0		100	94	128	135		7.2	8.4	2.4	7.0
	4.0	133	100		127	135	3.8	7.0		2.2	7.0
	8.0		93		119	129		7.7		2.6	7.0
	16.0					135					7.0
Antyrost	0.05		137					6.2			
(MH-30)	0.1		136	100				8.3	8.0		
	0.2		130	98				7.7	8.7		
Antywylegacz	2	150		92	139	133	5.3		8.5	5.7	7.5
(97% CCC)	4	145		105	137	135	4.0		8.2	5.0	7.0
	6		139	109	139			6.3	7.2	4.4	
	8	144		95	141	137	2.7		8.4	5.1	7.5
	10		135	111	138			6.7	8.2	5.4	
	12				132					6.1	
	14		125					8.7			
	16					137					6.0
Camposan	0.25		138					8.0			
(35% Etefon)	0.5		131	95	143			5.7	7.7	6.0	
	1.0		141	101	142			6.7	8.1	6.3	
	2.0	135		86	138		7.7		8.5	5.4	
	4.0	121			134		6.7			5.9	
	8.0	106					6.0				
LSD (P=0.05)		18.3	23.6	23.8	19.2	14.0	4.24	NS	NS	3.19	NS

*1 = more than 75% lodged, 9 = no lodging.
NS = not significant

biostimulators (Sawsan and El Hyatemy 1984). The aim of our experiments was to investigate the effect of growth regulators on growth, lodging, and yield of faba beans.

Materials and Methods

The experiments were carried out during 1977-81 at Pulawy on alluvial soils. Faba bean cultivar Nadwislanski was grown in 10 m² plots with 30 cm row spacing and 33-40 plants/m², as recommended by the Institute of Soil Science and Plant Cultivation. Plots were replicated 3-4 times. The following growth regulators were used.

1. Alar 85 (85% daminazide), also called B-9 or B-995, from Uniroyal, USA.

2. Antyrost (30% hydrazide of maleic acid), produced in Poland. Also on the market under the name Malzid 30 in East Germany and MH-30 in West Germany.

Table 2. Effect of growth regulators on faba bean yield and 1000-seed weight.

Treatments	Application rates (kg/ha)	Seed yield (t/ha)					1000-seed weight (g)				
		1977	1978	1979	1980	1981	1977	1978	1979	1980	1981
Control		6.05	3.62	4.46	2.87	3.80	506	476	481	540	429
Alar 85	0.25			4.77	1.77				488	550	
	0.5			4.00	1.99	3.77			499	524	459
	1.0			5.00	1.73	4.14			495	518	441
	2.0		3.30	4.68	1.53	4.28		474	498	509	437
	4.0	5.43	3.10		1.63	3.75	482	489		521	431
	8.0		2.92		1.26	4.39		515		505	457
	16.0					4.62					442
Antyrost (MH-30)	0.05		3.79					468			
	0.1		4.06	4.21				480	461		
	0.2		3.66	3.39				491	499		
Antywylegacz (97% CCC)	2	5.83		4.29	2.33	4.48	487		474	550	436
	4	5.45		4.43	2.34	4.90	488		498	531	457
	6		3.83	5.09	2.29			479	489	550	
	8	5.98		4.00	2.35	4.36	495		468	540	441
	10		3.97	4.74	2.22			495	486	534	
	12				2.15					536	
	14		3.56					483			
	16					4.11					436
Camposan (35% Etefon)	0.25		3.60					483			
	0.5		3.76	4.31	2.58			484	478	536	
	1.0		3.87	4.39	2.25			490	476	513	
	2.0	5.14		4.14	2.50		487		462	522	
	4.0	4.33			2.32		474			502	
	8.0	3.01					441				
LSD (P=0.05)		1.014	0.103	NS	1.059	NS	42.0	NS	NS	46.0	NS

*1 = more than 75% lodged, 9 = no lodging.
NS = not significant

3. Antywylegacz (97% chlorocholin chloride-CCC), produced in Poland, Cycocel from West Germany, and Retacel from Czechoslovakia.

4. Camposan (35% ethephon) from East Germany, which is also available as Flordimex TH and Ethrel in USA.

The chemicals were initially applied at the rates recommended for other crops but rates were later altered according to the data from our own experiments. Application rates are shown in Tables 1 and 2. Chemicals were applied as aqueous solutions at 400 l/ha, usually at the beginning of flowering and at the 3-4 leaf stage. Plant growth, development, and lodging were observed during growth. Measurement of plant height and determination of seed yield were done at harvest. The results were statistically analyzed.

Results and Discussion

In 1978 and 1980, Alar 85 significantly decreased plant growth. In the other years, there were no pronounced differences in plant growth between

treatments (Table 1). However, Alar 85 decreased lodging resistance and reduced seed yield (Table 2). In similar experiments in -Great Britain (McEwen 1970), B-9 applied at a rate of 3.8 kg a.i./ha at the four-leaf stage increased seed yield by 400 kg/ha in the first year but decreased seed yield by 240 kg/ha the following year. In the third year, the chemical was applied three times: 14 May (four-leaf stage), 17 June, and 3 July. As a result, the stems were shorter by 30% but lodging resistance was decreased. The number of podded stems increased from 32.9 to $42.5/m^2$ and the number of seeds increased from 1154 to $1280/m^2$. There was a decrease in 1000-seed weight from 301 to 280 g and yield was increased by 113 kg/ha. B-9 applied at a rate of 0.48 kg a.i./ha at the four-leaf stage did not cause any stem changes, but when applied 23 or 50 days later, the stems were shorter by 1 and 13 cm, respectively (control 120 cm). When the chemical was applied at 1.9 and 3.8 kg a.i./ha on the first two dates (four-leaf stage and 23 days later) the stems were shorter by 14 and 21 cm and by 16 and 32 cm. In a field experiment in Czechoslovakia (Hajek and Rozosova), Alar applied at 4 kg/ha in two stages--green bud and at the beginning of flowering (about 10% plants flowering)--did not affect plant development. However, the plants were a little shorter and, as in England (McEwen 1970), the plants were less resistant to lodging and had lower yields than the control.

Antyrost (MH-30) applied at 5, 10, and 15 kg/ha damaged faba beans, which is less than the recommended rate (Gorecki 1976) for killing grasses. However, when applied at 0.05, 0.1, and 0.2 kg/ha it had no effect on faba bean growth and development (Tables 1 and 2).

In our experiments, Antywylegacz (CCC) did not alter faba bean growth or yield (Tables 1 and 2). In a pot experiment by Herzog (1979), application of CCC at different concentrations and times (1-3 leaf stages) to two faba bean cultivars inhibited seedling growth but increased dry matter, first leaf area, and cold tolerance. However, in a 1 year field experiment conducted in England (McEwen 1970) with CCC applied at 5.6 kg a.i./ha at the four-leaf stage and with four rates of nitrogen application, there were no changes in plant growth, apart from decreased seed yield.

Camposan (Ethephon) applied at 0.25-2 l/ha did not alter faba bean plants but at 4 and 8 l/ha stems were shortened and seed yield reduced. (Tables 1 and 2).

None of the chemicals applied at any rate had a significant effect on plant development or 1000-seed weight.

References

Bochniarz, J., Bochniarz, M. and Telec, L. 1983. Wplyw CCC na cztery gatunki traw uprawiane na nasiona. Zesz. probl. PNR, No 282, s. 111-121.

Bochniarz, J. and Pleskacz, M. 1986. Wplyw oglawiania roslin na wyleganie, dojrzewanie i plonowanie bobiku. Pam. pul. In press.

Fojtik, A., Svetlik, V. and Haslbachova, H. 1976. Vliv Alaru a B-nine na morfologicke znaky a semenerskou vynosnost tetraploidniho jetele lucniho (Trifolium pratense L.) Rostlinna vyroba (Praha), 1976, 22 (7), s.701-708.

Gorecki, K. 1976. Regulatory wzrostu roslin w ksiazce "Pestycydy", PWRiL, Warszawa, s.176-293.

Hajek, D. and Rozosova, V. Studium vlivu rustuvych regulatoru Atoniku a Alaru 85 na morfologickie a vynosotvorne prvky u bobu (Vicia faba L.) Rostlinna vyroba, 27 (L.IV), c.2, s.113-120.

Herzog, H. 1979. Wachstumsverhalten und Kaltetoleranz bei Ackerbohnen (Vicia faba L.) unter verschiedenen Testbedingungen. III. Verhaltenssteuerung durch Waschstumsregulatoren. Zeitschrift fuer Acker - und Pflanzenbau 148: 72-82.

Kellerhals, M. and Keller, E.R. 1984. Effect of plant growth regulator combinations on fruit abscission in Vicia faba L. FABIS Newsletter 10:8-10.

McEwen, J. 1970. Fertilizer nitrogen and growth regulators for field beans (Vicia faba L.). II. Journal of Agricultural Science, Cambridge 74:67-72.

Sawsan A. A. and El Hyatemy, Y. 1984. Effect of using some chemicals as biostimulants on the growth and yield of faba bean. FABIS Newsletter 10:6-8.

Effect of Cotyledon Removal on Growth and Response of Faba Bean to Phosphorus and Zinc Application

N.P. Singh[1] and M.C. Saxena[2]

1. G.B. Pant University of Agriculture and Technology, Pantnagar,
INDIA
2. ICARDA,
P.O. Box 5466, Aleppo,
SYRIA

Abstract

The response of a local large-seeded faba bean landrace to application of phosphorus (as triple superphosphate) and zinc (as zinc sulphate) was evaluated with and without the removal of the cotyledons from 10-day old seedlings before transplanting in pots containing phosphorus-deficient Luvisol. Removal of cotyledons caused variation in the P and Zn supply to the seedlings and so increased plant response to the application of these nutrients as fertilizer. However, cotyledon removal depressed crop growth which was not alleviated by higher P and Zn application rates.

Introduction

Dicotyledonous plants, particularly food legumes, maintain large organic and inorganic nutrient reserves in their cotyledons. These reserves are used during germination and early seedling growth. Removal of the cotyledons should modify nutrient availability to the developing seedling and result in a change in the plant response to applied minerals in a medium marginally deficient in these nutrients. This was studied in relation to phosphorus and zinc supply in a soil with low levels of available phosphorus and zinc using a large-seeded faba bean genotype. In earlier studies, this genotype responded less to phosphorus application on a P-deficient soil than small-seeded food legumes such as chickpea and lentils.

Materials and Methods

Two sets of experiments were carried out simultaneously in pots in a greenhouse. Seeds of faba bean cultivar ILC 1814 were inoculated with a suitable strain of *Rhizobium leguminosarum* and sown in trays on 1 April 1985. Four uniform seedlings were transplanted per pot (8 kg soil) on 15 April 1985. In one set, the cotyledons were removed with a sharp knife before transplanting and a drop of fungicide solution placed on the cut surface. The seedlings in the other set had intact cotyledons. In both sets, three levels of P (0, 24, and 48 kg P_2O_5/ha) and two levels of Zn (0 and 5 kg Zn/ha) were applied with five replications. The P and Zn, as triple superphosphate (TSP) and zinc sulphate, respectively, were mixed in 2/3 top soil in pots. Nitrogen was also applied uniformly at 30 kg N/ha in all the treatments. The experimental soil contained 2.54 ppm available P, 1.50 ppm available Zn, and 0.28 ms/cm salts and had pH 8.5. Sufficient demineralized water was applied at regular intervals. All plants were harvested close to the soil surface 50 days after transplanting. Data were recorded on dry matter accumulation in leaf, stem, and root 50 days after transplanting, and plant height, number of branches, and nodes per plant at 30 and 50 days after transplanting. P concentration was determined in leaf and stem at 50 days after transplanting.

Results

Response of seedlings with intact cotyledons

Application of P caused significant differences only in dry matter accumulation in leaf and whole plant (leaf + stem) and P concentration in leaf and stem. Other growth parameters were unaffected (Table 1). There was significant improvement in leaf dry matter accumulation by plants treated with 48 kg P_2O_5/ha over the control, and in total dry matter accumulation with 24 and 48 kg P_2O_5/ha over the control. Application of 48 kg P_2O_5/ha significantly increased P concentration in the leaf over the control, and over the control and 24 kg P_2O_5/ha in the stem.

Zn application significantly reduced the number of nodes/plant at 30 days after transplanting and P concentration in the leaf. Other characters remained unaffected by Zn application.

Response of seedlings with cotyledons removed

P application at 48 kg P_2O_5/ha significantly increased the number of nodes/plant over the control at both stages (Table 2). There was a significant

improvement over the control in dry matter accumulation in leaf, stem, and whole plant, and P concentration in the stem with applications of 24 and 48 kg P_2O_5/ha. The difference between the first two treatments (24 and 48 kg P_2O_5/ha) was not significant.

Application of 5 kg Zn/ha resulted in a significant improvement in plant height at 50 days after transplanting, and in dry matter accumulation in stem, whole plant, and root compared to the control (no Zn).

Discussion

In both experiments, P application improved various growth characters even up to 48 kg P_2O_5/ha, whereas the effect of Zn application was small. The experimental soil was deficient in P while Zn availability was nearly sufficient, which may explain the observed response of faba bean to application of P and Zn. Similar results have also been reported by Shalaby and Mohamed (1978), Saxena (1979), Hamissa (1980), and El-Sheikh (1981).

There were marked differences in growth parameters depending upon whether the cotyledons were intact or removed. Plants developing from seedlings with cotyledons intact grew more than those from seedlings whose cotyledons were removed (Fig. 1). On average, the seedlings with intact cotyledons resulted in 272% higher dry matter accumulation in the whole plant compared to those with cotyledons removed. Removal of cotyledons also resulted in a lowering of the P concentration in leaf and stem (Tables 1 and 2).

Response to P and Zn application was different in the two experiments. The number of nodes/plant increased significantly with the application of 48 kg P_2O_5/ha over the control in plants with cotyledons removed, whereas in those with cotyledons intact, there was no such difference. Similarly, application of 24 and 48 kg P_2O_5/ha resulted in significantly higher dry matter accumulation in leaf, stem, and whole plant over the control in plants with cotyledons removed, whereas in plants with cotyledons intact such effects were observed only for the whole plant. There was also a significant improvement in dry matter accumulation in stem, whole plant, and root with 5 kg Zn/ha over the control (no Zn) in plants with cotyledons removed, but there was no such difference in plants with cotyledons intact.

Table 1. Effect of P and Zn application on the growth parameters and P content (dry weight basis) of faba bean plants with intact cotyledons.

Treatment	Plant height (cm)		No. of branches/plant		No. of nodes/plant		Dry weight (g)/plant 50 DAT			Root dry weight (g)/plant 50 DAT	P content (%) 50 DAT	
	30 DAT	50 DAT	30 DAT	50 DAT	30 DAT	50 DAT	Leaf	Stem	Total		Leaf	Stem
P Level (kg P_2O_5/ha)												
0	42.6	52.6	1.9	3.2	19.4	27.8	1.80	1.90	3.70	2.83	0.1069	0.0758
24	44.8	55.3	1.9	3.0	20.5	28.8	2.00	2.19	4.19	2.82	0.1138	0.0860
48	43.6	54.3	2.0	3.4	20.9	30.7	2.19	2.16	4.35	3.11	0.1208	0.1011
SE ±	0.61	1.06	0.14	0.15	0.70	1.16	0.083	0.120	0.157	0.176	0.0024	0.0033
Zn Level (kg/ha)												
0	43.2	54.0	1.9	3.3	21.1	29.7	2.05	2.13	4.18	2.83	0.1192	0.0895
5	44.2	54.1	2.0	3.1	19.4	28.5	1.92	2.03	3.95	3.01	0.1084	0.0858
SE ±	0.50	0.86	0.11	0.12	0.57	0.05	0.068	0.098	0.128	0.144	0.0020	0.0027

DAT = Days after transplanting

Table 2. Effect of P and Zn application on the growth parameters and P content (dry weight basis) of faba bean plants with cotyledons removed.

| Treatment	Plant height (cm)		No.of branches/plant		No.of nodes/plant		Dry weight (g)/plant 50 DAT			Root dry weight (g)/plant 50 DAT	P content (%) 50 DAT	
	30 DAT	50 DAT	30 DAT	50 DAT	30 DAT	50 DAT	Leaf	Stem	Total		Leaf	Stem
P Level (kg P_2O_5/ha)												
0	27.4	30.6	1.0	1.7	10.9	13.6	0.50	0.40	0.90	0.87	0.0914	0.0603
24	28.3	34.0	1.1	1.6	11.4	14.6	0.66	0.50	1.16	1.13	0.0983	0.0755
48	28.2	33.8	1.0	1.2	11.6	15.6	0.72	0.50	1.22	1.04	0.1040	0.0758
SE ±	1.09	1.37	0.04	0.14	0.18	0.46	0.028	0.029	0.042	0.101	0.0031	0.0034
Zn Level (kg Zn/ha)												
0	27.39	30.93	1.7	1.48	11.10	14.28	0.603	0.404	1.001	0.848	0.0958	0.0670
5	28.58	34.65	1.01	1.50	11.50	14.90	0.650	0.526	1.177	1.181	0.0999	0.0740
SE ±	0.89	1.12	0.03	0.11	0.15	0.37	0.023	0.024	0.034	0.082	0.0025	0.0028

DAT = Days after transplanting
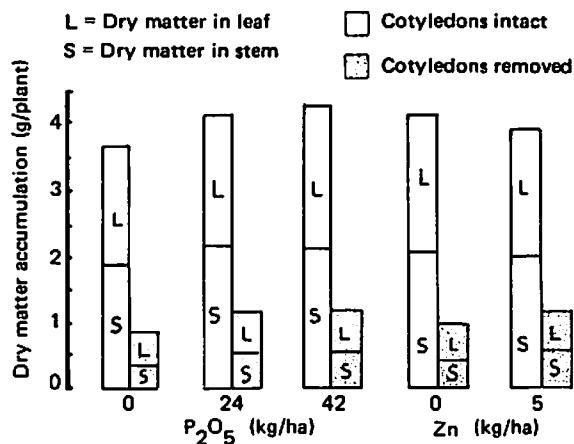
Fig. 1. Dry matter accumulation in plant parts of faba bean ILB 1814, 50 days after transplanting as influenced by P and Zn application and removal of cotyledons.

These results suggest that plants from seedlings whose cotyledons were removed were more responsive to application of the two test nutrients. However, the harmful effect of cotyledon removal could not be completely removed by increased nutrient supply. This means that the cotyledons have a metabolic function in plant growth that goes well beyond the supply of essential inorganic nutrients. It may well be a combination of nutritional and hormonal effects and should be further investigated.

Acknowledgement

References

El-Sheikh, M.H. 1981. Studies on faba bean. Effect of major cultural practices and micro elements on faba bean. Thesis, University of Alexandria, Egypt.

Hamissa, M.R. 1980. Response of faba beans (*Vicia faba*) to N, P, and K. FABIS Newsletter 2:40.

Saxena, M.C. 1979. Importance of phosphorus in balanced fertilization of some food crops in Western Asia and North Africa. Phosphorus in Agriculture No. 76:133-145.

Shalaby, Y.Y. and Mohamed, L.K. 1978. Variation in growth analysis of field beans due to plant density and phosphate fertilization at different planting dates. Egyptian Journal of Agronomy 3(1):1-11.

Effects of Plant Density on Vicia faba L. equina and Vicia faba L. minor in a Semi-Arid Environment in Southern Italy

Luigi Stringi, Riccardo Sarno, Gaetano Amato, and Lucio Gristina

Istituto di Agronomia Generale e Coltivazioni Erbacee, Universita' di Palermo,
viale delle Scienze,
90128 Palermo, ITALY

Abstract

Two trials were carried out to evaluate the effects of faba bean plant density in a semi-arid environment in southern Italy. Two varieties were used; Gemini 1 and Vesuvio. Grain yield increased up to a density of 30 plants/m^2. Further increases in density did not increase yield, due to competition. Seed yield/plant decreased as density increased up to 50 plants/m^2 and the number of seeds and pods/plant decreased as density increased to 45 plants/m^2. There was an increase in the height of the lowest podded node as density increased to 100 plants/m^2 and an increase in plant height and lodging with density. Also, ripening was 5-7 days earlier at the higher density.

Introduction

In Italy, the area cultivated with faba beans has decreased from 480000 ha in 1947 to 135000 ha in 1985. Most of this area is now concentrated in the marginal, semi-arid areas of the south and insular regions. In these regions, local races are traditionally grown at low plant densities (8-15 plants/m^2) and cultivation is labor intensive. Therefore, grain yields are poor, profits are low, and production is variable. However, the crop is important in these regions so it is necessary to improve the existing varieties and cultivation methods.

One of the basic aspects of cultivation is plant density which is highly dependent on the environment. Experimental results from different cultivation systems on response to row spacing and plant distribution are highly variable. For example, the best yields were obtained with 17 plants/m^2 in Iraq (El-Zahab *et al.* 1981), 75 plants/m^2 in Yugoslavia (Silc 1973), and 85-93 plants/m^2 in southern Slovakia (Repka *et al.* 1974). Comarovschi (1974) in Romania and Christensen (1974) in Denmark obtained highest yields with 40 seeds/m^2. Some recent data from ICARDA (1985) suggest an optimum plant population of 25 plants/m^2 in Lebanon and 33 plants/m^2 in Morocco. Finally, in the central regions of Italy, high plant densities (80-85 plants/m^2) gave the best results (Bonari and Macchia 1975; Bianchi 1979).

The objective of this study was to evaluate the effects of faba bean plant density in a typical semi-arid environment of southern Italy. The study is part of a research program which aims to encourage the cultivation of faba beans in Italy.

Materials and Methods

Two trials were carried out in 1982/83 and 1983/84 on adjacent plots at Pietranera research farm in Agrigento's province of Sicily where the soils are clay.

In one trial *Vicia faba equina* cv Gemini 1 (1000-seed weight 1073 g) was used and in the other *V. faba minor* cv Vesuvio (1000-seed weight 290 g). For each variety, 20 plant densities were grown (5-100 germinable seeds/m in increments of 5) in a randomized complete block design. Seeds were sown on 11 and 16 January 1983 with a row spacing of 70 cm.

During the trial period, the average annual rainfall was 504 mm, with 56 rainy days between October and March. The dry season started in April and lasted for 6 months. During the wet season, the monthly average temperatures were 9.4 - 18.8°C and during the dry season, 13.8 - 26.1°C.

The statistical analysis was conducted separately for the two varieties and the two years. For the more important parameters, a combined analysis of the results was done and the responses of the two types compared.

Results and Discussion

Analysis of the data confirmed that it is possible to modify some phenological traits and the yielding capacity of the two varieties by varying plant density. These modifications were positive up to a density above which competition has a negative effect.
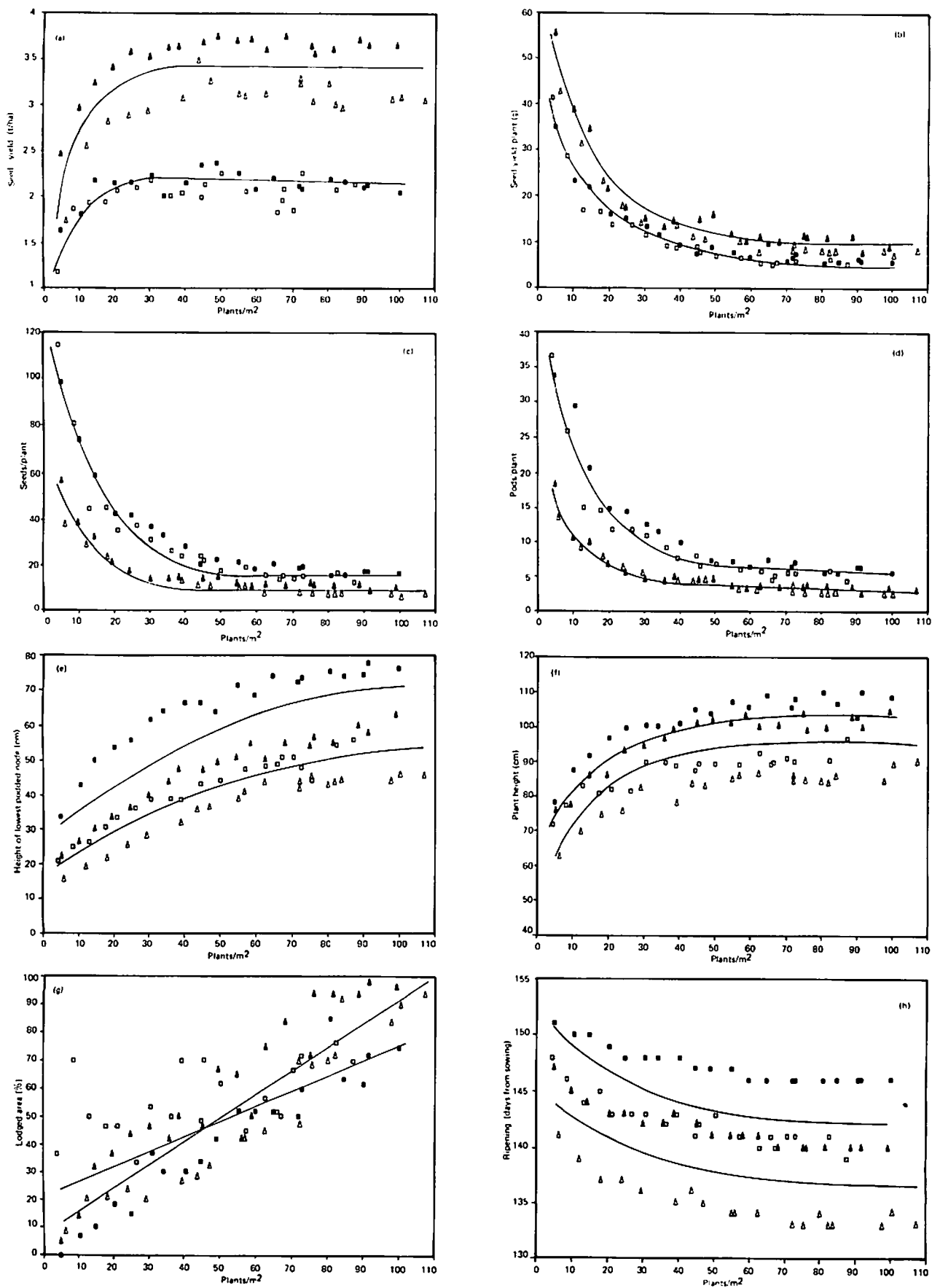
Fig. 1. Effect of plant density. *Vicia faba* L. *equina* cv Gemini 1 △ 1982/83, ▲ 1983/84; *V. faba* L. *minor* cv Vesuvio □ 1982/83, ■ 1983/84.

For both varieties, the grain yield increased up to a density of 30 plants/m^2 (on average, about 2.2 t/ha for cv Vesuvio and 3.3 t/ha for cv Gemini 1). Further increases in density produced no significant variation (Fig. 1a).

The seed yield/plant decreased as density increased up to 50 plants/m^2 (Fig. 1b). However, the increase in number of plants/m^2 increased yield only when the seed yield/plant was not less than 10 g; a greater number of plants at higher densities cannot compensate for the negative effects of competition.

There was a gradual decrease in the number of seeds and pods/plant as the plant density increased up to 45 plants/m^2 (Figs. 1c and 1d). Therefore, the best yields would be obtained from plants with no less than 30 and 15 seeds and 8 and 5 pods, for Vesuvio and Gemini 1, respectively, i.e., plant density must not exceed 30 plants/m^2.

Modifications have been observed in the height of the lowest podded node, and hence in the location of the yielding area along the stem (Fig. 1e). This was more evident on cv Vesuvio, which in the 2-year trial showed a progressive increase in the height of the lowest podded node up to 70 cm as plant density increased to 100 plants/m^2. However, at 30 plants/m^2, the average height of the lowest podded node was 45 cm for cv Vesuvio and 35 cm for cv Gemini 1. With this density, therefore, a distance was obtained between the ground and the first podded node which was considerably greater than that obtained with the traditional density of 8-15 plants/m^2. With mechanical harvesting, this density could permit a slight reduction in seed losses.

The increase in plant density also caused an increase in plant height (Fig. 1f) which could increase straw yield.

The increase in plant density also caused an increase in the lodged area; it was about 30% at 30 plants/m^2 and about 90% at 100 plants/m^2 (Fig. 1g).

Plant density also had a significant effect on the length of the growth cycle. Ripening was reached 5 - 7 days earlier at the higher plant density (100 plants/m^2) compared with the lower plant density of 5 plants/m^2 (Fig. 1h). This earliness could be determinant in a semi-arid environment because of the possibility of reducing or overcoming the negative effect of one of the more restricting factors, i.e.,

the early sudden spring aridity, often aggravated by "scirocco" wind.

Finally, the variation in plant density did not affect the protein or ash contents of the seeds.

Conclusions

The data show how, in this particular semi-arid environment, the effects of plant density on faba bean grain yield are exploitable up to 30 plants/m^2.

The dominant role of the environment was displayed by the response of the two varieties (*V. faba* L. *minor* cv Vesuvio and *V. faba* L. *equina* cv Gemini 1) which, though substantially different in morphology and biology, provided similar results. This showed that they cannot tolerate competition at densities higher than 30 plants/m^2.

The strong yield restriction at densities higher than 30 plants/m^2, was due to a soil water shortage at the stage when the plants demand more water. This illustrates the problem of faba bean cultivation as a rainfed crop in a semi-arid environment. The solution of this problem would be the development of more appropriate techniques of dry farming and identification of drought resistant genotypes.

References

Bianchi, A.A. 1979. Results of three years of experimental trials on the culture techniques of the horsebean for seeding (*Vicia faba minor* Beck). 2. Plant densities and distance between the rows. Rivista di Agronomia 13:201-206.

Bonari, E. and Macchia, M. 1975. Effect of plant density on yield and yield components of *Vicia faba* L. *minor* (Peterm.) Beck. Rivista di Agronomia 9(4):416-423.

Christensen, S.P.L. 1974. Various seed rates and row spacings for field beans and inter-row cultivation in field bean. Tidsskrift for Planteavl 78:379-388.

Comarovschi, G. 1974. Effect of sowing method on yield of bean. Abstract 944 *in* Field Crop Abstracts 32.

El-Zahab, A.A.A., Al-Babawy, A.A. and El-Latif, K.A. 1981. Density studies on faba bean (*Vicia faba* L.). 1. Seed yield and its components. Mesopotamia Journal of Agriculture 16:49-66.

ICARDA 1985. International Nursery Report No.7 Food Legume Nurseries 1982/83, 307-308.

Repka, J., Kostrej, A. and Rapi, J. 1974. Analysis of the production process of cultivated plants under the condition of southern Slovakia. 4. Effect of plant density on production properties and yield of horse beans. Pol'nohospodarstvo 20:436-443.

Silc, J. 1973. The effect of plant density on seed yield in field beans. Savremena Poljoprivreda 21:43-52.

Performance of Combining Pea (Pisum sativum L.) and Faba Bean (Vicia faba L.) Varieties under Irish Conditions

N. Dempsey and E. J. Walsh
Department of Agriculture,
University College Dublin,
Lyons, Newcastle,
Co. Dublin, IRELAND

Abstract

To assess the production capabilities and agronomic defects of combining peas and faba beans under Irish conditions, a field trial involving six diverse pea varieties, three early maturing University College Dublin-bred faba bean lines, and a commercially available faba bean variety was carried out in 1984. The mean yields of peas and faba beans, 5.35 and 5.74 t/ha, respectively, were not significantly different. In addition, the best varieties within each species were equally high yielding. The superiority of peas, in terms of early maturity, was clearly demonstrated but the inferior standing ability of peas at maturity, which was responsible for the placement of pods close to the ground, was considered to be more likely to cause harvesting problems than the somewhat later harvest date in faba beans. It was concluded that early maturing faba beans, such as the UCD-bred lines, would be more suitable than combining peas for cultivation under Irish conditions.

Introduction

With the introduction, in recent years, of financial support by the EEC for production and utilization of pulse crops, notably combining peas and faba beans, there has been considerable interest in these crops among Irish farmers as alternatives to traditional crop enterprises such as cereals. To date, the introduction of these incentives has had limited impact on pulse crop area and, although the combining pea area has expanded from less than 50 ha to an estimated 1,500 ha per annum, faba bean production in Ireland remains negligible.

Large-scale adoption of either crop is unlikely until growers are provided with information on production capabilities and agronomic defects. So far, this information has not been forthcoming; in particular, the relative merits of the two species when grown under Irish conditions have not been reported.

Few direct comparisons of combining peas and faba beans have been made, but data on average yields in the UK indicate that combining pea yields were, on average, 10% higher than faba bean yields during 1974-81. However, the average faba bean yield was exceedingly low in 1976 and, since then, the difference has been marginal (Johnson 1981; Hebblethwaite 1984; Gane *et al.* 1984). Results of the joint faba bean and pea trials conducted at eight locations in Great Britain, The Netherlands, Germany, France, and Austria during 1980-82 with eight faba bean varieties and three pea varieties showed that there is little difference between peas and faba beans in yielding ability (Ebmeyer 1984).

Barry and Storey (1977; 1979) investigated prospects for faba bean production in Ireland and identified late maturity as a major deterrent to commercial production. Since then, progress has been made in the development of earlier maturing varieties. In the faba bean breeding program of the University College Dublin (UCD), one cycle of mass selection for earliness in a population derived from European accessions reduced days to maturity by 6 days without any detectable reduction in yielding ability (Aylmer and Walsh 1979). Grogan (1983) found that, after three cycles of selection, the population was 8-10 days earlier than the original population and that this earliness was combined with a high yield potential.

Materials and Methods

Six commercially available pea varieties which included a number of contrasting seed and canopy

types, one commercially available faba bean variety, and three open pollinated faba bean lines from the UCD breeding program were grown in a replicated field trial at the University farm, Lyons, in 1984. The UCD-bred faba bean lines were derived from a population produced through three cycles of recurrent selection for early maturity under Irish conditions. A randomized complete block design was used with four replications. Faba bean plots consisted of 10 rows, while pea plots consisted of 12 rows. In both instances, rows were 2.5 m long and 20 cm apart. Data were recorded on the central eight rows in each plot, excluding 0.25 m at both ends of each row. An additional five discard rows of peas were inserted between contiguous faba bean and pea plots. Fertilizer (500 kg/ha, 0N:7P:30K) and a carbofuran pesticide (Yaltox at 30 kg/ha) were incorporated during seedbed preparation. Seed was sown by hand on 8-9 March at spacings consistent with laboratory germination data and plant density recommendations (PGRO 1984). A herbicide (1.25 l/ha Opogard, a.i. terbutryne and terbuthylazine) was applied pre-emergence. At maturity, pods were harvested by hand, artificially dried, then threshed. The following variables were recorded in each plot: (i) days to start of flowering; (ii) days to maturity, i.e., when 95% of pods were ripe; (iii) pod placement, i.e., the height interval within which 90% of pods were found at maturity; and (iv) seed yield, corrected to 20% moisture content.

Results and Discussion

The superiority of peas in terms of earlier maturity, was confirmed. The 12 day difference in days to maturity between the two species was highly significant (P<0.01) and although the statistical analysis indicated significant variation among faba bean varieties for days to maturity, the earliest maturing faba bean, FB-6, ripened significantly later than even the latest ripening pea entry, Progreta. This difference is, however, of doubtful agronomic significance.

The earliness in peas was due to a shorter reproductive phase, which was 21 days less than in faba beans. This more than compensated for the fact that peas began flowering some 9 days later than faba beans. It was encouraging to note the early maturity of the UCD-bred faba beans (FB-6, FB-12, and FB-13) relative to that of the commercial variety (Maris Bead), which was the result of a shorter vegetative phase rather than a shorter reproductive phase.

In general, peas were grossly inferior to faba beans in terms of standing ability and adaptation to combine harvesting. Lodging did not occur in any of the faba bean plots. The two conventional leaf pea varieties (Birte and Bohatyr) lodged during flowering and the normal-stipuled leafless varieties (Sentinel and Consort) and the tare-leaved variety (Progreta) lodged shortly afterwards. Amongst the pea entries, the small-stipuled leafless variety (Filby) had the best standing ability although even it was inferior to each of the faba bean entries. These differences in standing ability were reflected in the data on pod placement (Table 1). However, one pea variety (Bohatyr) lodged at an early stage but recovered exceptionally well so that at harvest time it carried the bulk of its pods 10-50 cm above the surface of the soil.

The mean yields of peas and faba beans were not significantly different, but highly significant (P<0.01) yield differences were apparent within each species. In the pea group, the small-stipuled leafless variety (Filby) was lower yielding than each of the other pea varieties, while the tare-leaved variety (Progreta) was higher yielding than all other varieties, with the exception of Birte, a conventional leaf variety. Yields of the normal-stipuled, leafless varieties were intermediate between those of the other two leaf types (Table 1). Within the faba bean group, the significant variation among varieties indicated by the analysis was entirely due to the yield superiority of FB-6, FB-12, and FB-13 over Maris Bead. The UCD-bred entries did not differ from each other in terms of seed yield per plot and were equivalent to the highest yielding pea variety, Progreta.

Acknowledgements

References

Aylmer, J.M. and Walsh, E.J. 1979. An evaluation of two approaches to breeding for earliness in field beans (Vicia faba L.). Irish Journal of Agricultural Research 18:253-261.

Barry, P. and Storey, T.S. 1977. A preliminary

Table 1. Days to start of flowering, days to maturity, pod placement, and seed yield of six pea and four faba bean varieties at Lyons in 1984.

Species and variety	Description	Days to start of flowering	Days to maturity	Pod place-ment (cm)	Seed yield (g/plot)
Pea					
Birte	Conventional leaf type	91	140	0-10	1543
Bohatyr	Conventional leaf type	91	141	10-50	1408
Progreta	Tare leaf type	92	142	5-20	1626
Sentinel	Normal stipule leafless type	88	140	7-30	1225
Consort	Normal stipule leafless type	90	141	5-25	1326
Filby	Small stipule leafless type	93	141	5-50	1083
Mean		91	141		1369
Faba bean					
FB-6	Lines produced through three	80	150	20-80	1512
FB-12	cycles of mass selection for	80	152	20-80	1600
FB-13	early maturity	80	152	20-80	1514
Maris Bead		88	159	20-80	1219
Mean		82	153		1461

investigation into the production of field beans (*Vicia faba* L.) in Ireland. Irish Journal of Agricultural Research 16:163-167.

Barry, P. and Storey, T.S. 1979. Influence of some cultural practices on the yield, development and quality of field beans (*Vicia faba* L.). Irish Journal of Agricultural Research. 18:77-78.

Ebmeyer, E. 1984. Results of the joint faba bean and pea trials of the years 1980-1982, Pages 169-177 *in Vicia faba*: Agronomy, Physiology and Breeding (Hebblethwaite, P.D., Dawkins, T.C.K., Heath, M.C. and Lockwood, G. eds). Commission of the European Communities, Luxembourg.

Gane, A.J., Biddle, A.J., Knott, C.M. and Eagle, D.J. 1984. Pea growing handbook. Fifth edition. Processors and Growers Research Organisation, Peterborough, England.

Grogan, D. 1983. Character association in a field bean (*Vicia faba* L.) population selected for earliness. MAgr. Sci. thesis, University College Dublin, Eire.

Hebblethwaite, P.D. 1984. Faba bean research in Europe. Pages 312-322 *in Vicia faba*: Agronomy, Physiology, and Breeding. (Hebblethwaite, P.D., Dawkins, T.C.K., Heath, M.C. and Lockwood, G. eds). Commission of the European Communities, Luxembourg.

Johnson, G. 1981. The bean bounces back. Farmers Weekly 18 (95), iii.

PGRO (Processors and Growers Research Organisation) 1984. The PGRO list of recommended varieties of combining peas, 1984. Advisory Leaflet, 7. Processors and Growers Research Organisation, Peterborough, England.

Pests and Diseases

Occurrence of Ascochyta Blight of Faba Bean in Egypt

S.A.M. Omar
Plant Pathology Institute,
Agricultural Research Center,
Giza, EGYPT

Abstract

During the 1985/86 growing season, ascochyta blight of faba bean was detected for the first time at Nubaria Research Station. The disease was observed on imported accessions, while the neighboring local lines were free from the disease. A survey showed no ascochyta blight in other cultivated faba bean regions. The causal organism was identified as *Ascochyta fabae* Speg. and symptoms and cultural characteristics of the isolate were described.

Introduction

Ascochyta fabae is found throughout the world (Hewett 1973). The disease attacks leaves, stems, pods, and seeds. Wet weather and low temperatures enhance disease development. The pathogen is spread mainly through seed, although infected crop debris may also be an important means of carryover (Yu 1947). The impact of the disease on yields varies, and sometimes a whole crop may be lost (Hewett 1973). Resistant cultivars have been reported and although control with fungicides is encouraging, clean seed is considered the only sure method of control (Bernier *et al.* 1984).

Materials and Methods

Isolation and Identification

Diseased leaves were collected from Nubaria Research Station farm. Samples were washed thoroughly with sterile distilled water then surface sterilized with sodium hypochlorite (3%) for 2 min. and dried between filter paper. Pieces of leaf were placed on potato dextrose agar (PDA) in petri dishes and incubated at 20 $\pm$2°C for 7 days. Spores were picked from the growing colonies and transferred to PDA slants. The fungus was identified as *Ascochyta fabae* Speg. by Dr R. A. Samson of Centraalbureau voor Schimmelcultures, Baarn, The Netherlands.

Cultural characteristics

Fungal growth was described visually and pycnidia and spores were measured microscopically using a calibrated micrometer eyepiece.

Sporulation of the fungus

Discs of *A. fabae* (5 mm diameter) were taken from 7-day old culture and placed on PDA, faba bean-dextrose agar (FDA), leaves sucrose agar (LSA), and Last and Hamley (medium - x 1956) media. Sporulation was graded visually using density of sporulation as follows: nil (0), few (+), moderate (++), and dense (+++).

Results and Discussion

Disease syndrome

Ascochyta leaf spot was observed on some accessions in the Nubaria region during December 1985 - January 1986. Spots were more or less circular (5-20 mm diameter) and some spots coalesced forming irregular shapes. The lesions were slightly sunken, brown in color with a definite dark chocolate brown margin. Some lesions collapsed. Black pycnidia (moderate to abundant) were clearly seen in the centers of lesions (Fig. 1). A few small, elongated spots with poor pycnidia were observed on the stems but there was no infection on the pods.

Cultural characteristics

Mycelial growth of *A. fabae* on PDA was white and light grey with scattered brownish pycnidia (150 - 220 μ).

The hyaline conidia mainly had one septum, a few had two septae, but conidia with three septae were rarely observed. Conidia measured 14-21 x 2.9-5.4 μ (Fig. 2).
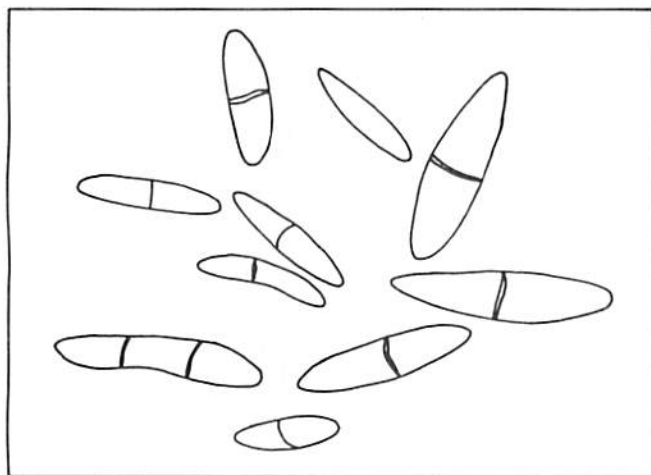
Fig. 1. Leaf lesion of *Ascochyta fabae.*

Fig. 2. *Ascochyta fabae* conidia.

Sporulation

There was abundant and rapid sporulation on medium - x, followed by FDA, LDA, and PDA (Table 1).

The occurrence of ascochyta blight in the Nubaria region confirms that the region is ideal for screening faba bean lines for foliar diseases. The disease was limited to imported accessions and did not occur on adjacent local varieties, suggesting that the source of infection may be the seed. The observed resistance of the local lines might be due to a low level of ascochyta inoculum and/or genetic resistance.

As there may be build up of ascochyta potential in the following seasons, external and internal quarantine and further studies are being done by legume disease pathologists in Egypt.

Table 1. Sporulation of *Ascochyta fabae* on four media.

Medium	Degree of sporulation
Last and Hamley (medium - X)	+ + +
Faba bean-dextrose agar	+ +
Leaf sucrose agar	+ +
Potato dextrose agar	+

References

Bernier, C. C., Hanounik, S. B. and Mohamed, H. A. 1984. Field Manual of Common Faba Bean Diseases in the Nile Valley. Information Bulletin No. 3. ICARDA, Aleppo, Syria.

Hewett, P.D. 1973. The field behaviour of seed-borne *Ascochyta fabae* and disease control in field beans. Annals of Applied Biology 74:287-295.

Last, F.T. and Hamley, R.E. 1956. A local lesion technique for measuring the infectivity of conidia of *Botrytis fabae* Sard. Annals of Applied Biology 44:410-418.

Yu, T.F. 1947. Ascochyta blight and leaf and pod spot of broad bean in China. Phytopathology 37:207-214.

Faba Bean Diseases in China

Liang Xun Yi
Zhejian Academy of Agricultural Sciences,
Hangzhou,
CHINA

Abstract

Faba beans are extensively cultivated in China and are one of the country's principal legume crops. Diseases have become one of the important factors affecting faba bean production; 12 fungal, 1 bacterial, and 11 viral diseases were recorded during 1922-79. In the south of China, where the crop is autumn-sown, chocolate spot and ascochyta blight were prevalent and severe, while in the northwest where

the crop is sown in spring, rust was predominant. In recent years, there have been reports of considerable damage caused by diseases such as wilt (*Fusarium oxysporum*), root rot (*F. solani*), basal rot (*F. avenaceum*), damping off (*Rhizoctonia solani*), and blister disease (*Olpidium viciae*). Broad bean wilt virus (BBWV) and bean leaf roll virus (BLRV) are widely disseminated in the south and the Yangtze River Valley and cause considerable damage. The broad bean stain virus (BBSV), turnip mosaic virus (TuMV), and broad bean true mosaic virus (BBTMV) were recently discovered in China.

Introduction

Faba beans are extensively cultivated in China and are one of the country's principal legume crops. According to United Nations' statistics, the world acreage of faba bean in 1981 was 3.62 million hectares, 2.20 m ha of which were in China (FAO 1981).

In China, faba beans are used as (i) the fully matured crop; seeds are stored, to be used for food, (ii) the developing beans at the green ripening stage as a vegetable at dinner, and (iii) green manure, etc.

Except in the northeast, faba beans are cultivated throughout China. The principal faba bean producing provinces include Yunnon, Zhejiang, Hunon, and those traversed by the Yangtze River Valley such as Sichuan, Hubei, and Jiangsu. In these provinces the crop is autumn-sown. In the northwest the crop is spring-sown. This region includes the provinces of Gansu, Qinghai, Shanxi, and Neimong Autonomous Region and constitutes a large proportion of the total area under faba beans. According to preliminary estimates for the 20 provinces, municipalities, and autonomous regions of China, the crop area harvested for the fully matured seed amounted to 1.10 m ha with a total production of 1.88 mt, and an average yield of 1698 kg/ha in 1985. The yields for the autumn-sown region are generally 1.5-2 t/ha while those for the spring-sown region can reach 3-4 t/ha.

Influence of faba bean diseases on production

In China, diseases have become one of the important factors affecting faba bean production. Although we have no accurate figures, a rough estimate can be made of a 10-20% reduction in yield due to diseases.

Based on an observation in 1959 in Ghahim rubar, Zhejiang province, some faba bean fields were seriously infected by *Botrytis fabae*, which caused over 50% yield loss.

Diseases affecting faba bean crops

As with other crops, faba bean diseases are caused by fungi, bacteria, nematodes, and viruses. In the period 1922-79, 12 fungal, 1 bacterial, and 10 viral diseases were reported in China (Yu 1979; Table 1).

Generally, fungal diseases have been the most serious threat to faba bean production in the past few years. In the autumn-sown region of southern China and in the Yangtze Valley, the incidence of chocolate spot (*Botrytis fabae*) and brown spot (*Ascochyta fabae*) were most prevalent and severe. Rust was localized and occasionally serious along the coastal region. In the spring-sown region of the northwest, however, rust (*Uromyces fabae*) was predominant, while in localized regions zonate spot disease (*Cercospora fabae*) caused greater loss in some years.

Recently, in some areas in the autumn-sown region of the south, there have been reports (Ruan *et al.* 1982) of considerable damage caused by broad bean wilt (*Fusarium oxysporum*), root rot (*F. solani*), basal rot (*F. avenaceum*), and damping-off (*Rhizoctonia solani* Kuhn). In some spring-sown regions of the northwest, blister disease (*Olpidium viciae* Kusano) has caused considerable damage.

In the past, recognition or diagnosis of a viral disease was largely based on plant symptoms and on inoculation or transmission tests, as serological techniques and electron microscopy were not available. Thus, viruses were named according to the symptoms they cause.

Research carried out in China in recent years (Zhiang *et al.* 1985) has accumulated some new facts about viral diseases such as broad bean wilt virus (BBWV) which is widely disseminated in southern China and causes considerable damage. The broad bean stain virus (BBSV) was found for the first time in the nurseries of Sichuan, Hubei, Zhejiang, and Jiangsu provinces. The soybean mosaic (SMV) and turnip mosaic viruses (TuMV) were found to be capable of infecting faba beans and broad bean true mosaic virus (BBTMV) was reported for the first time in China in 1985 (Shouwer and Yanyong 1985). Because of the

Table 1. Fungal, bacterial, and viral diseases of faba beans reported in China 1922-1979.

Fungal diseases

Chocolate spot (*Botrytis fabae* Sardina), 1945.
Botrytis cinerea spot (*Botrytis cinerea* pers), 1944.
Brown spot (=Ascochyta blight, =Ascochyta spot) (*Ascochyta fabae* Speg.), 1947.
Zonate spot (*Cercospora fabae* Fautrey), 1946.
Rust (*Uromyces fabae* (Pers) de Bary), 1937
Sclerotinose (=stem rot) (*Sclerotinia trifoliorum* Eriks), 1937.
Powdery mildew (*Erysiphe polygoni* (DC.) f.sp. *viciae-pisi*. Yul), 1946.
Pythium root rot =soft rot (*Pythium debaryanum* Hesse and *Pythium ultimum*), 1950.
Rhizoctonia stem rot (=*Rhizoctonia* damping-off and rot) (*Thanatephorus cucumeris* (Frank) Donk, *Rhizoctonia solani* Kuhn), 1936.
Fusarium root rot and wilt (=dry root rot) (*Fusarium avenaceum, F. solani* and *F. oxysporum*), 1948.
Downy mildew (*Pernospora viciae* (Berk) de Bary), 1922.
Verticillium wilt (*Verticillium albo-atrum* Rhe. and Berth.), 1950.

Bacterial diseases

Bacterial stem blight (*Pseudomonas fabae* (Yu) Burkholder), 1936.

Viral diseases

Diseases caused by viruses.
   Bean yellow mosaic virus, 1964.
   Bean leaf roll virus, 1964.
   Bean common mosaic virus, 1979.
   Broad bean mild mosaic virus, 1939.
   Pea enation mosaic virus, 1979.
   Broad bean wilt virus, 1979.

Diseases possibly caused by viruses or the viruses are not well characterized.
   Tooth tumor-like swelling vein, 1959.
   Broad bean acropetal necrosis, 1979.
   Broad bean red blotch virus, 1979.
   Broad bean yellow rosette, 1939.

complexity of environmental conditions, cultural practices, and varieties used, these diseases occur almost annually in certain areas of China, especially BBWV and BLRV which are occasionally severe in some regions.

References

FAO (Food and Agriculture Organisation) 1981. Production Year Book 1981. FAO, Rome, Italy.

Ruan, H., Yuchang, J., Weufu, L. and Jiahe, W. 1982. Two new forms of *Fusarium avenaceum* (FR) SACC. The pathogens of broad bean stem-end rot. Acta Phytopathologia Sinicia 12(2):25-32.

Shouwei, D. and Yauyoung, L. 1985. Characterization of broad bean true mosaic virus in China. Journal of Anhui Agricultural College 1:13-17.

Yu, T. F. 1979. *Vicia faba* Diseases. (In Chinese). Scientific Press, Peking, China. 168 pp.

Zhiang, X. Zuchin, P. Qi, C. Zhongda, F. and Cockbain, A.J. 1985. Virus diseases of the faba bean (*Vicia faba* L.) found in Yangtze River Valley. Journal of Nanjing Agricultural University 4:42-48.

Seed Quality and Nutrition

The Yield Performance and Proximate Analysis of Twelve Cultivars of Faba Beans Grown at Five Sites in the Northern Region of the Sudan

Farouk A. Salih[1] and S. B. El Hardallou[2]

1. Shambat Research Station,
   Khartoum North,
   SUDAN
2. Gezira University,
   Wad Medani,
   SUDAN

Abstract

Twelve faba bean cultivars were grown at five sites in northern Sudan. The best yields were obtained from the cultivars NEB 424.S, 188 x G-1, NEB 423, and NEB 425.S. The highest protein contents (on a dry basis) were recorded for NEB 428 (37.69%) and NEB 423 (37.61%) at Aliab, BM 9/3 (37.13%) at Zeidab, and NEB 424.S (36.97%) at Burgeig.

Introduction

Faba beans (*Vicia faba*) are widely believed to have originated in the Mediterranean - West Asian region (Cubero 1974; Bond 1976). In the Sudan, 95% of the total faba bean crop is produced in the northern region. Within Sudan there are different agro-ecological zones; cool, long winters in the north and mild, short winters in the south. We expect however, that variant faba bean genotypes differ in their adaptation to these zones.

Two of the five cultivated sites - Burgeig and Selaim - lie at 19° 10'N and 30° 29'E, while Hudeiba, Zeidab, and Aliab lie at 16° 42'N and 32° 25'E. The objective of this experiment was to test the adaptation and yield performance of the most promising faba bean varieties or lines in stock at Hudeiba Research Station under different environmental conditions. The grains were then subjected to proximate analysis.

Materials, Management, and Methods

The trial included 12 faba bean stocks planted in a randomized complete block, replicated six times at each of the locations Burgeig, Selaim, Hudeiba, Zeidab, and Aliab.

Local methods of land preparation and subsequent operations were used at each location. The experiment was planted at all locations during the last week of October 1979. The plots were 3.6 x 6.0 m, of which 2.4 x 5.8 m was harvested. Spacing between and within rows was 60 cm and 20 cm, respectively. Three seeds were sown per hole and after 2 weeks were thinned to one plant per hole (about 17 plants/m^2). Due to low rainfall for 9 months in a year (August to June), faba beans must be grown under furrow irrigation in the Sudan. The trial received 10 irrigations at intervals of 7 - 10 days at each site. Total seed was recorded for every plot.

Seed samples from each of the twelve cultivars at the five locations were carefully cleaned and foreign material removed, ground to a fine powder using a micro hammer mill with 0.5 mm mesh size, and stored in clean bottles for later use. Proximate analysis was carried out and results recorded on an "as is" basis with respect to moisture. Moisture and ash contents were determined according to AOAC (1975); ether extract, crude protein, and crude fiber as described by Pearson (1970). The carbohydrate content was calculated by difference.

Results and Discussion

Yield performance

The data on seed yield are presented in Table 1. Within all sites except Zeidab and Burgeig there were significant differences in seed yields of the different varieties. Seed yields were significantly better at Zeidab, Aliab, and Burgeig than at Hudeiba and Selaim. Even though Selaim is farthest north and has a longer and somewhat cooler season which suits the crop, the yield at this site was very low compared to the other sites, with the exception of Hudeiba. The low yields at Selaim were due to late

Table 1. Grain yield (kg/ha) performance of 12 cultivars of faba bean grown at five sites in the northern region of the Sudan.

Cultivar	Locations					
	Burgeig	Selaim	Hudeiba	Zeidab	Aliab	Mean
NEB 424.S	2454	1902	673	2447	2694	2034
188 x G.1	2501	1157	583	2516	2799	1911
NEB 423	1947	2006	559	2320	2556	1878
NEB 425.S	2732	1104	631	2159	2673	1859
NEB 428	2287	738	888	2508	2528	1799
NEB 425	2323	869	645	2161	2637	1727
Hudeiba 72	1954	961	688	2766	2106	1695
NEB 424	2228	978	393	2554	2292	1689
NEB 152.S	2061	1318	590	2447	1806	1644
BF 2/2	1654	907	562	2397	2637	1631
NEB 153	1968	1080	604	2356	2013	1605
BM 9/3	1949	590	712	2451	2156	1572
S.E. ±	283	295	76	197	212	
Mean	2171	1134	627	2423	2408	1753

planting, 3 weeks later than the optimum time (1 November) due to late land preparation, poor soil coupled with heavy weed infestation, and severe bird damage to the green pods.

At Hudeiba, all varieties were heavily infested with aphids by late December - early January. Aphids cause severe damage to nearly all varieties and result in drying of leaves and flowerless plants. At this site, the cultivar NEB 428 was the highest yielder, surpassing the yields of BF 2/2 and Hudeiba 72 (standard cultivars) by 37 and 22%, respectively.

At Aliab, the highest seed yield was produced by the cross selection line 188 x G.1 which significantly ($P = 0.05$) out-yielded BM 9/3, NEB 153, NEB 152.S, and H.72 by 23, 28, 35, and 25%, respectively. There were no significant differences between the cultivars NEB 424.S, NEB 425.S, NEB 428, NEB 423, NEB 425, 188 x G.1, and BF 2/2 as a control.

At Zeidab, the highest seed yield came from H.72 which exceeded the yields of 188 x G.1 and NEB 424 by 9 and 7.6%, respectively.

At Burgeig, NEB 425.S was the highest yielder, followed by 188 x G.1, and NEB 424.S. The average yields (2563 kg/ha) of the previously mentioned varieties exceeded the yields of the standard varieties, H.72 and BF 2/2, by 24 and 35%, respectively.

At Selaim, the three top yielding cultivars were NEB 423, NEB 424.S, and NEB 152.S. They out-yielded H.72 and BF 2/2 by 45 and 48%, respectively.

On overall performances over the five sites, the average yield of NEB 424.S and 188 x G.1 (1972 kg/ha) was greater than the yield of standard varieties BF 2/2 and H.72 by 17 and 14%, respectively. Based on average yield over the five sites, the best yields were obtained from NEB 424.S, 188 x G.1, NEB 423, and NEB 425.S, all of which may therefore be considered suitable for the agro-climatic conditions of northern Sudan.

Proximate analysis

The lowest mean moisture content of the grains was reported at Selaim (7.5%) and the highest at Aliab (8.51%) (Table 2). Campbell and Marquardt (1977) reported 13% moisture content for Canadian faba beans. Blair (1977) also found the moisture content of UK faba beans to be 13%. The moisture content is variable even for the same cultivar, depending on locality and other environmental factors, and length and type of storage. The high temperatures and low relative humidity recorded in the northern region of the Sudan result in high mean evaporation. Hence the relatively low moisture content recorded for faba bean grains in this study.

Table 2. Average percent composition of the 12 faba bean cultivars at the five sites.

	Location				
	Burgeig	**Selaim**	**Hudeiba**	**Zeidab**	**Aliab**
Moisture	7.86	7.50	8.12	8.47	8.51
Crude protein	31.45	29.68	24.86	31.00	32.01
Ether extract	1.10	1.01	0.93	1.29	1.25
Crude fiber	8.54	8.09	6.61	7.98	6.92
Ash	2.90	2.55	3.33	2.65	2.84
Carbohydrates (by difference)	48.15	51.17	56.15	48.61	48.47

Table 3. Cultivars of the highest protein content (on dry basis) and those with highest yield (kg/ha) at five sites.

Site	Cultivar	Protein content (%)	Cultivar	Yield
Aliab	NEB 428	37.69	188 x G.1	2799
	NEB 423	37.61	NEB 424.S	2694
Zeidab	BM 9/3	37.13	H.72	2766
	NEB 152.5	36.93	NEB 424	2554
Burgeig	NEB 424.S	36.97	NEB 425.S	2732
	BM 9/3	36.92	188 x G.1	2501
Selaim	NEB 152.S	35.13	NEB 423	2006
	NEB 424.S	34.22	NEB 424.S	1902
Hudeiba	188 x G.1	29.06	NEB 428	888
	NEB 428	28.50	BM 9/3	712

Within each site, there were no significant differences in the protein content of different cultivars. The mean protein contents were 24.86 and 29.68% at Hudeiba and Selaim, respectively (Table 2), which are relatively low compared to the other three sites. This can be attributed to aphid infection at Hudeiba and late planting at Selaim, the same factors that affected seed yield. Kelly (1973) attributed differences in the protein contents of legumes to environmental conditions, genotypes, and agricultural practices.

The highest protein content (on a dry basis) was recorded in NEB 428 (37.69%) and NEB 423 (37.61%) at Aliab, BM 9/3 (37.13%) at Zeidab, and NEB 424.S (36.97%) at Burgeig (Table 3). The cultivars with highest protein content also had the highest yield (Table 3). Faba beans can be used as a protein supplement to other staple foods in Sudan like sorghum, millet, and cassava which all have a lower protein content, or can provide a good protein supplement to produce weaning foods of high nutritive value (Ali *et al.* 1982). Faba bean protein is

relatively high in lysine and low in methionine (Marquardt 1984) while sorghum and millet are deficient in lysine and contain moderate quantities of methionine (Boulter *et al.* 1973).

The lowest mean fat contents were also reported at Hudeiba and Selaim; 0.93 and 1.01%, respectively (Table 2). The fat content of many of the legume seeds used for food is 1-2% (Aykroyd and Doughty 1964). Campbell and Marquardt (1977) reported a fat content of 0.8% in Canadian faba beans. Legume oils are primarily glyceryl triesters of long chain fatty acids and tropical legume seeds tend to be richer in oil than temperate legumes (Wolff and Kwoleck 1971).

The average crude fiber content was 6.61 - 8.54% (Table 2). Campbell and Marquardt (1977) reported 7.4% for Canadian faba beans while Blair (1977) reported 6.7% for UK faba beans.

Carbohydrate content, obtained by difference, was 48.15 - 56.15% (Table 2). The high carbohydrate content at Hudeiba and Selaim sites is directly related to the low protein content. Pritchard *et al.* (1973) found the available carbohydrate fraction (dextrin, starches, and ethanol-soluble sugars) to be 46 - 48% in winter and spring faba beans.

References

Ali, A.M., Ahmed, G.E.E. and El-Hardallou, S.B. 1982. Faba beans and their role in diets in Sudan. Page 317 *in* Faba Bean Improvement: Proceedings of the Faba Bean Conference (Hawtin, G. and Webb, C. eds), ICARDA/IFAD Nile Valley Project, 7-11 March 1981, Cairo, Egypt. Martinus Nijhoff, The Hague, The Netherlands.

AOAC 1975. Association of Official Analytical Chemists, Washington DC 20044, USA.

Aykroyd, W.R. and Doughty, J. 1964. Legumes in Human Nutrition. FAO Nutritional Studies No. 19, FAO, Rome. Cited, page 28 *in* Nutritional Improvement for Food Legumes by Breeding 1973 and page 189 *in* International Workshop of Grain Legumes 1975, ICRISAT.

Blair, R. 1977. Feedingstuffs 49 (29):15.

Bond, D.A. 1976. Field bean, *Vicia faba.* (Leguminosae-Papilionatae). *In* Evolution of Crop Plants. (Simmonds, N.W. ed.). Longman, London, UK.

Boulter, D., Evans, I.M., Thompson, A. and Yavwood, A. 1973. The amino acid composition of *Vigna unguiculata* (cow pea) meal in relation to

nutrition. Cited, page 205 *in* Nutritional Improvement by Breeding.

Campbell, L.D. and Marquardt, R.R. 1977. Poultry Science 56:442.

Cubero, J.I. 1974. On the evolution of *Vicia faba.* Theoretical and Applied Genetics 45:47-51.

Kelly, J.F. 1973. Increasing protein quantity and quality. Page 179 *in* Nutritional Improvement of Food Legumes by Breeding.

Marquardt, R.R. 1984. Faba beans as a potential protein rich feedstuff for poultry. FABIS 8:18.

Pearson, D. 1970. The Chemical Analysis of Food. J. and A. Churchill, 104 Gloucester Place, London.

Pritchard, P.J., Dryburgh, E.A. and Wilson, B.J. 1973. Carbohydrates of spring and winter field bean (*Vicia faba*). Journal of the Science of Food and Agriculture 24:663.

Wolff, I.A. and Kwolek, W.F. 1971. Lipids of the Leguminosae. Page 231 *in* Chemotaxonomy of the Leguminosae (Harborne, J.B., Boulter, D. and Turner, B.L. eds). Academic Press, London and New York.

Functional Properties of Faba Bean Seed Flour

Nilofar Newaz[1] and M. A. Newaz[2]

1. *Department of Biochemistry, Bangladesh Agricultural University, Mymensingh, BANGLADESH*
2. *Department of Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh, BANGLADESH*

Abstract

The functional properties of two faba bean genotypes, local and exotic, were investigated. There was little variation in biochemical composition between the two genotypes. Proteins from both genotypes were least soluble at about pH 4.0 and most soluble at pH 10. Water absorption capacity per g flour was 2.35g in the local genotype and 1.23 g in the exotic genotype. The minimum gelation concentration of the flour of both genotypes was 12% and foaming capacity (volume increase) was 42-48%.

Introduction

Protein sources continue to be in short supply worldwide and particularly in Bangladesh. Compared to the legumes commonly grown in Bangladesh, faba bean has relatively high yield potential and protein content. The crop has limited use in Bangladesh, but it could be used as a substitute for grass pea (*Lathyrus*), which contains a neurotoxin. This has already been done in India (Singh *et al.* 1982).

Although faba beans contain a wide and diverse group of anti-nutritional factors, the effects of these compounds are less acute than those caused by such factors in many other grain legumes. Some of these factors can be eliminated by heat treatment and others by selective breeding programs (Marquardt 1983).

Protein, the major constituent of food legumes, largely determines the functionality or suitability of legume flour for food. Proteins are generally functional in the presence of water and it is important to understand their interaction with water. The present investigation was undertaken to evaluate the functional properties of faba bean seed flour.

Materials and Methods

The seeds of two faba bean genotypes were used; one was a local, black-seeded cultivar called Kalimotor, and the other was the exotic, buff-colored genotype ILB 2858. Prior to analysis, the dry faba bean seeds were ground and passed through a 60-mesh sieve.

Proximate analyses were done in triplicate for moisture, protein (N x 6.25), fat, and ash content, according to AOAC methods (AOAC 1965). The results were expressed on a dry weight basis.

To determine the protein solubility of bean flour, 2 g dry bean meal were dissolved in 20 ml distilled water and the pH adjusted to the required value (pH 2-12) with either 1N HCl or 1N NaOH. The solution was mixed with a magnetic stirrer for half an hour, then centrifuged at 5,000 g for 15 min and the protein content of the supernatant determined by the Kjeldhal method. Analyses were performed in duplicate and the means reported.

Water absorption was measured using a modification of the centrifugation technique of Janicki and Walezek (1954). Bean flour (2.5 g) was weighed into a 50 ml centrifuge tube and mixed with 25 ml distilled water with continuous stirring for 1 min. The resulting slurry was centrifuged at 9000 rpm for 45 min. The supernatant was then decanted and the water retained per g sample was calculated. The same procedure was repeated to determine the water absorption in 5% NaCl.

The gelation properties of faba bean flour were evaluated by the method of Coffman and Garcia (1977), as modified by Sathe *et al.* (1982a). Suspensions of different concentrations of flour were prepared (2,4,6,8,10,12,14,16,18, and 20% w/v) in test tubes with 5 ml distilled water. After thorough mixing the tubes were heated in a boiling water bath for 1 hr then cooled under running tap water. They were further cooled in a refrigerator (4°C) for 2 hr. The least gelation concentration was the flour concentration at which the sample did not fall or slip in an inverted test tube.

Foaming capacity was studied according to the method of Coffman and Garcia (1977). A 2 g sample was whipped with 100 ml distilled water for 5 min in a Waring blender, then poured into a 250 ml graduated cylinder. The total volume was noted at 0, 0.5, 1.0, 1.5, 2.0, 3.0, and 4.0 hr. The volume increase with time at room temperature (31°C) was calculated according to the equation

$$\text{Volume increase (\%)} = \frac{\text{Vol. after whipping (ml)} - \text{Vol. before whipping (ml)}}{\text{Vol. before whipping (ml)}} \times 100$$

Results and Discussion

The proximate composition of faba bean flour is shown in Table 1. There is little variation in the major constituents between the two genotypes, which agrees with the results of Campbell and Marquardt (1977) and Blair (1977).

Protein solubility

The protein solubility profile of faba bean flour (Fig. 1) shows that protein was most soluble at an alkaline pH. Protein from these two genotypes was least soluble at about pH 4.0. The solubility increased with increasing pH: at pH 10 about 90% of the seed protein was soluble. Garcia (1981) and Sosulski *et al.* (1976), working with other legume flours, also reported the highest protein solubility at alkaline pH.

Table 1. Proximate composition of faba bean seed flour on a dry weight basis.

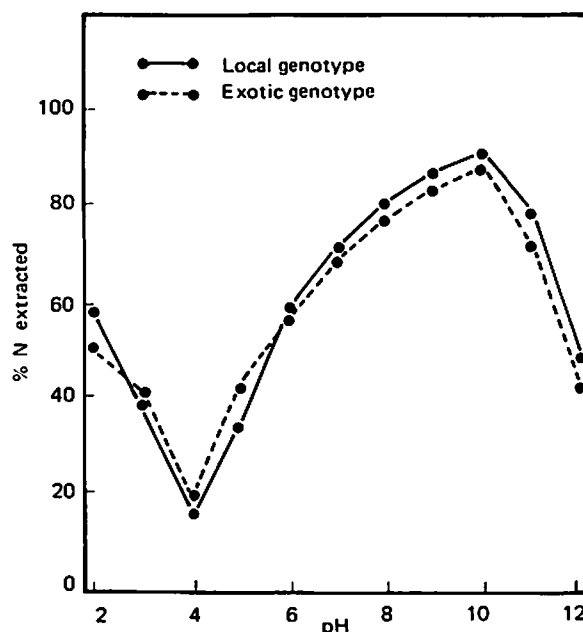| Component (%)	Local genotype	Exotic genotype
Moisture	7.32	6.65
Protein (N x 6.25)	27.21	26.44
Crude fat	3.26	2.65
Crude fiber	7.11	6.70
Ash	4.45	3.40

Fig. 1. Protein solubility profile of faba bean flour.

Water absorption capacity

The water absorption capacity of the local genotype was 2.35 g/g of flour (Table 2) which is higher than that of the exotic genotype and several other legumes such as mung bean, navy bean, cow pea, and rice bean (Mabesa and Novero 1983) and is almost the same as soybean flour (Sosulski et al. 1976). This difference in water absorption capacity between the two genotypes was possibly due to differences in polar groups.

Gelation

For both genotypes, the least gelation concentration was 12%. The same value has been reported for mung bean and navy bean flours but is higher in soybean (Mabesa and Novero 1983), winged bean, and lupin seed

flours (Sathe et al. 1982a and b). There is no definite relationship between protein concentration and gelling ability. Differences in gelling are possibly due to the ratios of different constituents such as proteins, carbohydrates, and lipids.

Foaming properties

The two genotypes did not differ much with respect to foaming capacity (Table 2). The values we obtained are much lower than those reported for soybean flour (Lin et al. 1974) but higher than those for winged bean (Sathe et al. 1982b).

Foamability is dependent on the configuration of the protein molecule. Graham and Phillips (1976) observed that flexible protein molecules give good

Table 2. Water absorption, gelation, and foaming capacities of faba bean flour.

Genotype	Water absorption (g/g flour)	Water absorption (g/g protein)	Water absorption in 5% NaCl (g/g flour)	Water absorption in 5% NaCl (g/g protein)	Least gelation conc.(%)	Foaming capacity (% volume increase)	Foaming stability after 4 hr (% volume increase)
Local	2.35	8.66	1.67	6.10	12	48	24
Exotic	1.23	4.60	1.20	4.35	12	42	22

foamability, but highly ordered globular molecules give low foamability because they cannot reduce the surface tension of the air-water interface. The stability of the foam prepared from faba bean flour was quite good. After 4 hr, the volume increase was reduced but the foam did not collapse completely.

References

AOAC (Association of Official Analytical Chemists). 1965. Official Methods of Analysis. Association of Official Analytical Chemists, Washington DC, USA.

Blair, R. 1977. Faba beans: an improved crop for animal feeding. Feedingstuffs 49(29):15-16.

Campbell, L.D. and Marquardt, R.R. 1977. Poultry Science 56:442-448.

Coffman, C.W. and Garcia, V.V. 1977. Functional properties and amino acid contents of a protein isolate from mung bean flour. Journal of Food Technology, UK 12:473-484.

Garcia, V.V. 1981. Water soluble proteins of winged beans, Psophocarpus tetragonolobus (L.) DC. Paper presented at the Second International Symposium on Winged Bean, Colombo, Sri Lanka, 19-23 January 1981.

Graham, D.E. and Phillips, M.C. 1976. The conformation of proteins at the air-water interface and their role in stabilizing form.

Page 237 in Foams (Akers, R.J. ed.). Academic Press, London, UK.

Janicki, N.A. and Walezak, J. 1954. Wateriness of meat and methods of its determination. Advances in Food Research 10:355-463.

Lin, M.J.Y., Humbert, E.S. and Sosulski, F. 1974. Certain functional properties of sunflower meal products. Journal of Food Science 39:368.

Mabesa, L.B. and Novero, F. 1983. Water absorption, water adsorption and gelation characteristics of flour from germinated legumes. The Philippine Agriculturist 66:137-143.

Marquardt, R.R. 1983. Antimetabolites in faba beans and their metabolic significance. FABIS Newsletter 7:1-4.

Sathe, S.K., Deshpande, S.S. and Salunkhe, D.K. 1982a. Functional properties of lupin seed proteins and protein concentrate. Journal of Food Science 47:491-497.

Sathe, S.K., Deshpande, S.S. and Salunkhe, D.K. 1982b. Functional properties of winged bean (Psophocarpus tetragonolobus (L.) DC) proteins. Journal of Food Science 47:503-509.

Singh, C.B. Ramgiri, S.B., Singh, S.B. and Khare, D. 1982. Faba bean, a high protein potential pulse crop. Genetic Culture 1:22.

Sosulski, F.W., Garrall, M.D. and Slinkard, A.E. 1976. Functional properties of ten legume flours. Canadian Institute of Food Science and Technology Journal 9:66.

BOOK REVIEWS

The Pea Crop - A Basis for Improvement

Edited by P.D. Hebblethwaite, M.C. Heath, and
T.C.K. Dawkins
ISBN 0-407-00922-1
Published by Butterworths, London, 1985
Hardcover price £ 60.00

The dried pea has been a good source of nutritious food since Neolithic times and is widely used for human consumption in developing countries. In recent years, interest in its use as an animal feed has increased in developed countries, particularly as an alternative to soya as a source of vegetable protein. There is also an increasing awareness of the beneficial role of peas as an arable break crop in the cropping systems common in Europe and other parts of the world.

'The Pea Crop' was the subject chosen for the University of Nottingham 40th Easter School in Agricultural Science. The aim of the conference was to bring together international scientists to present current research findings and review published work on a wide range of subjects including pea genetics, plant breeding, agronomy, crop and plant physiology, utilization, and marketing. While the majority of the papers covered the dried pea crop, some also dealt with vining and forage peas. A total of 42 papers were presented and these have been put together under the title 'The Pea Crop'.

The subject matter included in the 486-page book has been grouped into 10 sections covering various aspects of crop improvement, physiology, disease, pest, and weed control, and others.

As would be expected from a conference of this nature, the depth and style of presentation varies considerably between chapters. However, the book provides a very comprehensive coverage of the current understanding of the pea crop and is a basis for future improvement.

Grain Legume Crops

Edited by R. J. Summerfield and E. H. Roberts
ISBN 0-00-383037-3
Published by Collins Professional and Technical Books, London
Price £ 40.00

Grain legumes such as soybeans, groundnuts, common beans, peas, and chickpeas are important world crops. Others, such as cowpeas, faba beans, lentils, lima beans, lupins, mung beans, pigeonpeas, and winged beans are regionally or locally important, especially in warmer regions, and are expected to become more significant internationally in future.

There is considerable scope for improving and stabilizing the yields of all these crops and international research on them has expanded dramatically in recent years. The results of national and international research on these 13 major grain legume crops are drawn together to form this 880-page reference text. Forty-nine experts on grain legumes have contributed the latest information on the subject. All aspects of crop production and utilization are covered, with Part 1 dealing with general relations, Part 2 with individual species, and Part 3 with recent trends in international research.

Need More Information ?

Free Catalog of ICARDA Publications
Request your list of all currently available publications from STIP.

ICARDA Information Brochure
ICARDA's historical background and research objectives are outlined in English and Arabic. For your copy, contact STIP.

LENS (Lentil Newsletter)
This newsletter is produced twice a year at ICARDA. Short research articles are published and comprehensive reviews are invited regularly on specific areas of lentil research. The newsletter also includes book reviews, key abstracts on lentils, and recent lentil references. For further information write LENS.

RACHIS (Barley, Wheat and Triticale Newsletter)
This ICARDA service is aimed at cereals researchers in the Near East and North Africa region and Mediterranean-type environments. It publishes up-to-the-minute short scientific papers on the latest research results and news items. RACHIS seeks to contribute to improved barley, durum wheat, and triticale production in the region; to report results, achievements, and new ideas; and to discuss research problems. For further information, write RACHIS.

Field Guide to Major Insect Pests of Faba Bean in the Nile Valley (English and Arabic)
This pocket field guide for research and extension workers explains how to identify and control the main insect pests of faba bean in Egypt and Sudan. The distribution, description, and biological characteristics are given for each insect, along with the type of injury, assessment of damage, and recommended control measures. A key to injuries is included. Insects and the damage they cause on faba beans are illustrated with 41 color photos. For your copy, write FLIP.

Field Manual of Common Faba Bean Diseases in the Nile Valley (English and Arabic)
This pocket field manual is a tool for field workers to diagnose and control diseases of faba beans in Egypt and Sudan. Symptoms, development, and control of various diseases are discussed, and symptoms are illustrated with 38 color photos. Also included are rating scales for disease resistance in faba bean lines and a glossary of basic phyto-pathological terms. For your copy, write FLIP.

Field Guide to Major Insect Pests of Wheat and Barley (Arabic)
This field guide in Arabic covers fungal, bacterial, viral, and physiological diseases, as well as insects and nematodes, that attack wheat and barley crops in the Middle East and North Africa. Forty-four insects and diseases are discussed and illustrated with 72 color photos. For your copy, write Cereals Improvement Program.

ICARDA's Food Legume Improvement Program
In English and Arabic, the 24-page illustrated information brochure briefly describes research projects on lentil, faba bean, and chickpea treated either as single crops or as a group. For your copy, write FLIP.

Screening Chickpeas for Resistance to Ascochyta Blight A Slide-tape Audio-tutorial Module
This slide-tape audio-tutorial module is the first in the food legume training series. It is designed for the use of legume trainees during the training courses at ICARDA as well as for scientists and their support staff in the various national programs. This module is also useful educational material for universities and training departments in national research systems. For your copy of this publication or package, write Training Department.

Opportunities for Training and Post-Graduate Research at ICARDA
ICARDA has active training courses on the development and improvement of food legumes, cereals, and forages with ICARDA's research scientists, trained instructors, and proven programs. For a complete brochure of the training opportunities at ICARDA, write Training Department.

TO OBTAIN PUBLICATIONS:
Address requests for publications to the specific department or service cited above, at: ICARDA, P.O. Box 5466, Aleppo, Syria.

Announcement in Arabic

اعلان الى العلماء الباحثين العرب الكرام

يسر المركز الدولي للبحوث الزراعية في المناطق الجافة (ICARDA) ، اعلامكم بان مركز بحوث التنمية الدولية (IDRC) وافق على تقديم الدعم المادي لبرنامج فابيـــــس ، ولمدة ثلاث سنوات ، اعتبارا من بداية عام 1987 ولغاية 1989 . ويحيطكم علما بان ادراج اللغة العربية ضمن النشرة الاخبارية للفول " فابيس " يشكل آحد آهم اهداف هذا البرنامج .

وبمزيد من السرور تعلن اسرة تحرير " فابيس " للعلماء العرب العاملين فـــي مجال تحسين وتطوير الفول . انها ستبدأ اصدار نشرتها الاخبارية ، باللغتين العربية والانكليزية ، وذلك (بدأ من العدد 17) الذي سيصدر في شهر نيسان القادم .

يرجى من الاخوة العلماء الراغبين في نشر ابحاثهم باللغة العربية التفضـــــل بارسالها الى العنوان : فابيس ، ايكاردا ـ قسم التوثيق ، ص.ب 5466 ، حلـــــب ـ سورية .

ملاحظة : تتم كتابة البحث بلغة عربية واضحة ، وفق الترتيب التالي :

1) ملخص البحث يكتب باللغتين العربية والانكليزية .

2) المقدمة .

3) مواد وطرق البحث .

4) نتائج البحث .

5) المناقشة ، ويمكن دمجها مع النتائج (نتائج البحث والمناقشة) .

6) قائمة المراجع .

REPRINT COLLECTION

With the financial support of the International Development Research Center (IDRC), ICARDA is building up its document collection on faba beans.

We would be grateful if readers who have any relevant documents would send them to:

FABIS
Documentation Unit, ICARDA,
P.O. Box 5466, Aleppo, SYRIA

ARE YOU MOVING ?

If you are moving, please let us know your new address as soon as possible.
Send it to:

FABIS
Documentation Unit, ICARDA,
P.O.Box 5466, Aleppo, SYRIA

Contributors' Style Guide

Policy
The aim of FABIS Newsletter is to publish quickly the results of recent research on faba beans. Articles should normally be brief, confined to a single subject, good quality, and of primary interest to research, extension, and production workers, and administrators and policy makers.

Style
Articles should have an abstract (maximum 250 words) and whenever possible the following sections: introduction, materials and methods, and results and discussion. Authors should refer to recent issues of FABIS for guidance on format. Articles will be edited to maintain uniform style but substantial editing will be referred to the author for his/her approval; occasionally, papers may be returned for revision.

Disclaimers
The views expressed and the results presented in the newsletter are those of the author(s) and not the responsibility of ICARDA. Similarly, the use of the trade names does not constitute endorsement of or discrimination against any product by ICARDA.

Language
FABIS Newsletter is published in English but ICARDA will endeavor to publish and/or translate articles submitted in Arabic and French.

Manuscript
Articles should be typed double-spaced on one side of the page only. the original and two other legible copies should be submitted. The contributor should include his name and initials, title, program or department, institute, postal address, and telex number if available. Figures should be drawn in India ink; send original artwork, not photocopies. Define in footnotes or legends any unusual abbreviations or symbols used in a figure or table. Good quality black and white photographs are acceptable for publication. Photographs and figures should preferably be 8.5 cm or 17.4 cm wide.

Units of measurement are to be in the metric system; e.g. t/ha, kg, g, m, km, ml (= milliliter), m^2.

The numbers one to nine should be written as words except in combination with units of measure; all other numbers should be written as numerals; e.g., nine plants, 10 leaves, 9 g, ninth, 10th, 0700 hr.

Examples of common expressions and abbreviations
3 g; 18 mm; 300 m^2; 4 Mar 1983; 27%; 50 five-day old plants; 1.6 million; 23 u g; 5°C; 1980/81 season; 1980-82 seasons; Fig.; No.; FAO; USA. Fertilizers: 1 kg N or P_2O_5 or K_2O/ha.
Mon, Tues, Wed, Thurs, Fri, Sat, Sun; Jan, Feb, Mar, Apr, May, June, July, Aug, Sept, Oct, Nov, Dec. Versus = vs. least significant difference = LSD, standard error = SE ±, coefficient(s) of variation = CV(s). Probability: Use asterisks to denote probability * = P<0.05; ** = P<0.01; *** = P<0.001.

Botanical: Include the authority name at the first mention of scientific names. Cultivar(s) = cv(s), variety = var(s), species = sp./spp., subspecies = subsp., subgenus = subg., forma = f., forma specialis = f. sp.

References
Journal articles: Khalil, S. A. and Harrison, J.G. 1981. Methods of evaluating faba bean materials for chocolate spot. FABIS No. 3: 51-52.

Books: Witcombe, J. R. and Erskine, W. (eds.). 1984. Genetic resources and their exploitation - chickpea, faba beans, and lentils. Advances in Agricultural Biotechnology. Martinus Nijhoff/ Dr. W. Junk Publishers, The Hague, The Netherlands, 256 pp.

Articles from books: Hawtin, G. C. and Hebblethwaite, P. D. 1983. Background and history of faba bean production. Pages 3-22 *in* The Faba Bean (*Vicia faba* L.) (Hebblethwaite, P.D., ed.). Butterworths, London, England.

Papers in Proceedings: Hawtin, G. C. 1982. The genetic improvement of faba bean. Pages 15-32 *in* Faba Bean Improvement: Proceedings of the Faba Bean Conference (Hawtin, G. and Webb, C., eds.), ICARDA/IFAD Nile Valley Project, 7-11 Mar 1981, Cairo, Egypt.

Submission of articles
Contributions should be sent to FABIS, Documentation Unit, ICARDA, P.O. Box 5466, Aleppo, Syria.