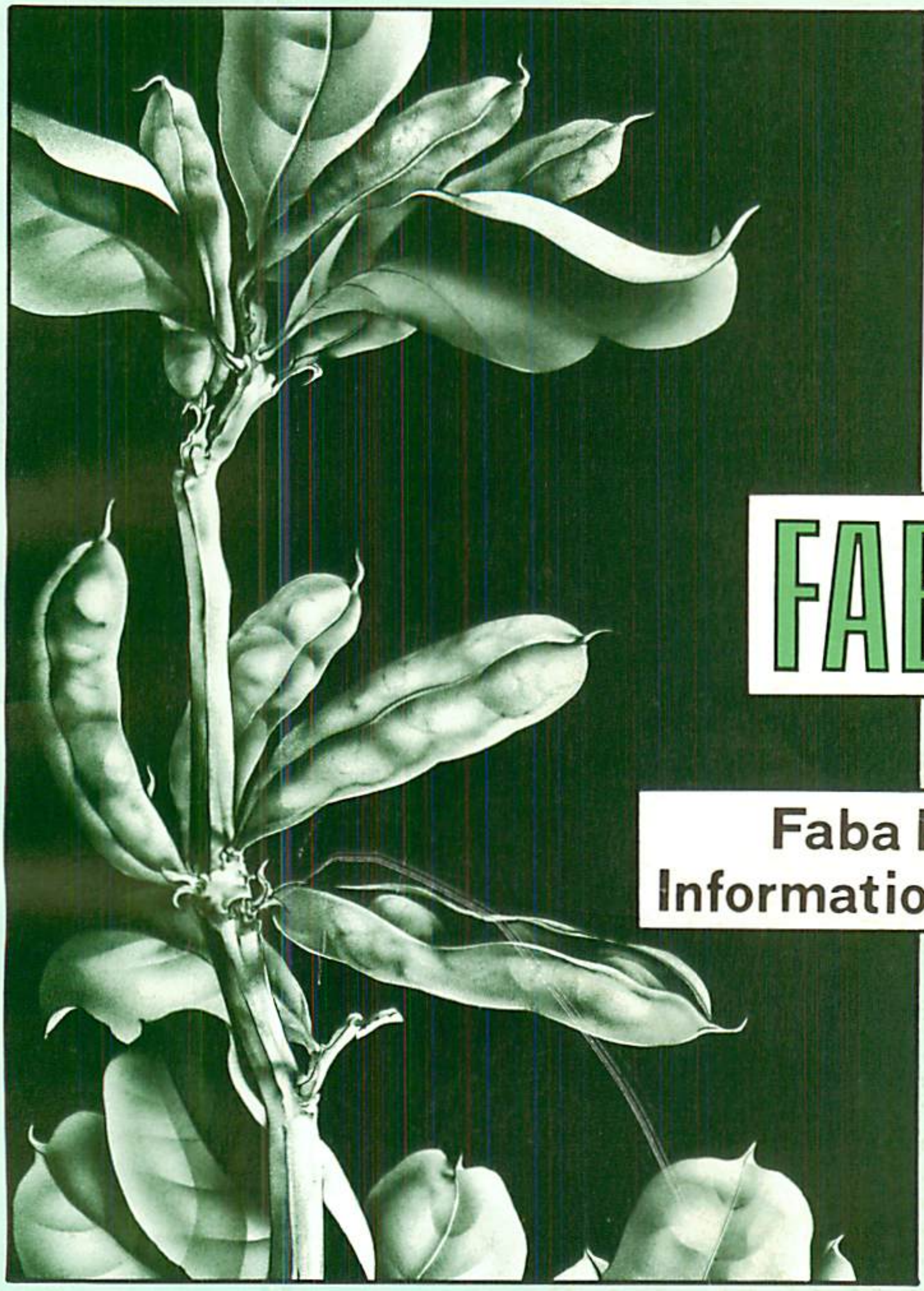

# FABIS

## Faba Bean Information Service

NEWSLETTER No. 31
July—December 1992

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.

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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 18 international research institutions that includes ICARDA. The network covers crop and livestock systems that supply three-quarters of the food of the developing world.

## FABIS

FABIS newsletter is produced twice a year by ICARDA. FABIS, the newsletter of the Faba Bean Information Service, is a forum for communicating results of research on faba bean and Viceae legumes. Short research articles provide rapid information exchange and comprehensive reviews are invited regularly on specific areas of faba bean research. The newsletter occasionally publishes book reviews on faba bean literature. Commencing with this issue, recent faba bean references will be published in an annual supplement.

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FABIS

# Faba Bean Information Service

FABIS Newsletter 31 July—December 1992

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### Towards a Faba Bean Progenitor!

### نحو إيجاد جد أعلى للفول

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**Abstract**

**During a recent IBPGR-sponsored mission surveying and collecting forage legume material from the Central Asian republics of the former Soviet Union, some aberrant *V. narbonensis* L. specimens with introgressive characteristics of the faba bean (*Vicia faba* L.) were found. The relationship between the faba bean and its putative allies is contentious. A progenitor has not yet been identified; however, the hypothesized characteristics of such a faba bean progenitor have been listed and some of these characteristics are seen in the aberrant *V. narbonensis* specimens. These specimens do not represent the progenitor, but their discovery suggests that greater effort should be focused on the collection, characterization and conservation of *Vicia* material from Soviet Central Asia.**

**ملخص**

برعاية المجلس الدولي للأصول الوراثية النباتية قامت مؤخراً بعثة بمسح وجمع الأصول الوراثية للبقوليات العلفية من جمهوريات آسيا الوسطى في الاتحاد السوفييتي السابق،وعثرت على بعض نماذج شاذة من *V. narbonensis* L. تتمتع بخصائص الفول (*Vicia faba* L.) المدخلة بالتهجين الإدماجي. إن العلاقة بين الفول وأقاربه المفترضين لازالت موضع جدل. ورغم أنه لم يتم حتى الآن التعرف على جد أعلى للفول فقد حددت خصائصه المفترضة كما لوحظت بعض من هذه الخصائص في نماذج شاذة من *V. narbonensis* التي لاتمثل الجد الأعلى، إلا أن اكتشافها يوحي بضرورة تركيز الجهود على جمع الأصول الوراثية للفول من آسيا الوسطى السوفييتية وتوصيفها وحفظها.

### The Ecogeographic Survey

The International Board for Plant Genetic Resources sponsored an initiative to survey, collect and conserve Vicieae and Cicereae (Leguminosae) germplasm from Soviet Central Asia during 1990. The initiative was divided into two distinct phases, an initial herbarium specimen survey mission followed by a germplasm-collecting mission. Interest in surveying and collecting *Vicia*, *Lathyrus*, *Lens*, *Pisum* and *Cicer* material from this region is high because of the large proportion of rare and endemic, perennial species from each of the included genera located in the area. A survey of genebank holdings, undertaken by IBPGR, found that this material was not actively represented in international collections. The objective of the herbarium survey was to clearly identify specific taxa and areas to be targeted during the following collecting mission. This strategy of preceding the collecting with an ecogeographic survey would, it was thought, increase the efficiency of the site location and germplasm acquisition elements of the collecting mission.

During the survey eight herbaria were visited in Leningrad and Central Asia, and over 6000 herbarium specimens of the five target genera were seen. From these specimens those with detailed ecogeographic passport data or those which were particularly interesting (odd forms, etc.) had their ecogeographic details included in an ecogeographic database. The process of collating and analyzing an ecogeographic database is discussed by Maxted et al. (1991a).

## Specimens of Particular Interest

During the ecogeographic survey of Central Asian Vicieae and Cicereae, two *V. narbonensis* specimens were found which showed some of the characteristics postulated for the putative faba bean progenitor by Maxted et al. (1991b). Both these specimens have characteristics that indicate some intermediacy between *V. narbonensis* and the cultivated faba bean. These characters place them outside the normal range of variation found in *V. narbonensis.*

### Specimen 1: Mashtakov s.n. (AA)

This specimen was held in the Herbarium of the Botanical Institute of the Academy of Science of Kazakh S.S. R. (AA) in Alma Ata, Kazakhstan. The specimen was made by F.M. Mashtakov from material cultivated at Kamenogorsk Agricultural Research Station in 1957.

The specimen label identifies it as *V. faba*, but using the keys provided by Fedtschenko (1948), Schäfer (1973), Khattab (1984) and Maxted (1991a), the material would be identified as belonging to *V. narbonensis.* The presence of a tendril, the shape of the stipule and the leaflet being asymmetric each indicate that the correct identification is *V. narbonensis* and not *V. faba*. The specimen is interesting because:

1. the stem is particularly stout in relation to overall plant size;
2. the stem is erect;
3. most of the leaves have short, simple tendrils (Fig. 1);
4. the mature legumes are all erect;
5. the legumes have simple, nontubercular hairs (Fig. 2);
6. there is spongy parenchyma between the seeds in the legume (Fig. 3), and
7. the seed is relatively large (9 × 10 mm).

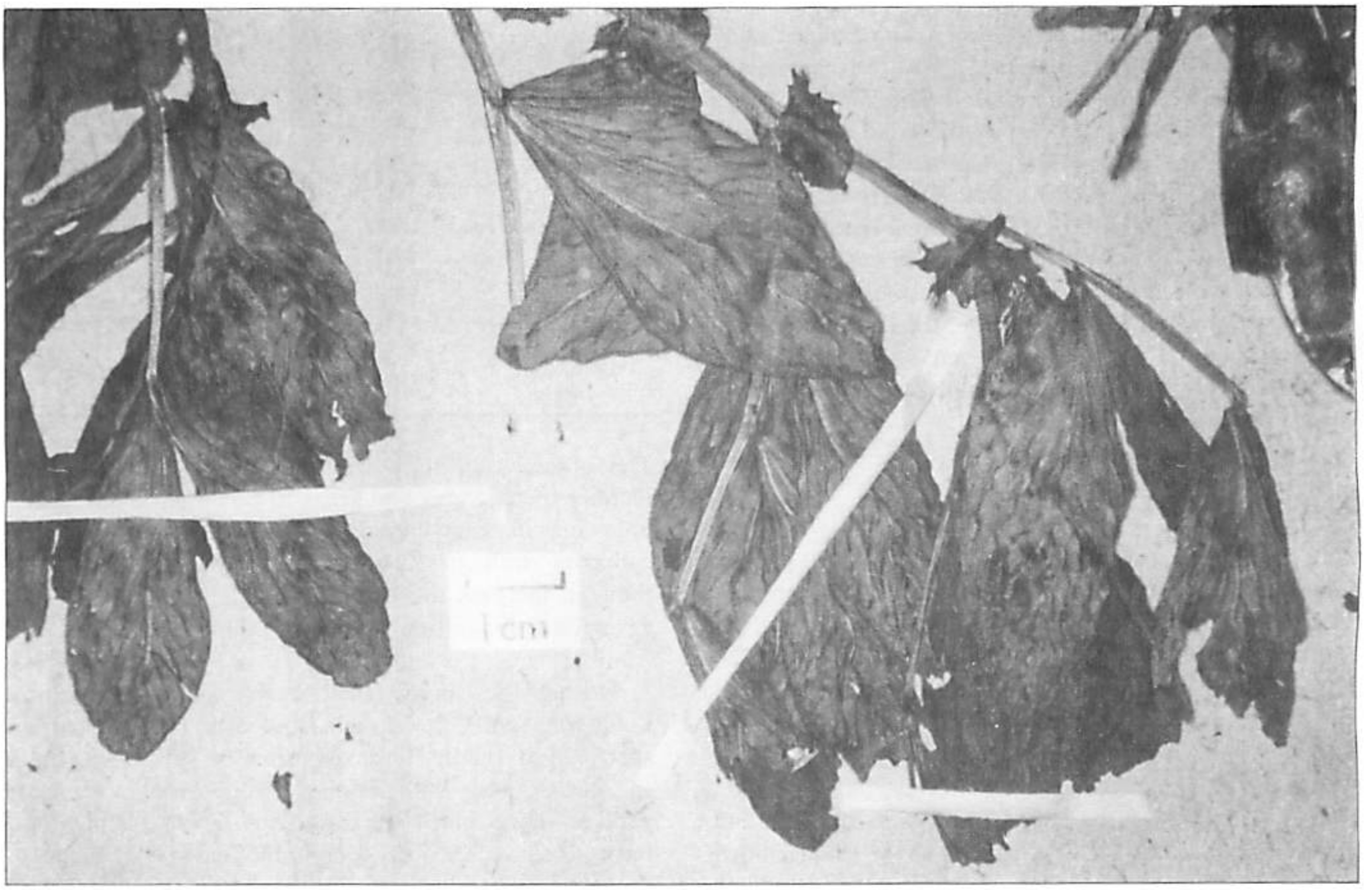


Fig. 1. *Vicia narbonensis*. Mashtakov s.n., AA. Leaf apex showing short, simple tendrils.

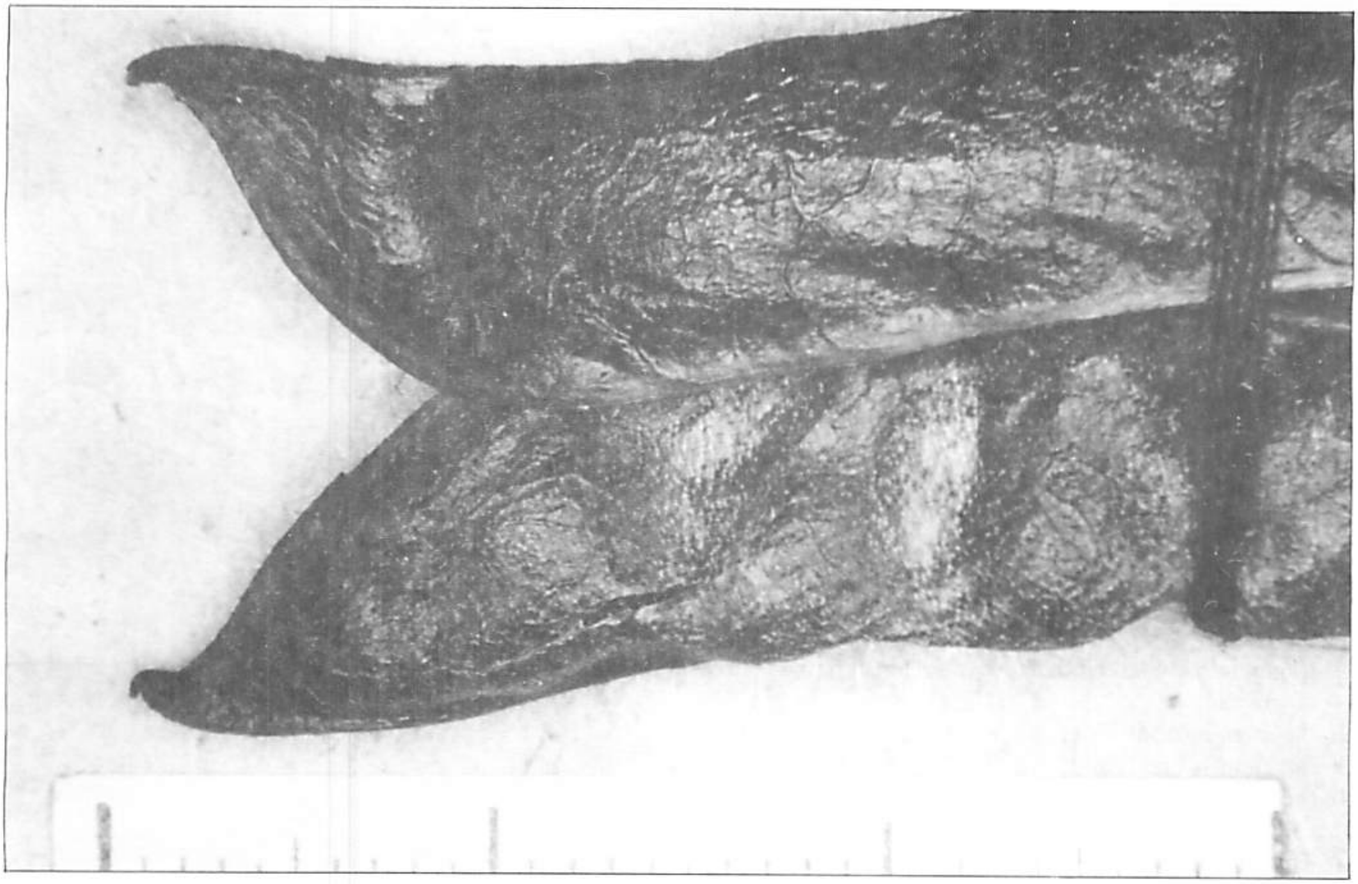

Fig. 2. *Vicia narbonensis*. Mashtakov s.n., AA. Legume showing simple, nontubercular hairs.

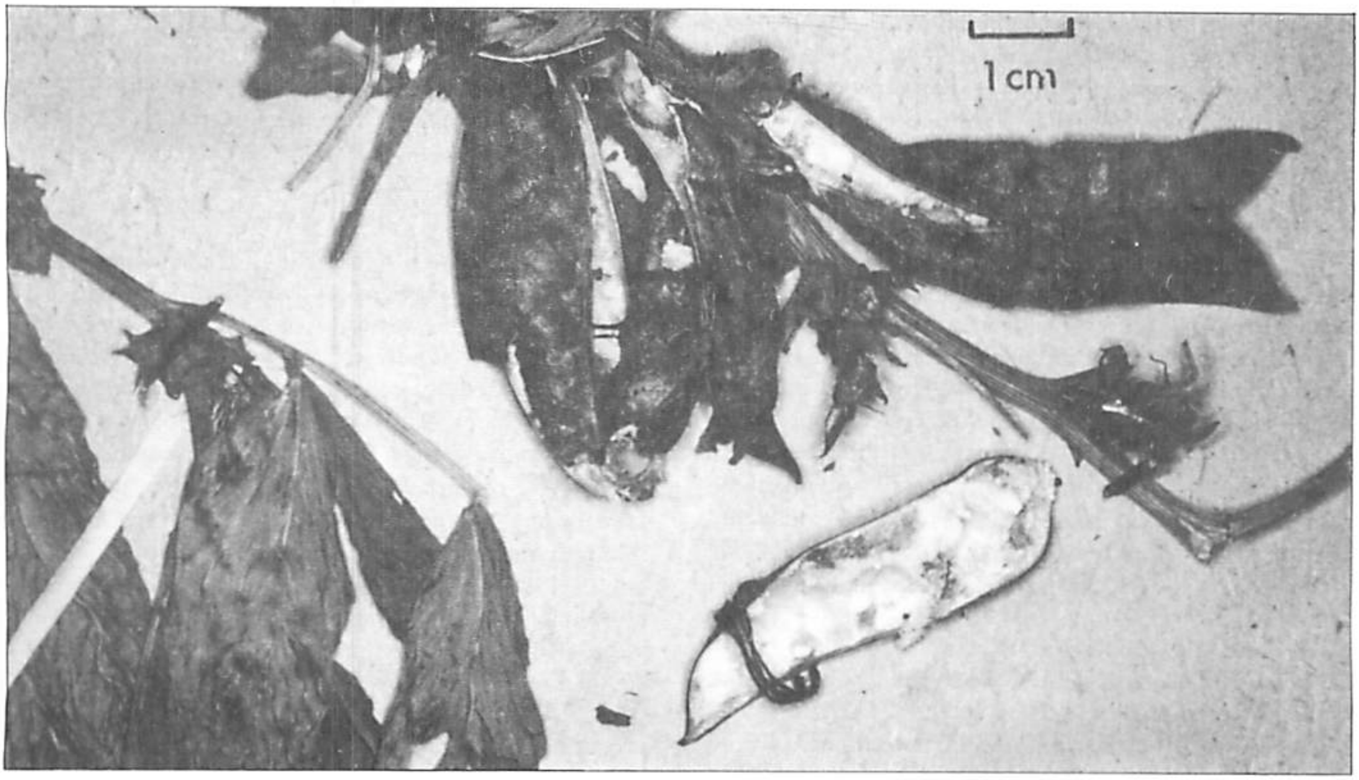


Fig. 3. *Vicia narbonensis*. Mashtakov s.n., AA. Legumes showing spongy parenchyma between the seeds.

In addition, this specimen is distinguished from all other *V. narbonensis* and *V. narbonensis* complex specimens because it has simple rather than tubercular hair on the legume and there is spongy parenchyma between the seeds within the legume. These two characters, combined with the others listed, indicate this specimen to be aberrant for *V. narbonensis.* These aberrations are those that might be expected of a hypothetical progenitor, as proposed by Maxted et al. (1991b).

**Specimen 2: Muratove 8.7.1925 (VIR)**

This specimen was held in the Herbarium of the N. I. Vavilov Institute of Plant Industry, (VIR) Leningrad. It was collected by I. Muratove on 8 July 1925 in Turkmania from a rock face. The specimen is identified as *V. narbonensis* and is interesting because:

1. the plant is very large for a wild specimen, the fragment included on the herbarium sheet being nearly 60 cm tall;
2. the stem is stout;
3. the stem is erect, and
4. the immature legumes are all erect (Fig. 4).

This specimen of *V. narbonensis* is not as obviously aberrant as Specimen 1. It does possess the characteristic tubercular hairs on the legume seen on *V. narbonensis* complex taxa. The combination of the four characteristics listed, especially the fact that the immature legumes are so obviously erect rather than patent (as in normal *V. narbonensis* specimens), makes this specimen stand outside the normal range of variation found in *V. narbonensis.*

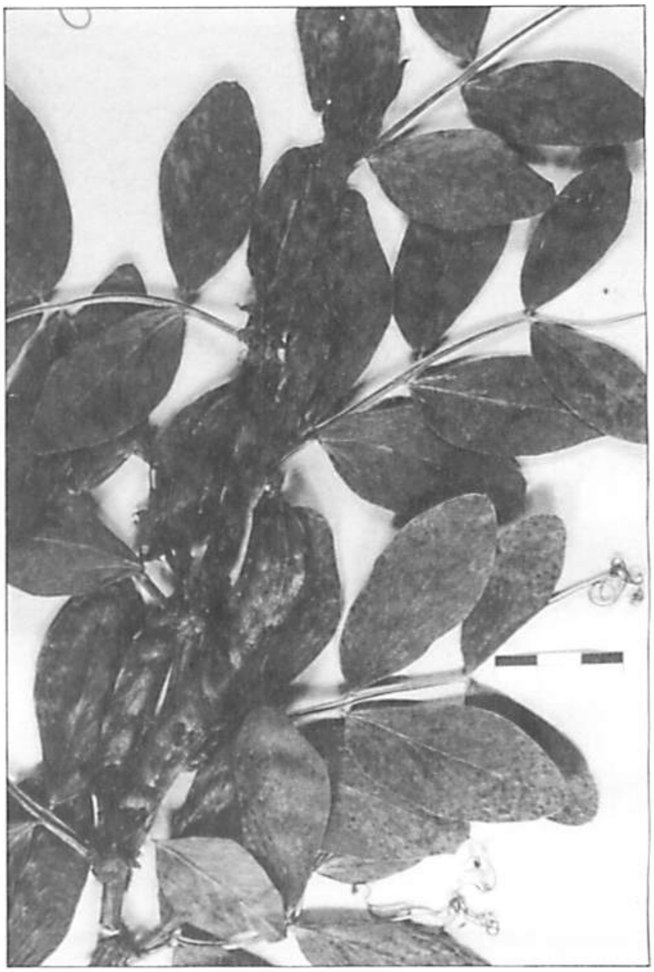

**Fig. 4. *Vicia narbonensis.* Muratova 8.7.1925,VIR. Upper plant showing immature legumes erect.**

## The Search for a Faba Bean Progenitor

Faba bean (*Vicia faba*) is unusual among pulse crops in that even after extensive taxonomic investigation there is still no clear picture of its ancestry or even of its close taxonomic allegiances (Smartt 1984). However, faba bean breeders have stimulated an interest in obtaining germplasm of the close wild relatives of faba bean as a source of novel characteristics that could potentially be introduced into faba bean. This has in turn stimulated hybridization studies between faba bean and its putative allies (Zohary 1977; Cubero 1982; Ramsay and Pickersgill 1984).

*Vicia narbonensis* is considered by many authors (Ball 1968; Plitmann 1970; Hanelt et al. 1972; Schäfer 1973; Kupicha 1976; Khattab 1984) to be morphologically the closest wild relative of faba bean. It is a common wild or minor forage species of southern Europe, the Mediterranean and western Asia, and is one species of a morphologically closely related group of less common species referred to collectively as the *V. narbonensis* complex (Schäfer 1973). Other authors (Zohary and Hopf 1973) tentatively suggest that another member of the complex, *V. galilaea* Plitm. & Zoh. in Plitm., may be the faba bean ancestor on the basis of this species being relatively morphologically similar to *V. faba.* Yamamoto et al. (1982), in a detailed karyotypic, phytochemical, morphological and hybridization study of section *Faba sensu* (Kupicha 1976), found that, of the *V. narbonensis* complex, *V. galilaea* was the closest to *V. faba.* They stress, however, that in their opinion *V. galilaea* is not the progenitor of *V. faba*.

Many researchers have attempted to locate the closest ally of *V. faba* within section *Faba sensu* (Kupicha 1976). Approaching the problem from this aspect assumes that section *Faba*, as defined by Kupicha, is a natural, homogeneous taxonomic unit within which the closest relative is retained. Not surprisingly this approach has found that the faba bean's closest allies lie in the *V. narbonensis* complex of species. Thus taxonomists have classified *V. faba* in one taxon with the *V. narbonensis* complex taxa. This approach makes the results biased in favor of including *V. faba* in a single taxon with its closest allies. For a clear view of the relationship between *V. faba* and other *Vicia* species, a broader approach must be taken. The broader approach gives scale to the allocation of series, section and generic rank and so allows the position of *V. faba* to be more "naturally" defined.

More recent authors (Stankevich 1978; Chrtkova-Zertova 1979; Khattab 1987; Maxted 1991a, 1991b) have noted that *V. faba* is quite distinct from section *Narbonensis sensu* (Maxted 1991b). These authors distinguish the *V. narbonensis* complex species from *V. faba* on numerous characters, e.g., plant habit, gross morphology, leaflet size and shape, whether or not their hairs are tubercular, flower color and size, legume and seed shape and size. The strength of these character correlations led Maxted (1991a) to conclude that *V. faba* was more isolated from its closest morphological allies than had been generally accepted.

However, these taxonomic studies of *V. faba* and its allies have enabled a clearer hypothesis to be formulated about the likely features of a faba bean progenitor. Cubero (1982) points out that the wild ancestor is likely to resemble the primitive cultivars of the cultivated species. He suggests it would have dehiscent pods and greater allogamy, although Ladizinsky (1975) disagrees, believing the progenitor should be autogamous like other annual *Vicia* species. Zohary (1977) suggests it is likely to have a diploid number of 2n = 14. Maxted et al. (1991b) suggest the progenitor would also have certain morphological features, such as simple tendrils, erect legumes, simple nontuberculate legume hairs and large seeds. All of these suggested characteristics would indicate intermediacy between *V. faba* and the *V. narbonensis* complex species, but none of the taxa currently accepted fit this ideotype.

The search for a hypothetical progenitor has focused in two areas. Ladizinsky (1975) and Cubero (1982) argue that the taxon within *V. faba* that shows least advancement and which they consider closest to the ancient form is ssp. *paucijuga* Murat. This subspecies is currently grown in Afghanistan, Pakistan and India, and has a relatively restricted distribution in comparison with ssp. *faba*. Zohary (1977) argues against this on the basis of archaeological evidence. He suggests that the progenitor, if it is extant, is more likely to be found further west in the fertile crescent countries of the Near East, which is the center of diversity of the putative allies of the faba bean (Maxted 1990). Maxted et al. (1991b) discuss these hypotheses and find that there is evidence to support both arguments. They concluded, however, that both regions (especially Afghanistan) are seriously under-collected for forage legume and their collection in these areas should be given a higher priority.

## Discussion

Following the examination of thousands of *V. narbonensis* complex specimens, two aberrant specimens do not make a progenitor and it would be very imprudent to draw conclusions from such a small sample. They are not specimens of the hypothetical missing link between the *V. narbonensis* complex and *V. faba*. However, these specimens do show a range of characteristics outside the accepted range of variation found in *V. narbonensis*. Therefore, they are interesting in terms of future *Vicia* collection and conservation policy. If *Vicia* material from Soviet Central Asia, seen during a brief herbarium survey, extends the accepted range of morphological variation found in *V. narbonensis*, then further, more detailed investigation may yield the hypothetical faba bean progenitor. As the results of the herbarium survey indicated, Soviet Central Asia is seriously under-collected for forage legumes and the existence of local aberrant forms underscores the necessity of giving the highest priority to their collection, characterization and conservation.

The synthesized ecogeographic data collected during the survey mission indicated that a collection mission should concentrate on collecting in four main areas of Central Asia: Kopet Dag, Turkmania; Western Tadzhikistan; the Pamirs, Tadzhikistan and the Tien Shien, Kirgizia. A full-scale collecting mission was planned to cover these areas during the spring and summer of 1990, but unfortunately this was not feasible because of local political problems. However, a limited-scale survey of forage legumes in Turkmania, Tadzhikistan and Uzbekistan was undertaken during June 1990. The mission resulted from collaboration between the N.I. Vavilov Institute of Plant Industry, Leningrad, the IBPGR and others. During this survey mission many endemics and rare Vicieae species were found, but none showed aberrance seen in the specimens discussed above. This brief collecting mission could only very superficially cover the four areas targeted and so this survey collecting mission should be followed by the establishment of a full collection and conservation program.

In terms of the search for the hypothetical faba bean progenitor, it seems that the aberrant specimens located in Central Asia justify the addition of a third area to the two already identified of Afghanistan, Pakistan and India (Ladizinsky 1975; Cubero 1982) and the Near East (Zohary 1977). Each of these three regions is under-collected for forage legumes and the collection and conservation of forages in these areas warrants a higher priority.

## Acknowledgements

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# Association Analysis over Environments in Faba Bean

# تحليل الاقتران في الفول في بيئات مختلفة

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## Abstract

**A set of diallel crosses involving seven parents and their 21 $F_1$s were studied to characterize the plant type behavior of a population under good and poor management conditions. The correlation coefficients suggested that yield attributes such as pods/plant, seeds/plant, pod-bearing nodes/plant, 100-seed weight and harvest index were positively correlated with seed yield. Path analysis indicated the importance of pods/plant, 100-seed weight, position of first pod, seeds/pod and days to 50% flowering in determining seed yield. Implications of association analysis and its role in the improvement of seed yield are discussed.**

## ملخص

دُرست مجموعة من الهُجن ثنائية الأليل شملت ٧ آباء و٢١ هجيناً من جيلها الأول وذلك لتوصيف نمط سلوك العشائر النباتية تحت ظروف إدارة جيدة وسيئة. وقد أوحت معاملات الارتباط بأن خصائص الغلة مثل القرون/النبات، البذور/النبات، العقد الحاملة للقرون/ النبات، وزن الـ ١٠٠ بذرة ودليل الحصاد ترتبط إيجابياً بغلة البذور. كما أشار تحليل باث إلى أهمية القرون/ النبات، وزن الـ ١٠٠ بذرة، موقع القرن الأول،البذور/ القرن وعدد الأيام حتى بلوغ ٥٠٪ من الإزهار في تحديد غلة البذور. وتُبحث حالياً مضامين تحليل الاقتران ودوره في تحسين غلةالبذور.

## Introduction

To obtain increased yield, understanding correlation between traits is of paramount importance, as they serve as a guide for incorporating the characters of economic importance. Using these corelations, the breeder can select the best donor parents for use in breeding programs. However, they do not give an exact picture of the relationship between characters. The path analysis suggested by Wright (1921) is a useful technique designed to ascertain the path along which relationships among variables are oriented. The present study on the association of various important yield attributes and their pathway is an effort in this direction.

## Materials and Methods

Seven diverse strains of faba bean and their 21 hybrids were evaluated under good management ($E_1$: irrigated and fertilized with DAP at 100 kg/ha at the time of sowing and 15 days after sowing) and poor management conditions ($E_2$: rain-fed and at the native soil fertility level, which was low). Treatment $E_1$ was flood irrigated. Sowing was done on 7 November 1986 and the layout was a randomized complete block design with three replications. Each entry was grown 30 cm apart with plants spaced at 10 cm in single-row plots of 3 m length.

Ten plants were randomly selected to record observations on 13 quantitative traits (Table 1). The simple correlations were calculated by a standard procedure outlined by Panse and Sukhatme (1958) and their significance was tested using a correlation (r) table. The path coefficient analysis at genotypic level was carried out according to the method modified by Dewey and Lu (1959) from the technique originally proposed by Wright (1921). Bartlett's test of homogeneity of error variances was used, which suggested homogeneity of error variances and therefore pooled analysis (P) was carried out for all the characters under study.

## Results and Discussion

Although data are not presented here, the character correlations in the present investigation suggested that the yield components, i.e., pods/plant, pod-bearing nodes/plant, 100-seed weight and harvest index, were positively correlated with yield. Under $E_1$, a positive association existed between seed yield/plant and pods/plant, number of pod-bearing nodes/plant, number of seeds/plant and harvest index. Under $E_2$, seed yield/plant showed a positive correlation with 100-seed weight as well. In pooled analysis, seed yield/plant had a positive association with days to 50% flowering, days to maturity, position of first pod, number of pods/plant, number of seeds/pod, 100-seed weight and harvest index. This existence of a positive association between any two traits suggested that improvement of one character will automatically improve the other.

Table 1. Genotypic path coefficients showing direct and indirect effects of various characters influencing seed yield under good ($E_1$) and poor ($E_2$) management.

| Character | Environment | Days to 50% flowering | Days to maturity | First pod position (cm) | Internode length (cm) | Plant height (cm) | No. primary branches/ plant | No. pods/ plant | No. pod-bearing nodes/ plant | No. seeds/ plant | No. seeds/ pod | 100-seed weight (g) | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% flowering | $E_1$ | 0.10† | 0.00 | -0.04 | 0.01 | 0.03 | -0.00 | 0.11 | -0.02 | 0.03 | 0.09 | -0.05 | 0.01 |
| | $E_2$ | -0.21 | 0.12 | 0.03 | -0.01 | - | - | 0.63 | -0.52 | 0.27 | 0.02 | -0.34 | 0.04 |
| Days to maturity | $E_1$ | 0.00 | 0.03 | 0.02 | 0.00 | -0.01 | -0.00 | 0.00 | -0.01 | -0.03 | -0.09 | 0.23 | 0.01 |
| | $E_2$ | -0.10 | 0.25 | 0.09 | -0.01 | - | - | -0.15 | 0.09 | 0.19 | -0.03 | -0.15 | 0.02 |
| First pod position (cm) | $E_1$ | -0.03 | 0.00 | 0.15 | -0.03 | -0.07 | 0.00 | -0.62 | 0.05 | -0.07 | -0.02 | 0.13 | 0.02 |
| | $E_2$ | -0.06 | 0.20 | 0.12 | -0.00 | - | - | -0.70 | 0.74 | -0.09 | -0.02 | -0.11 | -0.21 |
| Internode length (cm) | $E_1$ | -0.02 | -0.00 | 0.12 | -0.04 | -0.07 | -0.00 | -0.89 | 0.06 | -0.10 | -0.06 | 0.17 | 0.03 |
| | $E_2$ | -0.08 | 0.49 | 0.01 | -0.03 | - | - | -0.65 | 0.68 | -0.53 | 0.02 | -0.09 | -0.44 |
| Plant height (cm) | $E_1$ | -0.20 | 0.00 | 0.08 | -0.02 | -0.12 | 0.00 | -0.38 | 0.03 | -0.06 | -0.08 | 0.08 | 0.01 |
| | $E_2$ | - | - | - | - | - | - | - | - | - | - | - | - |
| No. primary branches/plant | $E_1$ | 0.01 | 0.00 | -0.04 | -0.01 | 0.04 | -0.01 | -0.10 | 0.00 | 0.00 | -0.00 | 0.03 | 0.01 |
| | $E_2$ | - | - | - | - | - | - | - | - | - | - | - | - |
| No. pods/plant | $E_1$ | 0.01 | 0.00 | -0.09 | 0.03 | 0.04 | 0.00 | 1.06 | -0.07 | 0.10 | -0.04 | -0.13 | -0.02 |
| | $E_2$ | 0.07 | -0.02 | -0.04 | 0.01 | - | - | 1.86 | -1.80 | 0.58 | 0.05 | -0.12 | 0.08 |
| No. pod-bearing nodes/plant | $E_1$ | 0.02 | 0.00 | -0.10 | 0.03 | 0.05 | 0.00 | 1.01 | -0.08 | 0.09 | -0.04 | -0.12 | -0.01 |
| | $E_2$ | 0.06 | -0.01 | -0.05 | 0.01 | - | - | 1.85 | -1.81 | 0.54 | 0.05 | -0.10 | 0.08 |
| No. seeds/plant | $E_1$ | 0.02 | -0.01 | -0.08 | 0.03 | 0.05 | -0.00 | 0.81 | -0.05 | 0.13 | 0.18 | -0.44 | -0.02 |
| | $E_2$ | 0.06 | 0.05 | -0.01 | 0.02 | - | - | 1.14 | -1.05 | 0.94 | -0.02 | -0.42 | 0.14 |
| No. seeds/pod | $E_1$ | 0.03 | -0.01 | -0.01 | 0.01 | 0.03 | 0.00 | -0.14 | 0.01 | 0.07 | 0.32 | -0.46 | -0.01 |
| | $E_2$ | 0.05 | 0.08 | 0.02 | 0.01 | - | - | -1.05 | 1.04 | 0.24 | -0.09 | -0.14 | 0.04 |
| 100-seed weight | $E_1$ | -0.01 | 0.01 | 0.03 | -0.01 | -0.02 | -0.00 | -0.23 | 0.02 | -0.10 | -0.25 | 0.61 | 0.02 |
| | $E_2$ | 0.09 | -0.04 | -0.02 | 0.00 | - | - | -0.27 | 0.21 | -0.47 | 0.01 | 0.84 | -0.13 |
| Harvest index | $E_1$ | -0.02 | -0.01 | -0.07 | 0.03 | 0.02 | 0.00 | 0.51 | -0.03 | 0.08 | 0.07 | -0.24 | -0.04 |
| | $E_2$ | -0.04 | 0.02 | -0.11 | 0.07 | - | - | 0.72 | -0.65 | 0.60 | -0.02 | -0.52 | 0.22 |

Residuals: $E_1$ = -0.01; $E_2$ = -0.00

† Underlined values denote direct effects.

Negative association existed between seed yield/plant and position of first pod, length of internode and plant height under $E_1$ and with 100-seed weight in the pooled analysis. This negative association indicates that simultaneous improvement of these traits is not possible. Hence, an independent culling level method has to be used for the improvement of such traits.

The trend of association for most of the traits was similar in the three analyses, but the magnitude of correlation coefficients varied for few traits from one environment to another. The varied estimates of correlation coefficients of different characters under different environments revealed the effect of environment on the expression of the traits. From the consistent estimates of the correlation coefficients for most of the yield-contributing traits, in all the three analyses, it could be concluded that the traits of pods/plant, seeds/plant, pod-bearing nodes/plant, 100-seed weight and harvest index, which possessed a strong positive association with seed yield, should be given due weight when formulating the selection criteria for obtaining higher yields. Similar findings have been reported by Naidu et al. (1985) and Sindhu et al. (1985).

Under $E_1$, pods/plant had the highest positive direct effect on seed yield/plant followed by 100-seed weight, while plant height exerted the highest negative direct effects on seed yield followed by number of pod-bearing nodes/plant (Table 1). Under $E_2$, pods/plant showed the highest positive direct effect on seed yield followed by seeds/pod, while number of pod-bearing nodes/plant had the highest negative direct effect on seed yield followed by days to 50% flowering.

In pooled analysis, the genotypic variances for dependent variable were less than or equal to zero, and therefore path analysis over environments could not be done. Similarly, path coefficients for number of primary branches/plant and plant height have not been worked out under $E_2$.

In accordance with the present findings, Neal and McVetty (1984) and Naidu et al. (1985) have reported pods/plant having the highest positive direct effect on seed yield. The main reasons for the invariably significant role of pods/plant in determining yield may be that each pod contains within itself the other two primary components, number of seeds/pod and seed size (weight).

The indirect effect of pods/plant was negative through position of the first pod, number of pod-bearing nodes/plant and 100-seed weight. Number of pods/plant has a strong influence on seed yield, but the direct effect of this influence is partially counterbalanced by negative indirect effects through the other three components. These negative effects are mostly smaller in value; however, in combination they can affect the yield. This is a clear case of character compensation of yield in faba bean.

Although ranked next to pods/plant in its direct positive effect on grain yield, the utility of number of seeds/pod is doubtful because of its poor genotypic association with seed yield. The 100-seed weight showed a positive, direct effect on seed yield in both environments, suggesting its importance as a yield-contributing trait in faba bean.

The direct effect of number of pod-bearing nodes/plant was negative on faba bean yield in both environments but showed a positive genotypic correlation with seed yield. This may be due to larger negative indirect effects through days to maturity, position of first pod, seed/pod, 100-seed weight and harvest index. The negative direct effects on seed yield of harvest index under $E_1$ and of days to 50% flowering and seeds/plant under $E_2$ were associated positively with seed yield, which may be explained on the basis of yield component compensation.

This study indicates that, to improve seed yield, breeders should concentrate on the characters pods/plant, 100-seed weight, position of first pod and days to maturity, as these traits have a positive, direct effect on seed yield under both types of management.

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# Characterization of Faba Bean Populations by Isoenzyme Patterns of GOT and PGI

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## Abstract

**The Glutamate Oxaloacetate Transaminase (GOT) and Phosphoglucose Isomerase (PGI) isoenzymatic band patterns of nine faba bean populations from Ethiopia and Afghanistan were detected using the Starck-gel electrophoresis method. The Ethiopian populations exhibited a high polymorphism for the GOT system, whereas the PGI system was monomorphic for all the studied populations. The polymorphism observed for GOT may allow the identification of variants useful for breeding and for future evaluation of *V. faba* L. collections.**

# توصيف عشائر الفول بواسطة أنماط خطوط اللون المتماثلة الأنزيم في GOT و PGI

## ملخص

تم رصد أنماط خطوط اللون المتماثلة الأنزيم في *Glutamate Oxaloacetate Transaminase* (GOT) و *Phosphoglucose Isomerase* (PGI) لتسع عشائر من الفول واردة من إثيوبيا وأفغانستان باستخدام طريقة الفصل الكهربائي في هلام ستارك. أظهرت العشائر الأثيوبية تعدداً شكلياً واسعاً لمجموعة GOT في حين كانت PGI متماثلة في جميع العشائر المدروسة. وقد يتيح التعدد الشكلي الملحوظ في GOT تحديد الجوانب المتباينة المفيدة في التربية وفي التقييم المستقبلي لمجموعات *V. faba* L.

## Introduction

In recent years, studies on variability of storage protein electrophoresis patterns in seeds of *Vicia faba* L. have aroused great interest. The purpose of such studies is to improve protein production for essential constituents and particularly for sulfur aminoacids, which are notoriously lacking in grain legumes.

Interesting genotypes with modifications in protein patterns have been discovered in populations originating from Afghanistan and Ethiopia (Polignano et al. 1990).

Additional information besides protein polymorphism can be obtained from the analysis of isoenzymatic patterns. They have been widely used for characterization of genetic resources in different plant species as reported by Andersen and Fairbanks (1990).

In *Vicia faba* L., isoenzymatic polymorphism has been used for taxonomic studies (Ladizinsky 1975; Yamamoto et al. 1982), for varietal identification (Bassiri and Rouhani 1977; Gates and Boulter 1979, 1980; Kaser and Steiner 1983) and for other aspects of breeding activities such as genetic control of some enzymatic systems (Suso and Moreno 1982; De Mora et al. 1983; Mancini et al. 1989) and assessment of heterozygosity (Peat and Adham 1984).

Only recently, Amet (1986) analyzed variation of two enzymatic systems, Glutamate Oxaloacetate Transaminase (GOT) and Phosphoglucose Isomerase (PGI), in accessions of faba bean of different geographic origin and remarked on the lack of exhaustive information about potential genetic variability present in the "genepool" of the species. He anticipated more extensive research on this topic.

The purposes of this study were: (1) to ascertain the variability of isozyme patterns for GOT and PGI systems in faba bean populations originating from Afghanistan and Ethiopia that exhibited different storage protein patterns; (2) to investigate possible associations between storage protein polymorphism and enzymatic polymorphism with particular attention to major legumin fractions, and (3) to obtain preliminary indications on the possibility of using the two isoenzymatic systems for a more extensive study of the whole collection.

## Materials and Methods

The 121 plants analyzed were obtained from individuals belonging to nine faba bean populations originating from Afghanistan and Ethiopia. The corresponding seed storage proteins were characterized by different electrophoretic patterns for presence or absence of the major legumin fractions (Table 1). Plants were grown in a greenhouse.

Table 1. *Vicia faba* populations analyzed for enzymatic patterns.

| Origin | Population | Code | Protein pattern† | No. of plants |
|---|---|---|---|---|
| Ethiopia | MG 106458 | A | 2 | 14 |
| | MG 106468 | B | 4 | 26 |
| | MG 108322 | C | 2 | 15 |
| | MG 108335 | D | 2 | 10 |
| | MG 109250 | E | 4 | 17 |
| Afghanistan | MG 109292 | F | 3 | 19 |
| | MG 109301 | G | 4 | 6 |
| | MG 109302 | H | 4 | 6 |
| | MG 109305 | I | 4 | 13 |

† Number of legumin variants having molecular weight of 35-37 Kd (Polignano et al. 1990).

For enzymatic analysis, extraction was performed using the youngest leaves collected from 3-week-old plants. Leaf tissue (400 mg) was ground in 2 ml extraction buffer (Tris 0.1 M citric acid, pH 7.5; cystine 0.1% w/v; ascorbic acid 0.1% w/v; PVP 1% w/v), and centrifuged at 10,000 rpm for 5 minutes. Filter paper wicks were soaked in the supernatant and the extract was then electrophoresed on starch gel at 4°C and 50 mA for about 4 hours. At the end of the run, the gel was cut in two slices, each about 3 mm thick. Buffers and staining solutions are listed in Table 2.

The similarity coefficient value between pairs of different patterns was calculated according to Sokal and Sneath (1963).

## Results and Discussion

Figure 1 exhibits an interpretive drawing of the electrophoretic patterns relative to GOT observed in the nine studied populations.

Table 2. Buffers and staining methods for isozymes GOT and PGI.

| Isozyme† | Running buffer (TC) | Gel buffer | Staining solution |
|---|---|---|---|
| GOT | Tris/1, 60.57 g | 1:10 TC | 0.1 M Tris-HCl buffer, pH 8, 100 ml |
| | EDTA, 5.99 g | | Pyridoxal-5 phosphate, 30 mg PVP, |
| | Boric acid, 15 g | | 40 mg Aspartic acid, 10 mg Ketoglutamic acid, |
| | pH 8.5 | | 80 mg Fast Blue BB |
| PGI | As above | 1:10 TC | 0.05 M Tris-HCl buffer, pH 8, 100 ml |
| | | | Fructose D-6-phosphate, 100 mg $MgCl_2$, |
| | | | 10 mg NADP, 10 mg MTT,g |
| | | | 10 mg PMS, 3g mg |
| | | | Glucose-6-phosphate, 10 units |

† GOT = Glutamate Oxaloacetate Transaminase; PGI = Phosphoglucose Isomerase


Fig. 1. Interpretive drawing of the electrophoretic patterns relative to GOT observed in nine *V. faba* populations (A-I).

**Table 3. Presence and relative frequency (%) of isozyme bands (GOT and PGI) observed in nine populations of *V. faba.***

| Isozyme | Band | Populations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | H | I |
| GOT-1 | | 71.4 | 76.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| GOT-2 | 1 | 100 | 0 | 66.7 | 20.0 | 100 | 100 | 100 | 100 | 100 |
| | 2 | 42.9 | 61.5 | 33.3 | 100 | 0 | 0 | 0 | 33.3 | 0 |
| | 3 | 0 | 96.2 | 6.7 | 0 | 100 | 100 | 100 | 100 | 100 |
| GOT-3 | 1 | 100 | 7.7 | 100 | 100 | 0 | 100 | 100 | 100 | 15.4 |
| | 2 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 0 | 84.6 |
| PGI-1 | 1 | 85.7 | 53.9 | 100 | 100 | 52.9 | 45.5 | 66.6 | 0 | 0 |
| | 2 | 14.3 | 46.2 | 0 | 0 | 47.1 | 54.5 | 33.3 | 100 | 100 |
| PGI-2 | 1 | 85.7 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 14.3 | 100 | 100 | 0 | 100 | 100 | 100 | 100 | 100 |

In Table 3, data are presented regarding presence and relative frequency of the single bands observed for the two systems. For GOT, three activity zones were observed: GOT-1 (the fastest band), GOT-2 and GOT-3. A total of 6 GOT bands were detected in all the examined populations; consequently the GOT pattern is rather simple and clear differences in band patterns between the populations can be observed easily.

The most variable zone was GOT-2, with three bands, the second one appearing less frequently. In particular, the fastest band of GOT-2 was common in all populations except for B. GOT-1 was observed only in two Ethiopian populations and the relative band was less intense than the ones present in the other zones. Also for GOT-3, observed in all the populations, at least one band was present and the two bands were characterized by a small difference in their mobility.

The presence of three activity zones does not agree with the observation of other authors who reported only two zones, the second one being more variable (Suso and Moreno 1982; De Mora et al. 1983; Amet 1986). On the contrary, according with our results and using polyacrilamide gels, Mancini et al. (1989) observed three zones and the consistent presence of a monomorphic band relative to GOT-1 in all the analyzed samples.

As for the PGI system, two zones of activity were observed in all populations: PGI-1 (faster band) and PGI-2, and each one was characterized by two bands with a different mobility. No polymorphism was observed for this system.

The similarity coefficients showed a wide range of variation from 0.17 to 1.00 (Table 4). The same GOT band pattern was detected in populations F and G, and a similar result also observed in populations H and C. The comparison between populations A and E showed the lowest value of similarity coefficient. Intermediate values were observed for other comparisons. An example of patterns relative to the GOT and PGT enzymatic systems observed in a single Ethiopian genotype (MG 106468) is shown in Figure 2.

Table 4. Similarity coefficient in nine populations of *V. faba*.

| Genotype | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|
| A | 0.50 | 0.67 | 0.83 | 0.17 | 0.50 | 0.50 | 0.67 | 0.33 |
| B | | 0.50 | 0.33 | 0.33 | 0.33 | 0.33 | 0.50 | 0.50 |
| C | | | 0.67 | 0.50 | 0.67 | 0.83 | 1.00 | 0.67 |
| D | | | | 0.33 | 0.67 | 0.67 | 0.83 | 0.50 |
| E | | | | | 0.67 | 0.67 | 0.50 | 0.83 |
| F | | | | | | 1.00 | 0.83 | 0.83 |
| G | | | | | | | 0.83 | 0.83 |
| H | | | | | | | | 0.83 |

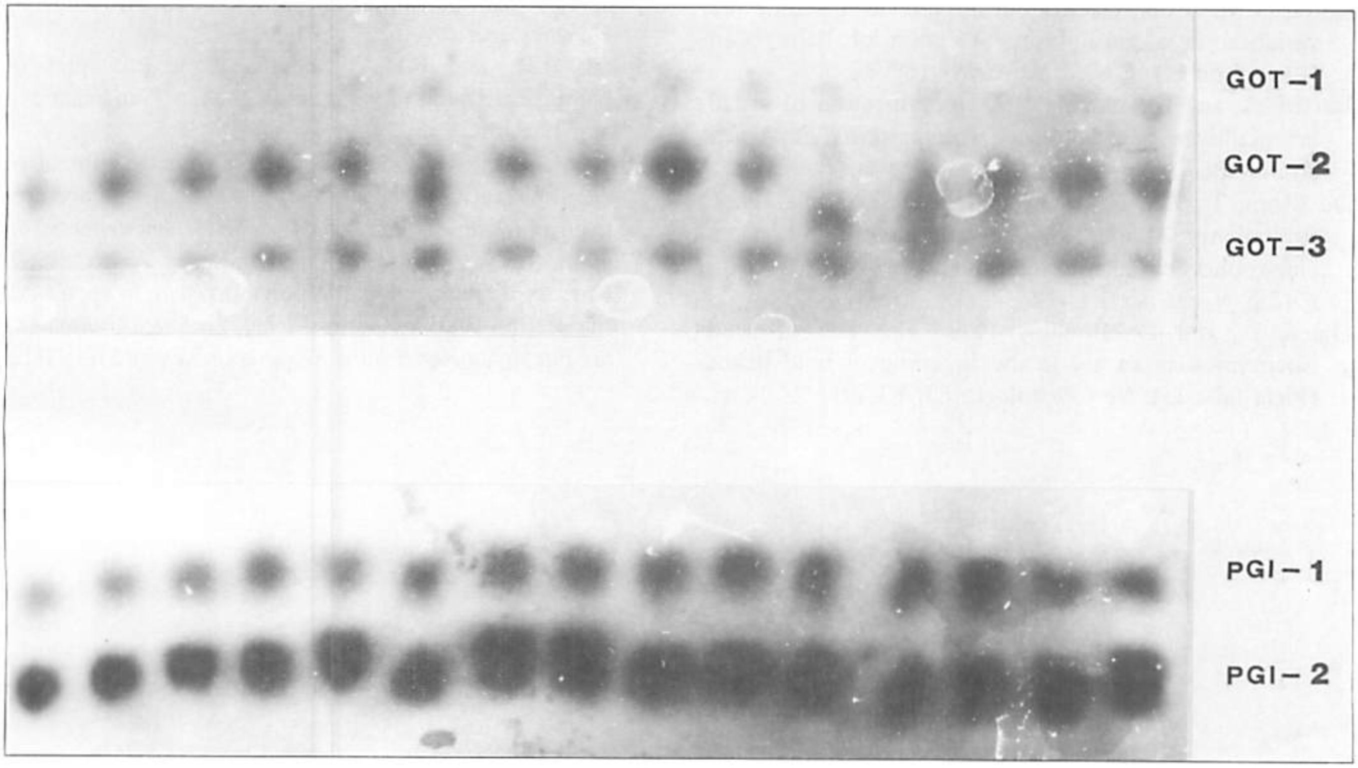


Fig. 2. Electrophoretic patterns relative to the GOT and PGI systems observed in a single *V. faba* population (MG 106468) from Ethiopia.

## Conclusions

Even if data are not enough to draw final conclusions, the study provided some indications. The Ethiopian populations exhibited a higher polymorphism for the GOT system, whereas the PGI system was monomorphic for all the studied populations. No relationship seems to exist between particular legumin fractions in protein patterns and isozyme polymorphism of the two studied systems. Finally, the polymorphism observed for GOT may allow the identification, at genic level, of variants useful for breeding and for future evaluation and diversification of *V. faba* collections.

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# Agronomy and Mechanization

## Effect of Watering Intervals and Hill Planting on Faba Bean Seed Yield and Its Components

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### Abstract

**The effects of three plant densities of 33.3, 49.9 and 66.7 plants/m², corresponding to 2, 3 and 4 seeds/hill, respectively, and two water regimes (irrigation at 7- and 14-day intervals) on faba bean (cv. BF 2/2) yield and its components were investigated during two seasons (1986/87 and 1987/88) at Shambat Research Station. In both seasons watering regime and plant density had a significant effect on seed yield: the highest yields were obtained from the crop irrigated at 7-day intervals and sown at 3 seeds/hill. These rates are recommended as part of the improved production practices for growing faba bean in the Shambat region of Sudan.**

## تأثير الفواصل الزمنية للري ومعدلات البذار "في الجورة الواحدة" في الغلة البذرية للفول ومكوناتها

### ملخص

دُرِست تاثيرات ثلاث كثافات نباتية: ٣٣،٣، ٤٩،٩ و ٦٦،٧ نبتة/م٢ حيث تقابل ٢، ٣، ٤ بذرات/ الجورة الواحدة على التوالي، ونظامي ري ( رية كل ٧ أيام ورية كل ١٤ يوم ) في غلة الفول (الصنف BF 2/2) ومكوناتها خلال موسمي زراعة (١٩٨٦/٨٧ و١٩٨٧/٨٨ ) في محطة بحوث شمباط. وكان لنظام الري والكثافة النباتية تاثير كبير على غلة البذورفي كلا الموسمين: فقد تم الحصول على أعلى الغلال من المحصول الذي تمت سقايته كل ٧ أيام ومعدل بذاره ٣ بذرات/الجورة الواحدة. ويوصى بهذين المعدلين كجزء من معاملات الإنتاج المحسنة لزراعة الفول في منطقة شمباط بالسودان.

## Introduction

Faba bean (*Vicia faba* L.) is the most important pulse in Sudan. It is the main staple food for millions of people and perhaps the main source of protein for middle and low income groups.

The hot spells occurring during the growing season produce appreciable drought stress at certain growth stages of faba beans, which has been identified as a yield-limiting factor for faba bean cultivation in Sudan. Irrigation minimizes the stress by increasing plant vigor and reducing the plant's susceptibility to attack by the root rot/wilt disease complex.

Irrigation water in Sudan is becoming limited because of the increased demands in the cultivated areas, and more expensive because of increases in the price of fuel needed for lifting water. increase in fuel prices. In Sudan many researchers reported that faba bean greatly benefited from watering at 7-day intervals until maturity (Ali et al. 1965–67; Ayoub 1971–73; Babiker 1975-76; Salih 1977; Salih 1985). The response of faba bean to moisture stress at different stages of plant growth (i.e., early vegetative, early pod development and late grain-filling stages) was studied at three different sites in Sudan. The results showed that omission of one irrigation during the vegetative phase produced no significant effect on yield compared with a irrigation at 10-day intervals throughout the growing period. In contrast, water stress during the reproductive phase resulted in considerable reduction in seed yield, and early pod development was the most sensitive stage of plant growth to water stress. This study showed that a savings of three irrigations can be achieved by adopting a 15-day interval irrigation regime, which was less damaging than missing two irrigations during the reproductive stage of growth in the 10-day interval regime (Mohamed et al. 1988).

Faba beans are known to be highly variable in their response to plant population. Ishag (1970) did not find any significant reduction in grain yield when plant spacing was varied between 10 and 30 cm or when 2 or 3 plants/hill were used, but yield was significantly decreased seed yield was obtained from 3 seeds/hill in cv. BF 2/2 but no difference was noticed in cv. Rebaya 40 by sowing at 1 to 3 seeds/hill. This may be attributed to differences in leaf angle between the two cultivars. Ageeb (1976) showed that variation in row spacing (60, 40 and 20 cm), plant spacing (20, 10 and 5 cm) and the number of plants per hill (1 and 2) had no effect on the grain yield of cv. Hudeiba 72. Salih (1978), in a study of the effect of plant density at Zeitab, found that the seed yield at 2, 3 and 4 seeds/hill was greater than the yield at 1 seed/hill by 25, 34 and 39%, respectively. Recently, Salih (1987b) reported that there was a linear seed yield increase with increasing number of plants per from 1 to 3 seeds/hill.

The objective of this investigation was twofold: to study the effect of irrigation intervals on faba bean yield in an attempt to find the optimum interval which would not stain yield losses, and to find the optimum plant population for different watering regimes.

## Materials and Methods

Three plant populations (33.3, 49.9 and 66.7 plants/$m^2$) were tested under two water regimes (irrigation at 7- and 14-day intervals) in a split-plot design with four replicates. Watering interval was assigned to the main plots and plant population to subplot. The subplots were 3.6 × 6.0 m, of which 2.4 × 5.2 m was harvested for seed yield. The experiment was sown on 27 October 1986 and 1 November 1987 at Shambat Research Farm in heavy clay soil with pH 8.5. Planting was done on both sides of 60-cm ridges at 20-cm plant spacing with 2, 3 and 4 seeds/hill to give the theoretical plant populations of 33.3, 49.9 and 66.7 plants/$m^2$. The irrigations were given to establish the crop before the start of a differential moisture regime. The number of waterings given at 7- and 14-day regimes were 12 and 6, respectively, in each season. The cultivar used was BF 2/2.

Total seed yield was recorded for each subplot. The number of pods/plant, 100-seed weight and plant height were determined from 20 randomly selected plants per subplot. The flowering date of each experimental subplot was determined when more than 50% of the plants were in bloom. The maturity date was recorded when about three-quarters of the pods along the plants were dried and most of the rest had turned from green to yellow. Maturity of the seed was accompanied by a rapid dropping of leaves and drying of the stem. Plant stand was determined by counting the number of plants in each subplot at harvesting time.

## Results and Discussion

The overall mean seed yield of 1986/87 exceeded that of 1987/88 by 26.6% and that was due to number of pods/plant, which was higher in 1986/87 than in 1987/88 by 47%. The meteorological data presented in Table 1 showed that the maximum and minimum temperature average for the period 1–10 December, which coincides with 50% flowering, was 5°C higher in the 1987/88 season than in 1986/87. This induced more flower shedding in 1987/88 than in 1986/87, and consequently fewer pods/plant were formed in that season.

The effect of irrigation on the grain yield was highly significant in two seasons. Irrigation at 7-day intervals increased the yield by 1280 and 1195 kg/ha over the irrigation at 14-day intervals in 1986/87 and 1987/88, respectively (Table 2).

The frequent irrigation, besides its main role in satisfying the crop's needs, creates a cooler microclimate less favorable for wilt/root rot disease and more favorable to plant growth and development (Ageeb 1979). In an earlier experiment at Shambat and Wad Medani, irrigation every 7 days increased the grain yield by 83 and 128%, respectively, compared with a 14-day interval (Salih and Ageeb 1983).

Irrigation at 7-day intervals resulted in significant increases in the seed yield/plant, 100-seed weight and number of pods/plant (Table 2). Water stress greatly reduced the formation of fruiting bodies and hence the total number of pods that developed at maturity. These results are in agreement with those of Salter and Goode (1967) and Salih (1985). In another study at Shambat, Salih (1987a) reported that the effect of 7-day watering in comparison with 14-day intervals on number of pods/plant was significant only once in 3 years of testing.

In this study irrigation had no effect on number of seeds/pod, number of plants/$m^2$, plant height, plant stand percent and days to 50% flowering in both seasons (Table 2). Salih (1985) reported that watering every 7 days significantly increased number of seeds/pod by 7.5% compared with the 14-day regime. Salih (1987a) confirmed that frequent irrigation had no significant effect on number of plants/$m^2$.

Plant population had no significant effect on seed yield in either season. This was because the actual stand obtained was less than what was aimed at in the treatments. Salih (1987b) reported that the highest seed

**Table 1. Mean maximum and minimum temperatures (°C) for Shambat during October–March 1986/87 and 1987/88 seasons.**

| Month | Period (10-day average) | Maximum 1986/87 | Maximum 1987/88 | Minimum 1986/87 | Minimum 1987/88 |
|---|---|---|---|---|---|
| | 1–10 | 38.3 | 39.5 | 24.4 | 26.6 |
| October | 11–20 | 44.3 | 39.5 | 24.7 | 26.5 |
| | 21–31 | 38.6 | 36.1 | 23.5 | 21.7 |
| | 1–10 | 35.5 | 36.9 | 20.4 | 20.5 |
| November | 11–20 | 33.9 | 36.1 | 18.2 | 20.4 |
| | 21–30 | 35.2 | 34.9 | 19.7 | 18.8 |
| | 1–10 | 27.2 | 32.4 | 12.7 | 17.8 |
| December | 11–20 | 28.6 | 31.8 | 13.1 | 17.3 |
| | 21–31 | 30.8 | 29.3 | 13.7 | 13.6 |
| | 1–10 | 28.7 | 31.8 | 11.5 | 14.1 |
| January | 11–20 | 32.6 | 26.6 | 14.5 | 13.1 |
| | 21–31 | 30.6 | 32.1 | 15.8 | 14.9 |
| | 1–10 | 33.0 | 32.5 | 17.0 | 16.3 |
| February | 11–20 | 34.6 | 30.6 | 16.2 | 14.0 |
| | 21–29 | 35.3 | 33.2 | 17.3 | 14.2 |
| | 1–10 | 32.4 | 40.2 | 17.8 | 20.9 |
| March | 11–20 | 35.8 | 34.8 | 15.7 | 19.7 |
| | 21–31 | 38.5 | 36.6 | 18.9 | 18.6 |

**Table 2. Effect of plant population and watering interval on seed yield and some yield components of faba bean (cv. BF 2/2) during the 1986/87 and 1987/88 seasons.**

| | Seed yield (kg/ha) | Seed yield/ plant (g) | No. of pods/ plant | No. of seeds/ pod | 100-seed weight (g) | No. of plants/ $m^2$ | Plant stand (%) | Plant height (cm) | Days to 50% flowering | Days to full maturity |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1986/87 Season | | | | | |
| Watering intervals (days) | | | | | | | | | | |
| 7 | 3289 | 12.0 | 20.6 | 2.55 | 41.4 | 31.6 | 64.7 | 84.3 | 34.7 | 104.2 |
| 14 | 2009 | 7.2 | 18.6 | 2.59 | 39.0 | 27.3 | 57.0 | 76.9 | 35.7 | 103.5 |
| S.E. ± | 31.1 | 0.66 | 0.25 | 0.02 | 0.22 | 1.14 | 1.47 | 5.11 | 0.72 | 0.13 |
| Plant populations (plants/$m^2$) | | | | | | | | | | |
| 33.3 | 2717 | 11.9 | 22.0 | 2.68 | 35.0 | 23.5 | 70.7 | 80.0 | 35.3 | 103.7 |
| 49.9 | 2733 | 9.9 | 19.9 | 2.47 | 41.4 | 29.2 | 58.5 | 81.7 | 35.0 | 104.0 |
| 66.6 | 2499 | 7.1 | 17.0 | 2.55 | 44.1 | 35.6 | 53.4 | 80.1 | 35.2 | 104.0 |
| S.E. ± | 186.6 | 0.93 | 1.45 | 0.13 | 0.38 | 2.08 | 3.40 | 1.53 | 0.20 | 0.14 |
| Mean | 2649 | 9.6 | 19.6 | 2.57 | 40.2 | 29.4 | 60.8 | 80.6 | 35.2 | 103.9 |
| | | | | | 1987/88 Season | | | | | |
| Watering intervals (days) | | | | | | | | | | |
| 7 | 2542 | 12.5 | 11.7 | 2.66 | 41.5 | 30.6 | 64.2 | 82.7 | 36.7 | 103.3 |
| 14 | 1347 | 9.9 | 9.1 | 2.58 | 38.7 | 30.2 | 62.8 | 76.5 | 37.5 | 101.1 |
| S.E. ± | 42.4 | 0.42 | 0.39 | 0.05 | 0.42 | 2.95 | 5.70 | 1.69 | 0.67 | 0.29 |
| Plant populations (plants/$m^2$) | | | | | | | | | | |
| 33.3 | 1966 | 14.5 | 12.4 | 2.54 | 37.8 | 23.1 | 71.3 | 78.3 | 37.3 | 102.7 |
| 49.9 | 2028 | 11.0 | 9.9 | 2.68 | 40.0 | 32.8 | 65.7 | 79.8 | 37.2 | 102.7 |
| 66.6 | 1838 | 8.3 | 8.8 | 2.63 | 42.5 | 35.4 | 53.5 | 80.7 | 36.8 | 101.3 |
| S.E. ± | 96.6 | 0.45 | 0.82 | 0.07 | 0.40 | 1.18 | 2.22 | 0.57 | 0.25 | 0.42 |
| Mean | 1944 | 11.3 | 10.4 | 2.62 | 40.1 | 30.4 | 63.5 | 79.6 | 37.1 | 102.2 |

yield was obtained from a population density of 3 seeds/hill (49.9 plants/m$^2$). Also from Shambat, Taha et al. (1983) reported that plants at a density of 3 seeds/hill outyielded those at a density of 1 and 2 seeds/hill by 12.7 and 10.2%, respectively.

In both seasons the number of pods/plant decreased with increase in plant density from 33.3 to 66.6 plants/m$^2$, as has been reported by others (Ageeb 1976; Pandey 1981; Salih 1983). Also, the seed yield/plant decreased as the population increased. The reverse was true with 100-seed weight. These results were in agreement with Salih (1987b). The effect of plant population on the number of seeds/pod, plant height, days to 50% flowering and days to maturity was not significant in either year. Some workers found little or no effect of plant population on 100-seed weight and number of seeds/pod (El-Saeed 1968; Kambal 1968; Ishag 1971; Ageeb 1976; Pandey 1981; Salih 1983, 1987b).

The interactions between plant population density (number of seeds/hill) and watering regimes for all the studied characters in both years were not significant. It is recommended that for economical seed yield, faba beans should be planted at Shambat in two rows per ridge (60 cm wide), with 3-seeded hills 20 cm apart and be irrigated at weekly intervals.

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# *Physiology and Microbiology*

## Effect of Variety and Plant Density on the Pattern of Dry-Matter Accumulation in Faba Bean

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### Abstract

**A field experiment was conducted on loam and silty clay loam soils during the winter seasons of 1980/81 and 1982/83, respectively, at the Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar to study the pattern of dry-matter accumulation and distribution in stem, leaf and pod as affected by variety and plant density. With the advancement in crop age the dry-matter accumulation in stem and leaf increased up to 105 days after sowing and in pod and whole plant up to maturity. The dry-matter accumulation in stem, leaf and whole plant at maturity was significantly higher in BS 1 than in UPS 1 during 1980/81. The dry-matter accumulation in whole plant increased with an increase in plant density up to 200 plants/m².**

## تأثير الصنف و الكثافة النباتية على نمط تراكم المادة الجافة في الفول

### ملخص

أجريت في مركز بحوث المحاصيل التابع لـ .G.B، جامعة بانت للزراعة والتكنولوجيا في بانتناجار، تجربة حقلية على الترب الطمية والترب الطمية الجيرية السلتية خلال الموسمين الزراعيين الشتويين ١٩٨٠/٨١ و ١٩٨٢/٨٣ على التوالي، وذلك بهدف دراسة نمط تراكم وتوزع المادة الجافة في سوق نبات الفول وأوراقه وقرونه حسب تأثره بالصنف والكثافة النباتية. ومع نمو النبات ازداد تراكم المادة الجافة في السوق والأوراق حتى ١٠٥ أيام بعد الزراعة ،أما في القرون والنبات ككل فارتفع حتى النضج. وقد كان تراكم المادة الجافة في السوق والأوراق والنبات ككل عند النضج أعلى معنوياً في الصنف BS1 منه في الصنف UPS1 خلال موسم ١٩٨٠/٨١، كما تزايد تراكم المادة الجافة في النبات ككل حينما تزايدت الكثافة النباتية حتى ٢٠٠ نبتة/م2.

## Introduction

Faba bean (*Vicia faba* L.) is an important food legume crop in the world but it has not been given due attention in Indian agriculture so far (Khare et al. 1984). For assessing its production potential under Indian conditions, an understanding of the dry-matter accumulation pattern in various plant parts will be useful. This investigation was undertaken to study the pattern of dry-matter accumulation in different plant parts as affected by variety and plant density.

## Materials and Methods

A field experiment was conducted during the winter seasons of 1980/81 and 1982/83 on loam and silty clay loam soils, respectively, at the Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar, under irrigated conditions. The loam soil in the 1980/81 experiment was low in organic carbon and high in available phosphorus and potassium; the silty clay loam soil in 1982/83 was high in organic carbon and available potassium, and medium in available phosphorus content. The soils of both fields were neutral in reaction.

The treatments, consisting of two varieties (UPS 1 and BS 1) and five plant densities (12.5, 25, 50, 100 and 200 plants/m²), were laid out in a randomized block design with four replications. A uniform basal application of diammonium phosphate (18% N and 46% $P_2O_5$) was made at the rate of 100 kg/ha. Seeds were sown in furrows 20 cm apart during the first week of November. Two seeds/hill were put at distances of 2.5, 5, 10, 20 and 40 cm. A single plant was allowed to grow at each place. Samples were taken for recording dry-matter accumulation in different plant parts and the whole plant at 35, 70, 105 and 140 days after sowing (DAS).

**Table 1. Total dry-matter accumulation (g/m²) at successive stages of growth as affected by variety and plant density.**

| | Days after sowing | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1980–81 | | | | 1982–83 | | | |
| Treatment | 35 | 70 | 105 | 140 | 35 | 70 | 105 | 140 |
| **Variety** | | | | | | | | |
| UPS 1 | 27.6 | 129.3 | 574.0 | 978.0 | 39.3 | 127.1 | 328.6 | 822.0 |
| BS 1 | 27.3 | 127.0 | 495.8 | 963.6 | 38.7 | 135.1 | 426.0 | 845.3 |
| LSD (P = 0.05) | NS | 2.1 | 11.2 | NS | NS | 3.0 | 15.9 | 20.0 |
| **Plant density (plants/m²)** | | | | | | | | |
| 12.5 | 12.8 | 90.3 | 357.0 | 867.2 | 21.3 | 88.3 | 257.3 | 675.3 |
| 25 | 21.6 | 96.1 | 428.9 | 972.4 | 32.8 | 102.2 | 315.2 | 758.2 |
| 50 | 28.9 | 114.5 | 554.0 | 983.3 | 40.3 | 132.1 | 397.4 | 803.4 |
| 100 | 34.3 | 150.9 | 609.0 | 991.5 | 48.3 | 160.3 | 511.6 | 938.5 |
| 200 | 39.6 | 188.9 | 724.5 | 1040.3 | 52.2 | 172.7 | 544.3 | 991.3 |
| LSD (P = 0.05) | 2.1 | 3.4 | 17.8 | 20.0 | 1.2 | 4.8 | 25.2 | 30.0 |

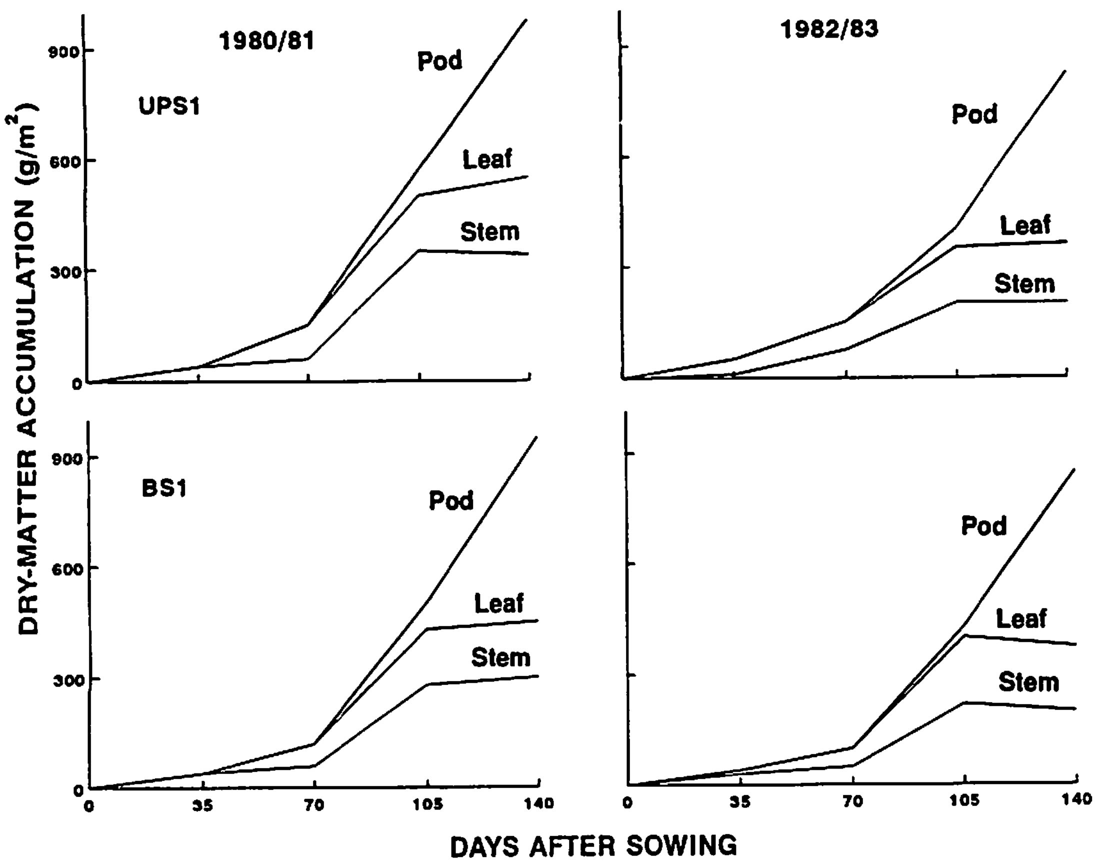


**Fig. 1. Dry-matter accumulation in various plant parts at successive stages of growth as affected by variety. LSD (P = 0.05) at 140 DAS: 1980/81, NS; 1982/83, 20.0.**

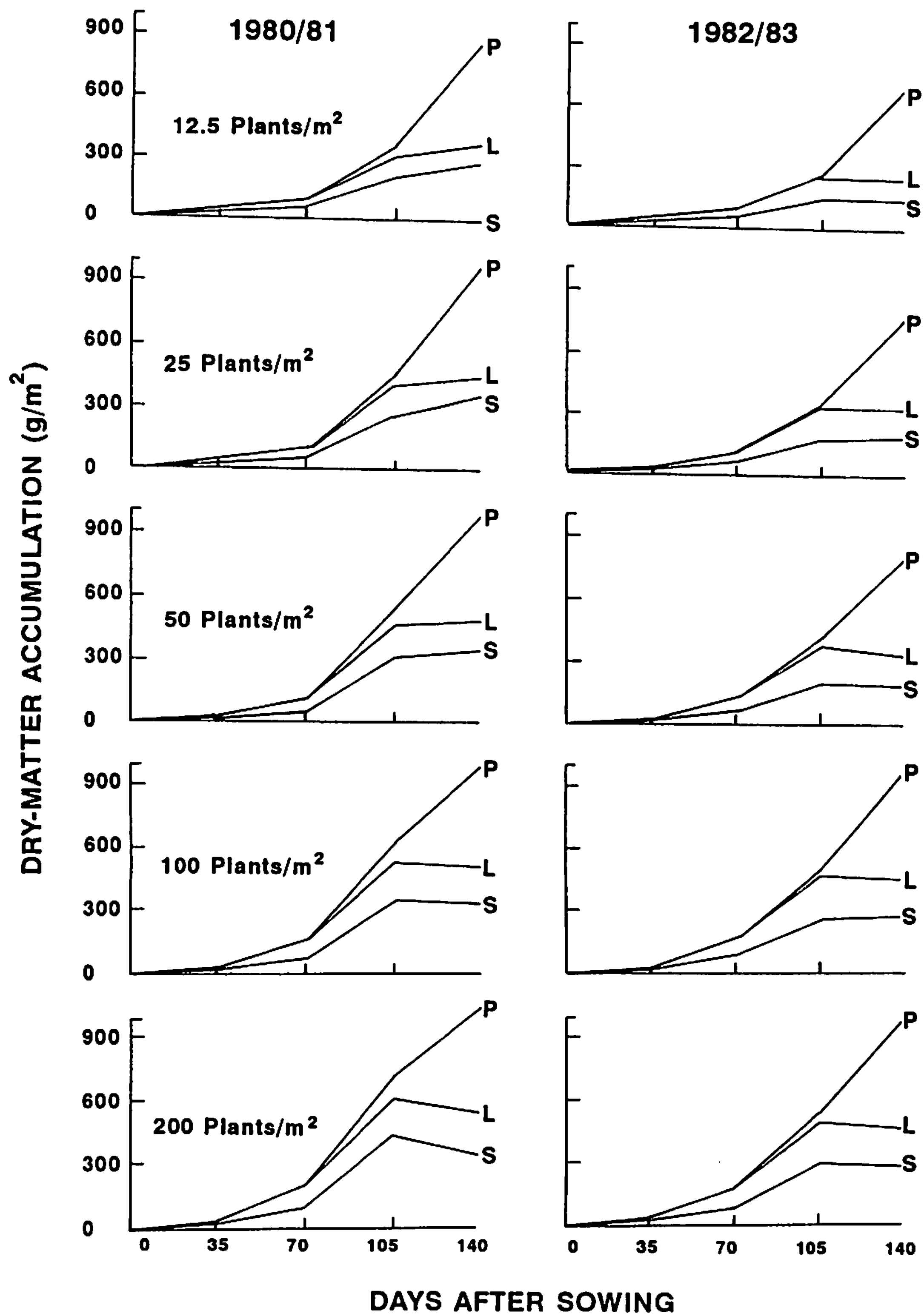


Fig. 2. Dry-matter accumulation in various plant parts at successive stages of growth as affected by plant density. LSD ($P = 0.05$) at 140 DAS: 1980/81, 20.0; 1982/83, 30.0. P = pod; L = leaf; S = stem.

## Results and Discussion

### Effect of variety

Dry-matter accumulation in stem and leaf increased with advancement in crop age in both varieties up to 105 DAS and decreased later in both years (Fig. 1). Ishaq (1973) also observed maximum dry weight of stem and leaf of four varieties of faba bean at the initiation of pod-filling stage. Dry-matter accumulation at maturity (140 DAS) was significantly higher in stem and leaf of BS 1 than of UPS 1 in 1982/83 and in the stem of UPS 1 in 1980/81. The total dry matter increased up to maturity in both varieties in both years (Table 1). The rate of increase in total dry-matter accumulation, especially during the period 105-140 DAS, was 12.3 g $m^{-2}$ $day^{-1}$, mainly owing to fast development of pods. However, varietal differences with respect to dry-matter accumulation in pod at maturity were not significant. About 46% of total dry matter was accumulated during 105-140 DAS. BS 1 accumulated significantly more dry matter than UPS 1 at maturity in 1982/83, whereas the differences between varieties in 1980/81 were not significant.

### Effect of plant density

A gradual increase in total dry-matter accumulation ($g/m^2$) was observed with increased plant density up to 200 plants/$m^2$ at all growth stages during both years (Table 1). However, at 140 DAS, significantly higher dry matter in stem was recorded with 25 and 200 plants/$m^2$ than with 12.5, 50 and 100 plants/$m^2$ in 1980/81. In 1982/83, densities of 100 and 200 plants/$m^2$ were significantly higher in stem dry matter than the other plant densities (Fig. 2). A significant increase in dry-matter accumulation in leaf at maturity was observed with increasing plant density up to 200 plants/$m^2$, but the differences between 25 and 50 plants/$m^2$ in both years and between 100 and 200 plants/$m^2$ in 1982/83 were not significant. In both years, dry-matter accumulation in pod at maturity increased significantly with each increase in plant density up to 200 plants/$m^2$ except that differences between 12.5 and 25, and 50 and 100 plants/$m^2$ in 1980/81 and 12.5 and 50, 25 and 50, and 50 and 100 plants/$m^2$ in 1982/83 were not significant.

Total dry-matter accumulation increased significantly with increase in plant density in both years at all stages of crop growth except at 140 DAS when the differences in total dry-matter accumulation at 25, 50 and 100 plants/$m^2$ in 1980/81 were not significant (Table 1). The average increase in total dry-matter accumulation at 140 days over a plant density of 12.5 plants/$m^2$ was 10, 16, 25 and 31% at 25, 50, 100 and 200 plants/$m^2$, respectively. This highlights the importance of plant density in realizing high dry-matter accumulation.

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# Effect of Insect Pollination on Abortion Rate in Faba Bean

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## Abstract

**A study was undertaken at INRA Rennes to assess the consequences of various pollinating conditions under insect-proof cages and in an open field on abortion rate of reproductive organs in two faba bean lines. One line (D-27) was self fertile and the other (D-23) was not. Outcrossing rate also was studied under these pollinating conditions. Results showed that for the self-fertile line D-27 insect pollination had no effect on seed production or abortion rate. However, insect visitations were obligatory to secure fertilization in D-23 and to significantly reduce abortion rate. The calculated outcrossing rate for the self-fertile line D-27 proved to be very low (less than 10% of recombinants in progenies) compared with allogamy rate (about 50% of alternate visits between the two lines).**

# تأثير تلقيح الحشرات في معدل فشل محصول الفول

## ملخص

نُفذت دراسة في إنرا، رين، لتقييم انعكاسات ظروف تلقيح متعددة، ضمن أقفاص مانعة للحشرات وفي حقول مفتوحة، على معدل فشل أعضاء التكاثر في سلالتين من الفول، إحداهما (د-٢٧ ) ذاتية التلقيح والأخرى (د-٢٣ ) لم تكن كذلك. كما دُرِس معدل التلقيح الخلطي تحت ظروف التلقيح نفسها. أظهرت النتائج أن تلقيح الحشرات بالنسبة للسلالة د-٢٧، الذاتية التلقيح، لم يكن له أي أثر في إنتاج البذور أو معدل الفشل . وكان لابد من تردد الحشرات على السلالة د-٢٣ لضمان التلقيح، وتخفيض معدل الفشل بشكل كبير. لقد تبين أن معدل التلقيح الخلطي المحسوب للسلالة الذاتية التلقيح،د-٢٧، منخفض جداً (أقل من ١٠٪ من مواد الترابط الوراثية في الأنساب) بالمقارنة مع معدل التمازج (حوالي ٥٠٪ من الزيارات المتعاقبة بين السلالتين ).

## Introduction

Faba bean (*Vicia faba* L.) is a self-compatible species including self-fertile, nonself-fertile and intermediate types according to their need for insect visitations to secure fertilization. In self-fertile types, fertilization can be achieved without any outside intervention, whereas in other types fertilization depends on insects (principally honeybees and bumblebees) for tripping the staminal column.

This legume crop is widely grown in France and some other European countries, but expansion of crop area is difficult because of the unreliability of its yield in our conditions. Part of this unreliability may be attributed to high abortion rates. One possible hypothesis to explain the abortion rate is that insect activity might be a limiting factor in cases where they are not numerous enough to secure sufficient fertilization.

The aim of this study was to determine the actual role of different pollinators on flower and pod abortions, yield and yield components, and effective outcrossing rate.

## Materials and Methods

Trials were conducted at the INRA Plant Breeding Station near Rennes using two spring faba bean lines provided by Dr G. Duc. The self-fertile line D-27 had a beige-colored testa; the nonself-fertile line D-23 had a purple-colored coat.

A randomized complete block with three replications was used. A factorial arrangement of the two studied varieties D-23 and D-27 (two lines of 10 plants each) with five treatments:

1. Ab = Cages with honeybees (*Apis mellifica*)
2. Bo = Cages with bumblebees (*Bombus lapidarius*)
3. Au = Cages with no insects or tripping of flowers by hand
4. Dm = Cages with no insects but with hand tripping of flowers
5. Pl = No cage with open pollination

Cages were 3 x 3 x 2 m (l x w x h) covered by 2 mm mesh put on each plot before the flowering period. A small hive (a queen with 5000 honeybees) or a special box with a queen of *Bombus lapidarius* was put under each cage for treatments 1 and 2.

Abortion rates were obtained for flowers, young pods (2 cm length), old pods (>5 cm) and mature pods (at harvest). Counts were taken every 2 days on five plants of each variety per plot. Pollinating efficiency was determined using yield component data. Outcrossing rates were evaluated from counts of the number of purple seeds using the progenies of self-fertile line D-27 from each insect treatment.

## Results

Line D-27 had more flowers than line D-23 (96 vs. 65 flowers per plant) and nectar secretions were significantly more abundant in D-27 than in D-23 (0.57 vs. 0.14 $\mu$l per plant). Also, sugar concentration of the nectar was higher in D-27 than in D-23 (30% vs. 19%). Nevertheless, there were no differences in attractivity to pollinating insects.

Flora abortion rates were generally low for D-23 (from 3 to 8%) compared with D-27 (9 to 23%) (Table 1). The highest abortion rates were obtained from treatment 1 with honeybees, 8% and 23% for D-23 and D-27, respectively.

Abortions in young pods were higher than those for flowers (4 to 28 times higher for D-23 and 2 to 6 times higher for D-27). For all treatments except selfing, abortion rates were higher in the self-fertile line D-27 than in D-23. In the case of selfing, abortions of young pods in D-23 were significantly higher than in D-27 (1.6 times) and higher by 2.6 times than in the other treatments of D-23.

For old pods (length >5 cm) abortion rates were considerably lower in all treatments (Table 1), the highest value occurring in the selfing treatment of D-23.

The absolute abortion rate, corresponding to the percentage of flowers without mature pods, was between 35 and 41% in treatments of line D-23 and between 62 and 68% in line D-27. Differences between genotypes were statistically significant, but with the selfing treatment the absolute abortion rate of D-23 was 1.4 times higher than the corresponding value in D-27 and 2.2 times higher than those of other treatments in D-23.

Few differences were observed within genotypes among treatments for yield components (Table 2). The only significant differences recorded arose from the poor behavior of D-23 under selfing conditions, essentially for seeds per plant, number of seeds per pod and seed yield per plant. On the contrary, as a result of compensating phenomena, 1000-seed weight was from 1.4 to 1.7 times higher for this genotype under enforced selfing.

The outcrossing rate was close to 10% from the progenies of the beige-coated line D-23 (the beige coat character is monogenic, recessive and allelic of the red testa color, which is dominant) and corresponds to the percentage of plants with purple testa in these progenies. This value was slightly different for honeybee and bumblebee treatments but not significantly. On the contrary, this outcrossing rate was significantly different

**Table 1. Mean values of abortion rates at different developing stages for the self-fertile line D-27 and the nonself-fertile line D-23 under various pollination treatments.**

| | Line | Ab† | Bo | Au | Dm | Pl |
|---|---|---|---|---|---|---|
| Abortion rate at the flower stage | D-27 | 23 ± 4.0a‡ | 12 ± 3.8bc | 14 ± 1.5b | 9 ± 1.8bcd | 13 ± 1.8bc |
| | D-23 | 8 ± 2.0cde | 5 ± 1.6de | 3 ± 0.7e | 3 ± 1.0e | 4 ± 1.3de |
| Abortion rate at the young pod stage | D-27 | 55 ± 5.3b | 60 ± 3.4b | 53 ± 3.5b | 56 ± 4.2b | 53 ± 3.2b |
| | D-23 | 33 ± 3.7c | 32 ± 5.2c | 83 ± 5.9a | 32 ± 2.9c | 30 ± 6.3c |
| Abortion rate at the mature pod stage | D-27 | 2 ± 0.6c | 2 ± 0.9c | 3 ± 0.7c | 10 ± 8.1bc | 8 ± 2.7bc |
| | D-23 | 4 ± 1.5c | 7 ± 1.2c | 28 ± 14.5a | 2 ± 1.0c | 18 ± 5.7ab |
| Absolute abortion rate | D-27 | 68 ± 2.1b | 67 ± 2.7b | 62 ± 2.5b | 62 ± 3.0b | 62 ± 3.0b |
| | D-23 | 41 ± 2.6c | 39 ± 4.5c | 86 ± 5.7a | 35 ± 3.1c | 41 ± 7.3c |

† Abbreviations for treatments are as in text.

‡ The same letter after treatment values indicates an identical statistical level between treatments for each stage.

**Table 2. Mean values of yield and yield components for the self-fertile line D-27 and the nonself-fertile line D-23 under various pollination treatments.**

| | Line | Ab† | Bo | Au | Dm | Pl |
|---|---|---|---|---|---|---|
| Number of seeds per pod | D-27 | 3.3 ± 0.0ab‡ | 3.3 ± 0.1ab | 3.1 ± 0.1abc | 3.4 ± 0.1a | 3.0 ± 0.2bc |
| | D-23 | 2.8 ± 0.2c | 3.1 ± 0.1abc | 2.3 ± 0.1d | 2.8 ± 0.2c | 3 ± 0.2abc |
| 1000-seed weight (g) | D-27 | 429 ± 22bcd | 416 ± 18bcd | 441 ± 16bc | 436 ± 15bcd | 401 ± 25cd |
| | D-23 | 449 ± 7bc | 418 ± 11bcd | 658 ± 12a | 457 ± 15c | 387 ± 29d |
| Yield/plant (g) | D-27 | 31.6 ± 4.2a | 33.3 ± 4.9a | 39.9 ± 3.5a | 41.1 ± 2.7a | 31.6 ± 0.2a |
| | D-23 | 31.1 ± 2.8a | 33.5 ± 2.3a | 5.7 ± 0.2b | 32.7 ± 2.1a | 30.2 ± 2.4a |
| Number of seeds/plant | D-27 | 73.3 ± 2.8abc | 80 ± 10.8abc | 90.9 ± 9.4ab | 94.4 ± 5.7a | 79.5 ± 5.4abc |
| | D-23 | 69.4 ± 6.3c | 80.2 ± 5.7abc | 8.6 ± 0.3d | 71.9 ± 6bc | 78.2 ± 4.7abc |
| Outcrossing rate | D-27 | 9.4 ± 0.6a | 11.6 ± 0.8a | 0 | 0 | 5.1 ± 0.5b |

† Abbreviations for treatments are as in text.
‡ The same letter after treatment values indicates an identical statistical level between treatments for each stage.

between insect treatments under cages and the outside treatment (9.4 and 5.1%, respectively). This difference can be explained by considering that in the field environment, most of the faba bean genotypes had beige testa. Thus, insects that visited plants in the analyzed trial had a high probability of carrying "beige pollen" from surrounding plants. Alternate visits to D-27 were direct, without detours to the purple-coated line D-23. These factors explain why we recorded only half the percentage of the colored seeds obtained under cage conditions.

## Discussion

This study corroborates the existence of important phenomena for abortion of reproductive organs previously reported for faba bean (Raphanel 1984) and other closely related species (Delaude and Tasei 1972). The variations observed under our experimental conditions prompt the following remarks.

First, it is likely that the low abortion rate observed in treatments with honey bees was associated with too frequent visits of insects which were obviously too numerous (about 5000 bees per hive) for the few plants at their disposal.

The self-fertile line D-27 showed more susceptibility to flower and young pod abortions that the nonself-fertile line D-23. This can be related to the higher flower production exhibited by the self-fertile line, so that a higher level of flower abortion resulted in the same level of seed production (Table 2). Under selfing, the abortion rates of flowers and young pods, as well as the values of yield and yield components obtained with the self-fertile line D-27, were not different from those exhibited under other pollination treatments.

The nonself-fertile line D-23, on the other hand, was characterized by considerably more flower and pod abortions under selfing than under the other modes of pollination. Yield components were significantly lower under selfing than under other pollination treatments, except for seed size which was greater because of a normal phenomenon of compensation. In reality, line D-23 is not completely nonself-fertile because it was observed that under selfing conditions, the maximum abortion rate was 86%, indicating that 14% of the flowers were able to produce pods in the absence of external pollination. For each treatment other than selfing, abortion rates and yield components were identical.

The observed outcrossing rates were very low in our experiment (between 5 and 11%) when estimated by morphological markers as well as by enzymatical ones. This level of hybridization does not compare with the allogamy rate (between 40 and 60%) generally proposed for spring type faba bean under our environmental conditions (Bonjean and Helle 1979). This observation raises the important question of the relation existing between the frequency of insect visits on flowers and the actual rate of hybridization to be expected in the progenies.

In conclusion, it is obvious from our results that insect intervention is not absolutely necessary to ensure pollination in self-fertile genotypes of faba bean. However, bee visitations are necessary to fertilize nonself-fertile material such as line D-23, which represents the most common situation in our local material. For such material, insect activity leads to a large reduction in abortion rates and to a significant yield increase. Finally, it appears that, even if self fertility by itself does not give higher production, in the absence or low activity of pollinating insects, this phenomenon permits the plant to produce normally. Self fertility can be considered from this point of view as a regulating factor that may secure yield, for example in countries with a low density of natural pollinators.

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# Pests and Diseases

## Induction of Resistance in Faba Bean against Chocolate Spot and Rust Diseases Using Ethephon Seed Treatment

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### Abstract

Ethephon treatment proved efficient in inducing resistance of faba bean to both chocolate spot (*Botrytis fabae* and *B. cinerea*) and rust disease (*Uromyces fabae*). Soaking seed in 800 ppm ethephon resulted in a significant reduction in the severity of both diseases and a noticeable increase in yield of seeds/plant. The same treatment caused a pronounced reduction in the percentage of browning and spreading of *Botrytis* lesions beneath infection droplets placed on the abaxial surface of detached leaves. Treatment of 1000 ppm showed even lower figures of disease severity of chocolate spot and rust. Treatments of 600 and 800 ppm of ethephon showed an increase in phytoalexin accumulation in leaf tissues after 24 h of exposure to *B. fabae* or *B. cinerea*.

## إكساب الفول صفة المقاومة ضد التبقع البني وأمراض الصدأ بمعاملة البذور بمادة الإثيفون

### ملخص

لقد أثبتت المعاملة بمادة الإثيفون فعاليتها في إكساب الفول صفة المقاومة لكل من التبقع البني ( *Botrytis fabae* و *B. cinerea*) ومرض الصدأ (*Uromyces fabae*). أدى نقع البذور في محلول بتركيز ٨٠٠ جزء بالمليون من مادة الإثيفون إلى تخفيض شدة الإصابة بالمرضين كثيراً وزيادة ملحوظة في غلة البذور/ النبات. كما أدت المعاملة نفسها إلى تخفيض واضح في النسبة المئوية للاصطباغ باللون البني وفي انتشار بقع *Botrytis* إلى أسفل نقيطات الإصابة الموجودة على السطح الوحشي من الأوراق المنفصلة، بل أظهرت المعاملة بمحلول تركيزه ١٠٠٠ جزء بالمليون أرقاماً أدنى عن شدة الإصابة بالتبقع البني والصدأ. وأدت المعاملتان ٦٠٠ و ٨٠٠ جزء بالمليون من مادة الإثيفون إلى زيادة في تراكم الفايتولكسين في نسج الورقة بعد مرور ٢٤ ساعة من تعرضها ل *B.fabae* أو *B. cinerea*.

### Introduction

Fruit ripening and plant senescence are all subject to ethylene treatment (Abeles 1973). Stress factors, including pathogen attack, increase the biosynthesis of ethylene (Lieberman 1979). It has been reported that ethylene enhances the synthesis and activity of different enzymes involved in defence mechanisms (Daly et al. 1970; Sheen and Diashun 1976; Boller et al. 1983; Haruyoma et al. 1988; Aly and Afifi 1989). Ethylene production has been correlated with the induction of several proteins that presumably function in defenses against fungal and bacterial attack (Toppan et al. 1982). Hargreaves et al. (1977) found phytoalexin accumulation in tissues bearing limited lesions caused by *Botrytis cinerea* or *B. fabae*. Wyerone acid was the predominant phytoalexin produced by leaves, particularly during the first 3 days after inoculation. Ethylene treatment may induce more phytoalexin accumulation. Induction of phytoalexin by ethylene was reported by Chautze and Stahmann (1969). On the other hand, Paradies et al. (1980) reported that ethylene does not appear to function as a sole elicitor for the induction of phytoalexins. Induction of resistance in barley plants against powdery mildew was reported by Aly et al. (1988) and Aly and Afifi (1989). In faba bean, Aly (1989) found ethephon treatments (800 and 1000 ppm) were effective against chocolate spot and stemphylium blight diseases in detached-leaf and whole-plant tests.

The present work was designed to test the effect of ethephon treatment in inducing resistance in faba bean, grown under field conditions, to some fungal diseases and its effect on yield. The effect of this treatment on phytoalexin accumulation in relation to induction of disease resistance also was investigated.

## Materials and Methods

The field experiment was carried out at Bahtim Agricultural Research Station during the 1989/90 growing season. Seeds of faba bean (Giza 3) were soaked in solutions of 600, 800 and 1000 ppm ethephon (2-chloroethyl phosphonic acid) for 20 h before sowing. Seeds soaked in the same volume of tap water served as controls. In addition, a fungicidal treatment of Dithane M 45 (0.3%) was used. Three applications were carried out in mid-January, the 1st of February and mid-February, 1990. Seeds were sown double (2 per hole), 30 cm apart, in two rows, each 4 m long. Four replicates were specified for each treatment. Common agricultural practices were followed.

### Fungal inoculation

*Botrytis fabae* was grown on salted faba bean extract agar medium. A spore suspension ($10^5$ conidia/ml) was sprayed over the plants after sunset during the 3rd week of January.

### Disease assessment

Chocolate spot disease was assessed as the percentage of leaf lamina affected. An average of three leaves from the flowering nodes was calculated for each plant. Ten plants were used for each replicate. The assessment was made at the medium stage of growth (mid-March). Rust disease was assessed at the beginning of April. The scale Bernier et al. (1984), which ranges from 1 to 9, was followed for disease assessment.

### Inoculation of detached leaves

Leaves without any signs of damage were detached from the middle of the flowering nodes. The abaxial surfaces of detached leaves were gently washed with distilled water and dried with tissue paper before inoculation. Leaves were placed on moistened filter paper in plastic boxes, then inoculated on their abaxial epidermis with 20-ml droplets containing 200 conidia of *B. fabae* or 2000 conidia of *B. cinerea*. Incubation was carried out at 18 ± 2°C under fluorescent lamps. Data were recorded as browning of infection sites and spreading of lesions according to Mansfield and Deverall (1974).

### Extraction and determination of wyerone acid by thin layer chromatography (TLC)

Leaf discs 1 cm from inoculation sites and their peripheral tissues were cut 24 and 48 h after inoculation. The leaf discs were homogenized using mortar and pestle with dimethyl ether, the ether was decanted, and the debris centrifuged at 3000 rpm for 3 min. The supernatent was collected and dried in a rotary evaporator at 35°C. The residue was washed with 10 ml absolute ethanol, then evaporated to dryness. The residue was resuspended in absolute ethanol at the rate of 1 ml/g fresh weight of the sample for phytoalexin determination. The method of Letcher et al. (1970) was used for separation and determination of wyerone acid. The concentration of wyerone acid was calculated from the formula:

$\mu$g wyerone acid/ml = optical density at max (356 nm) × 9.04.

### Effect on growth, yield and yield components

Plant were randomly chosen from each replicate for determination of plant height, number of branches, number of pods/plant, number of seeds/pod, weight of 100 seeds and seed yield/plants. Statistical analysis was carried out using Tukey's multiple range test according to Neler et al. (1985).

## Results

### Effect of ethephon vs. Dithane M 45 treatment on chocolate spot and rust diseases

Results in Table 1 show that ethephon treatments of 1000 and 800 ppm significantly reduced chocolate spot disease severity. Treatments of 1000 and 800 ppm reduced disease severity about 65 and 50%, respectively. Ethephon treatment of 600 ppm and Dithane M 45 foliar application showed similar results; both reduced disease severity by about 30%. Dithane M 45 foliar application produced the highest significant reduction of rust disease severity. All ethephon treatments (600, 800 and 1000 ppm) were less effective.

**Table 1. Effect of soaking seed with ethephon and foliar application of Dithane M 45 on chocolate spot and rust diseases of faba bean.**

| | Disease severity† | |
|---|---|---|
| Treatment | Chocolate‡ | Rust‡ |
| Ethephon (600 ppm) | 8.30ab§ | 5.10ab |
| Ethephon (800 ppm) | 6.20b | 5.35ab |
| Ethephon (1000 ppm) | 4.28b | 4.80ab |
| Dithane M 45 (0.3%) | 8.80ab | 4.70ab |
| Control | 12.30a | 6.90a |

† Percentage of leaf lamina area affected.
‡ Rating scale ranged from 1-9 where 9 = most susceptible.
§ Figures with the same letter are not significantly different.

**Table 2. Influence of soaking seed with ethephon and foliar application of Dithane M 45 on growth, yield and yield components of faba bean.**

| Treatment | Plant height (cm) | No. branches | No. pods/ plant | No. seeds/ pod | 100-seed weight (g) | Seed yield/ plant (g) |
|---|---|---|---|---|---|---|
| Ethephon (600 ppm) | 60.0ab† | 2.6a | 18.7a | 3.2a | 61.9a | 36.6a |
| Ethephon (800 ppm) | 57.9c | 3.1a | 19.0a | 3.3a | 63.4a | 39.9a |
| Ethephon (1000 ppm) | 55.5c | 3.0a | 16.2a | 3.2a | 60.0a | 31.3a |
| Dithane M 45 (0.3%) | 68.6ab | 3.2a | 19.6a | 3.3a | 59.8a | 38.1a |
| Control | 72.1a | 3.4a | 18.1a | 3.2a | 57.8a | 32.6a |

† Figures with same letter are not significantly different.

**Table 3. Effect of ethephon treatments on percentage of browning† and spreading‡ of lesions of *Botrytis fabae*§ and *B. cinerea*¶ on detached leaves of faba bean.**

| | *B. fabae* | | | | *B. cinerea* | | | |
|---|---|---|---|---|---|---|---|---|
| | 24 h | | 48 h | | 24 h | | 48 h | |
| Treatment | Browning | Spreading | Browning | Spreading | Browning | Spreading | Browning | Spreading |
| 0 ppm | 72.2 | 57.0 | 96.6 | 87.2 | 17.1 | 0.0 | 23.4 | 15.3 |
| 600 ppm | 57.0 | 27.4 | 82.0 | 47.6 | 8.0 | 0.0 | 20.9 | 0.0 |
| 800 ppm | 47.2 | 28.7 | 77.0 | 28.0 | 11.0 | 0.0 | 20.4 | 0.0 |
| 1000 ppm | 57.3 | 28.1 | 79.5 | 33.3 | 8.6 | 0.0 | 10.0 | 0.0 |

† Percentage of browning beneath the inoculum droplet.
‡ Percentage of spreading lesions.
§ Inoculum droplets 20 µl each containing 200 conidia.
¶ Inoculum droplets 20 µl each containing 2000 conidia.

**Influence of ethephon vs. Dithane M 45 treatments treatments on growth, yield and yield components of faba bean**

Ethephon treatments significantly reduced plant height (Table 2). Treatments of 800 and 1000 ppm had the highest reduction, followed by 600 ppm. Other agronomic characters (number of branches, number of pods per plant, number of seeds per pod, 100-seed weight and seed yield per plant) showed no significant differences.

**Effect of ethephon treatments on percentage of browning and spreading of lesions of *B. fabae* and *B. cinerea* on detached leaves**

All ethephon treatments reduced both percentage of browning and spreading of lesions of *Botrytis fabae* (Table 3). Treatment of 800 ppm showed a pronounced effect, especially in reducing the percentage of spreading lesions 48 h after inoculation. All ethephon treatments reduced percentage of lesions browning and restricted spreading of *B. cinerea* 24 and 48 h after inoculation.

**Effect of ethephon treatments on the elicitation of wyerone acid by *B. fabae* and *B. cinerea***

Ethephon seed treatments had a slight effect on accumulation of wyerone acid elicited by *B. fabae* and *B. cinerea* (Table 4). Treatments of 600 and 800 ppm showed an increase in wyerone acid concentration 24 h after inoculation by either *B. fabae* or *B. cinerea*. Forty-eight h after inoculation, wyerone acid content showed no clear differences between tissues of treated or untreated plants (Table 4). The same trend was shown in leaf tissues inoculated with *B. cinerea*. For the 1000 ppm ethephon treatment, a general reduction in wyerone acid level was detected 24 and 48 h after inoculation with *B. cinerea* and 48 h after inoculation with *B. fabae*.

## Discussion

Ethephon treatment proved its efficiency in inducing resistance against both chocolate spot and rust diseases. The ethephon concentration of 800 ppm was significantly

Table 4. Effect of ethephon treatment on the elicitation of wyerone acid† by *Botrytis fabae* and *B. cinerea*.

| Treatment | *B. fabae*‡ 24 h | *B. fabae*‡ 48 h | *B. cinerea*§ 24 h | *B. cinerea*§ 48 h |
|---|---|---|---|---|
| 0 ppm | 22.5 | 31.9 | 29.0 | 35.0 |
| 600 ppm | 29.8 | 29.9 | 36.5 | 38.1 |
| 800 ppm | 27.3 | 30.2 | 34.6 | 36.2 |
| 1000 ppm | 24.0 | 28.2 | 24.2 | 28.7 |

† µg/g fresh weight.
‡ Inoculum droplets 20 µl each containing 200 conidia.
§ Inoculum droplets 20 µl each containing 2000 conidia.

more effective in controlling chocolate spot than the recommended fungicidal treatment (Dithane M 45). The results with chocolate spot were in complete accordance with those obtained by Aly (1989). The 600 and 800 ppm ethephon treatments caused a slight increase of wyerone acid accumulation in response to *B. fabae* or *B. cinerea*, 24 h after inoculation. Wyerone acid content showed a negligible increase after 48 h. These results indicate that wyerone acid did not play a principal role in restricting the infection of *B. fabae*, perhaps because of the ability of *B. fabae* to metabolize wyerone acid into less toxic products (Mansfield and Deverall 1974).

Other defense mechanisms may have been involved in reducing disease severity in the treated plants. It has been reported that ethylene stimulates the accumulation of hydroxyproline rich in glycoprotein in the cell wall, which is considered a common defense mechanism against pathogens in dicots (Toppan et al. 1982; Roby et al. 1985). Treatment with ethylene or ethylene induced oxidative activities by enzymes, including peroxidase (PO) and polyphenol oxidase (PPO) (Sheen and Diochun 1976; Horuyama et al. 1988; Aly and Afifi 1989). The increase in PO activity enhances lignification in response to infection, which may restrict the penetration (Ride 1983). On the other hand, the activity of PPO and PO oxidizes phenolic compounds into their oxidative products. Deverall and Wood (1961) reported that oxidized phenolics inactivate pectic enzymes of *B. fabae*; such inhibition of cell wall-degrading enzyme may affect the rate of colonization by the fungus and subsequent tissue maceration. Recently, it was found that ethylene treatment increased chitinase (Roby et al. 1985) and gluconase (Mouch and Staehelin 1989) activity. Both enzymes have been implicated in defense reactions of plants against potential pathogens (Abeles et al. 1971; Boller et al. 1983).

Ethephon application minimized the severity of chocolate spot and rust diseases of faba bean plants and to some extent increased seed yield.

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# Imazapyr for Broomrape (*Orobanche crenata* Forsk.) Control in Faba Bean

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## Abstract

**Field studies were conducted in two locations to determine the effectiveness of imazapyr for the control of broomrape on faba bean. Generally, imazapyr applied preemergence at 25 g/ha was well tolerated by the crop, although its activity changed according to the type of soil and parasite control was poor. Applied postemergence at single rates of 2.5–5.0 g/ha, or as double applications of 2.5 g/ha at 2-week intervals, imazapyr provided good broomrape control without crop injury.**

# استخدام مادة إمازابير لمكافحة الهالوك (*Orobanche crenata* Forsk.) في الفول

## ملخص

أجريت دراسات حقلية في موقعين.لتحديد فعالية مادة إمازابير في مكافحة الهالوك في الفول. وبشكل عام كان تحمل المحصول جيداً نتيجة إضافة إمازابير بمعدل ٢٥كغ/هـ قبل ظهور البادرات، علماً أن فعاليته تباينت طبقاً لنوعية التربة وكانت مكافحته للطفيليات ضعيفة. في حين أتاحت إضافته بعد ظهور البادرات،ولمرة واحدة، بمعدل مابين ٥- ٢,٥كغ/هـ أو إضافته مرتين بمعدل ٢,٥كغ/هـ بفاصل أسبوعين، مكافحة جيدة للهالوك دون تعريض المحصول لأي ضرر.

## Introduction

*Orobanche crenata* Forsk. is one of the most important parasitic weeds in the Mediterranean area and Middle East (Parker 1986). In Spain, it parasitizes mainly legume crops, such as faba bean (*Vicia faba* L.), pea (*Pisum sativum* L.), lentil (*Lens culinaris* Medik.) and vetch (*Vicia sativa* L.) (García-Torres et al. 1987). Glyphosate applied postemergence at about 60 g/ha efficiently controls broomrape in many crops (Jacobson and Levy 1986; García-Torres et al. 1987). However, because of its limited selectivity, this herbicide treatment can only be used on certain crops such as faba bean (Mesa-García et al. 1984).

Recently the efficacy of imidazolinone herbicides for broomrape control, particularly imazapyr and imazethapyr, was shown (García-Torres and López-Granados 1991). Generally the effectiveness of any herbicide treatment was largely dependent on the duration of broomrape infestation. For late-planting and low-yield cropping systems, which normally have short and slight broomrape infestations, crop preemergence treatments of imazapyr at 12.5–25.0 g/ha resulted in efficient control without damaging the crop. Early planting and high-yield cropping systems, which normally are subject to heavy and lasting parasite infestations, would normally require a combination of preemergence and postemergence treatments.

The aim of this study was to obtain more information about the potential use of imazapyr (Arsenal) at low rates applied preemergence, postemergence or both for the control of crenate broomrape (*O. crenata*) on faba bean, since this can be an economical treatment.

## Materials and Methods

Field experiments were conducted in western Andalusia (southwestern Spain) on a Typic Chromoxerets soil, with clay texture, organic matter (OM) = 1.3% and pH = 8.4, in Tomejil (Carmona, Sevilla), and on a Typic Xerofluyents soil, with sandy-loam texture, OM = 2.3% and pH = 8.3 in Alameda del Obispo (Córdoba) during 1990/91.

For the experiment of primarily preemergence treatments, the sowing date was 6 November 1990 at both locations. For experiments of mainly postemergence treatments, sowing dates were 27 November and 7 December, at Alameda and Tomejil, respectively. The cultivar used was Alameda. Plots consisted of four rows, 70 cm apart, 12 m long. Faba bean was sown by hand at 5–7 cm depth, at 120 kg/ha. Before sowing, the soil was free of or contained a low density of *Orobanche* seeds; infection of crenate broomrape was established on 50% of each row of each plot by placing a mixture of 100 mg of *Orobanche* seeds and 50 g of soil per meter of row during sowing, at a similar depth.

The herbicide treatments were applied using an experimental sprayer with a boom 2 m wide, which delivered 175 L/ha at 300 kPa (3 kg/cm$^2$). The plots were evaluated for crop phytotoxicity using a rating scale of 0–100, where 0 indicated no injury, 10–30 slight injury, 40–60 moderate injury, 70–90 severe injury and 100 indicated 100% toxicity. Preemergence herbicide treatments were evaluated about 4 and 6 weeks after crop emergence, and postemergence herbicide treatments were evaluated about 2 and 4 weeks after each treatment. In selected treatments the two central rows of each plot were hand-harvested by late May or early June. Plants were then dried and cleaned and the seeds were weighed to determine yield.

Broomrape control was evaluated by counting the number of *Orobanche* plants in each plot that had emerged above the soil surface several times during the emergence period. In addition, broomrapes from each plot were collected by hand at crop harvest, dried and weighed.

The herbicide used was imazapyr. Postemergence treatments were applied in March when most of the broomrapes were about 0.5–1.0 cm high. The methods of application and rates are indicated in Tables 1 and 2.

## Results and Discussion

The activity of the herbicide as preemergence application varied with location (Table 1). Crop phytotoxicity was negligible in Alameda at all rates; in Tomejil imazapyr at 50 g/ha or higher resulted in crop injury and yield reduction compared with the noninfested (NI) check.

At Tomejil, imazapyr at 50 g/ha or higher rates effectively reduced the emergence of broomrape plants, while at Alameda almost no control was observed, even at the highest rate.

The difference in activity of imazapyr in both locations can be explained on the basis of soil differences, because most ionic herbicides strongly affect pH, clay content, mineralogy and OM content of soil. According to

**Table 1. Faba bean phytotoxicity and broomrape control with imazapyr applied preemergence except as indicated.**

| Treatments (g/ha) | Phytotoxicity | Broomrape (no./m) (I) | Yield (kg/ha) (NI) |
|---|---|---|---|
| **Tomejil** | | | |
| Imazapyr 12.5 | 0 | 36 (4) | 3559 (560) |
| Imazapyr 25 | 4 (7) | 37 (9) | 3537 (238) |
| Imazapyr 50 | 37 (13) | 12 (3) | 2781 (540) |
| Imazapyr 75 | 58 (13) | 3 (3) | 2062 (381) |
| Imazapyr 100 | 79 (2) | 1 (0.6) | 1714 (713) |
| Imazapyr 25 PE + 2.5 POST | 10 (12) | 16 (9) | 3430 (566) |
| Infested check | 0 | 38 (8) | ND |
| Noninfested check | 0 | 0 | 3051(494) |
| **Alameda** | | | |
| Imazapyr 12.5 | 0 | 53 (14) | 3307 (279) |
| Imazapyr 25 | 0 | 57 (15) | 2392 (846) |
| Imazapyr 50 | 0 | 34 (4) | 3465 (284) |
| Imazapyr 75 | 0 | 53 (27) | 2383 (566) |
| Imazapyr 100 | 0 | 41 (14) | 3089 (952) |
| Imazapyr 25 PE + 2.5 POST | 0 | 41 (5) | 2893 (445) |
| Infested check | 0 | 58 (10) | ND |
| Noninfested check | 0 | 7 (6) | 2346 (874) |

**Table 2. Faba bean phytotoxicity and broomrape control with imazapyr applied postemergence.**

| Treatment (g/ha) | Phytotoxicity | Broomrape (no./m) (I) | Yield (kg/ha) I | Yield (kg/ha) NI | Broomrape dry weight (kg/ha) |
|---|---|---|---|---|---|
| **Tomejil** | | | | | |
| Imazapyr 1 | 0 | 20 (4) | 1420 (141) | 3119 (328) | 323 (114) |
| Imazapyr 2.5 | 4 (2) | 5 (5) | 1798 (339) | 2877 (389) | 75 (89) |
| Imazapyr 5 | 21 (6) | 1 (0.7) | 2089 (281) | 3013 (119) | 12 (6) |
| Imazapyr 10 | 41 (2) | 0.1 (0.1) | 2027 (221) | 2837 (391) | 3 (6) |
| Imazapyr 2.5 PE + 2.5 POST | 0 | 2 (1.3) | 1881 (192) | 2869 (265) | 35 (33) |
| Imazapyr 5 PE + 5 POST | 10 (14) | 1 (1) | 2062 (195) | 3113 (116) | 7 (9) |
| Glyphosate 60 | 4 (5) | 1 (1.5) | 2131 (213) | 3223 (445) | 9 (12) |
| Infested check | 0 | 37 (3) | 1212 (385) | 3424 (107) | 460 (86) |
| Noninfested check | 0 | 7 (14) | 2365 (718) | 3107 (232) | 0 |
| **Alameda** | | | | | |
| Imazapyr 1 | 0 | 4 (3) | 1911 (419) | 2558 (425) | 51 (48) |
| Imazapyr 2.5 | 7 (5) | 1 (0.4) | 2286 (309) | 2593 (542) | 8 (9) |
| Imazapyr 5 | 36 (5) | 0.3 (0.4) | 2573 (597) | 3215 (514) | 7 (8) |
| Imazapyr 10 | 49 (2) | 0 | 2300 (438) | 2527 (391) | 0 |
| Imazapyr 2.5 PE + 2.5 POST | 6 (7) | 0.4 (0.7) | 2525 (480) | 2889 (637) | 6 (11) |
| Imazapyr 5 PE + 5 POST | 32 (3) | 0 | 2381 (377) | 2849 (185) | 0 |
| Glyphosate 60 | 12 (3) | 0.1 (0.2) | ND | ---- | 0 |
| Infested check | 0 | 13 (7) | 2063 (628) | ---- | 126 (49) |
| Noninfested check | 0 | 0 (0) | ND | 2642 (218) | 0 |

Values in parentheses are SD values.
PE = Preemergence; POST = Postemergence; I = Infested; NI = Noninfested; ND = No data.

Stougard et al. (1990), this type of herbicide is less strongly adsorbed, more mobile and more efficacious in coarse-textured and high-pH soils. However, imazapyr was more active in the heavy textured soil of Alameda. Since the pH was similar in both locations, this discrepancy can be attributed to the differences in OM content of the soil, which was higher at Alameda (2.3%) than at Tomejil (1.3%). In general, as OM content increases, adsorption increases and herbicide activity decrease.

The results of imazapyr applications as postemergence treatments are shown in Table 2. Application of 2.5 g/ha postemergence did not cause crop phytotoxicity and at 5 g/ha caused low to moderate phytotoxicity. However, none of these treatments reduced crop yield compared with the NI check. Conversely, although phytotoxicity was appreciable 20 days after the 10 g/ha treatment, it gradually disappeared and did not affect the NI crop yield compared with the untreated check.

Imazapyr applied at rates from 1 to 10 g/ha resulted in good control of broomrape, increasing in effectiveness as rates increased. Imazapyr treatments at 2.5 g/ha or at higher rates reduced the severity of infection (number of broomrape plants/m) and the broomrape dry weight by about 80%.

On the other hand, application of imazapyr at 25 g/ha preemergence and 2.5 g/ha postemergence did not show crop injury or reduce crop yield at any location, but gave moderate control of broomrape at Tomejil and low control at Alameda (Table 1). The lower efficiency at Almeda can be largely attributed to higher adsorption of the herbicide because of the slightly higher OM content of the soil.

According to the results shown herein and those of previous studies (García-Torres and López-Granados 1991), we can conclude that imazapyr applied preemergence at rates ranging from 12.5 to 25 g/ha is well tolerated by the crop, but its broomrape control is poor for early sown faba bean, which normally undergoes heavy and lasting parasite infestations. On the other hand, we must keep in mind that edaphic properties of soil, OM more than texture, played an important role in determining the effectiveness and phytotoxicity of imazapyr applied preemergence.

In general, postemergence treatments at 2.5 g/ha showed effectiveness and phytotoxicity similar to the "standard" treatment of glyphosate at 60 g/ha. In a broomrape control program, combined treatments of imazapyr preemergence at 25 g/ha and postemergence at 2.5 or 5 g/ha can be recommended. Furthermore, several cultivars of faba bean did not show differences in susceptibility to imazapyr up to 100 g/ha when applied preemergence at Alameda (data not shown).

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# Enhancement Effect of N, P and K on Glyphosate for Broomrape (*Orobanche crenata* Forsk.) Control in Faba Bean (*Vicia faba* L.)

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## Abstract

**Field studies were conducted in two locations to determine the effect of N, P and K fertilizers in combination with glyphosate on broomrape-infested and broomrape-free faba bean. Broomrape control from glyphosate at a given rate was enhanced when $(NH_4)_2SO_4$ at 3% (w/v) or $K_2HPO_4$ at 2% was added to the spraying solution in comparison with the same rate of glyphosate alone. However, the negative side of this fertilizer enhancement effect was that crop phytotoxicity also increased.**

# تعزيز تأثير الآزوت والفوسفور والبوتاسيوم في مادة جليفوسيت المستخدمة في مكافحة الهالوك (*Orobanche crenata* Forsk.) في الفول (*Vicia faba* L.)

## ملخص

نُفذت دراسات حقلية في موقعين بغية تحديد تأثير الأسمدة الآزوتية والفوسفورية والبوتاسية المُضافة مع مادة جليفوسيت، في الفول المصاب بالهالوك والفول غير المُصاب به . تعززت مكافحة جليفوسيت للهالوك بمعدل معين عند إضافة $(NH_4)_2SO_4$ بتركيز٣٪ (w/v) أو إضافة $K_2HPO_4$ بتركيز ٢٪ إلى محلول الرش بالمقارنة مع المعدل نفسه من جليفوسيت لوحده. غير أن الجانب السلبي لتعزيز تأثير هذه الأسمدة يتجلى في كونه يزيد أيضاً من التأثيرات السمية في المحصول.

## Introduction

Broomrape (*Orobanche crenata* Forsk.) is one of the most important parasitic weeds in the Mediterranean area and Middle East (Parker 1986). Many species are parasitized by this weed, which is particularly aggressive to legumes such as faba bean (*Vicia faba* L.) and causes yield reduction.

Several methods such as crop rotations, trap crops, delay of sowing dates and solarization, have been used to control *Orobanche*; however, they are neither practical nor economical under most farm conditions. Furthermore, the introduction of genetic resistance to broomrape in commercial cultivars has succeeded in some crops like sunflower (*Helianthus annus* L.) but not in others like faba bean.

The herbicide glyphosate applied postemergence at about 60 g/ha efficiently controls broomrape in faba bean (Jacobson and Levy 1986; García-Torres et al. 1987). It was registered in Spain for this use in 1983 and over 50% of the Spanish faba bean farmers currently use it. Agronomists in Egypt (Nassib et al. 1990) have shown that glyphosate at 30 g/ha combined with N, P and K is as effective as the standard rate of glyphosate (60 g/ha). Nevertheless, this was not the case for all locations. Therefore, the aim of the study herein presented was to determine the effect of combinations of N, P and K with glyphosate at reduced rates on broomrape control and phytotoxicity/crop tolerance under weed-free conditions.

## Materials and Methods

Field experiments were conducted in western Andalusia (southwest Spain) in two locations: Tomejil (Carmone, Sevilla) and Alameda del Obispo (Córdoba). Sowing dates were 26 November 1990 at Alameda and 10 December at Tomejil. Plots consisted of four rows 70 cm apart and 12 m long. Faba bean was sown by hand to a depth of 5-7 cm, at 120 kg/ha. The soil was free of *Orobanche* seeds. At the time of crop sowing, infection of crenate broomrape was established on half of each row of each plot, with a mixture of 100 mg of *Orobanche* seeds and 50 g of soil/m of row.

Herbicide treatments were applied as a postemergence spray, at the beginning of April when most of the broomrapes were about 0.5-1.0 cm high. The application rates are shown in Table 1. The nutrients added to the solution were: N, 3% w/v of $(NH_4)_2SO_4$; P and K, 2% w/v of $K_2HPO_4$. An experimental sprayer with as SS8001 nozzle delivering 175 L/ha was used to apply the treatments. A completely randomized block design with four replications was used.

Crop phytotoxicity was evaluated 2 and 4 weeks after treatments using a rating scale of 0–100, where 0 indicated no injury, 10–30 slight injury, 40–60 moderate injury, 70–90 severe injury and 100 complete crop kill. Broomrape control was evaluated several times in each plot during the emergence period by counting the number of *Orobanche* plants that had emerged above the soil surface. In addition, broomrapes from each plot were collected by hand at crop harvest, dried and weighed. Broomrape-infested and broomrape-free plots were harvested in early June by hand and the yield determined.

## Results and Discussion

Broomrape control and crop phytotoxicity from glyphosate were enhanced when $(NH_4)_2SO_4$ was added to the spraying solution (Table 1). For example, at Tomejil, from glyphosate at 30 g/ha, there was no phytotoxicity and broomrape control was medium high (70%), while from glyphosate at 30 g/ha + $(NH_4)_2SO_4$ phytotoxicity was low and broomrape control very high (97%). Similar results were obtained at Alameda. Phytotoxicity and broomrape control also increased slightly with the addition of $K_2HPO_4$ or $K_2HPO_4$ + $(NH_4)_2SO_4$ to glyphosate at 60 g/ha.

Generally, glyphosate treatments increased faba bean yield in comparison with the nontreated check when the crop was infested with broomrape. Furthermore, in Tomejil, the addition of $(NH_4)_2SO_4$ at low glyphosate rates (30 and 60 g/ha) increased yield of broomrape-infested faba bean in comparison with similar rates of glyphosate without N fertilizer because of better broomrape control. On the contrary, the addition of N to glyphosate tended to decrease yield of broomrape-free faba bean compared with glyphosate without nitrogen.

**Table 1. Broomrape control and faba bean phytotoxicity from glyphosate and N, P and K treatments at two locations in Spain.**

| Treatment (g/ha) | Phytotoxicity | Infestation: Broomrape number | Infestation: Dry weight | Yield (kg/ha): Infested | Yield (kg/ha): Noninfested |
|---|---|---|---|---|---|
| **Tomejil** | | | | | |
| Glyphosate 30 | 0 | 8 (5.2)† | 121 (28) | 2326 (366) | 3546 (187) |
| Glyphosate 60 | 9 (6) | 1 (0.4) | 9 (10) | 2890 (104) | 3414 (221) |
| Glyphosate 120 | 27 (3) | 0 (0) | 0 | 3473 (215) | 2505 (437) |
| Glyphosate 30 + $(NH_4)_2SO_4$ | 20 (8) | 1 (0.3) | 13 (23) | 2958 (347) | 2694 (183) |
| Glyphosate 60 + $(NH_4)_2SO_4$ | 35 (7) | 0 | 0 | 3177 (184) | 2505 (182) |
| Glyphosate 120 + $(NH_4)_2SO_4$ | 49 (2) | 0 | 0 | 2953 (174) | 1899 (79) |
| Glyphosate 60 + $K_2HPO_4$ | 41 (2) | 0 | 0 | 2339 (166) | 2436 (244) |
| Glyphosate 60 + $(NH_4)_2SO_4$ + $K_2HPO_4$ | 41 (2) | 0 | 0 | 2399 (190) | 3055 (203) |
| Infested check | 0 (0) | 30 (11) | 459 (163) | 1649 (238) | 3381 (327) |
| Noninfested check | 0 (0) | 0.2 (0.0) | 0 | 2892 (479) | 3212 (290) |
| **Alameda** | | | | | |
| Glyphosate 30 | 0 (0) | 5 (1) | 49 (46) | 2138 (416) | 2599 (639) |
| Glyphosate 60 | 12 (3) | 0.5 (0) | 3 (6) | 2331 (489) | 2546 (267) |
| Glyphosate 120 | 35 (9) | 0 (0) | 0 | 2139 (311) | 2276 (677) |
| Glyphosate 30 + $(NH_4)_2SO_4$ | 15 (5) | 2 (0) | 18 (29) | 2194 (314) | 2519 (203) |
| Glyphosate 60 + $(NH_4)_2SO_4$ | 35 (13) | 0 (0) | 0 | 2415 (614) | 2561 (525) |
| Glyphosate 120 + $(NH_4)_2SO_4$ | 52 (3) | 0 (0) | 0 | 1857 (286) | 1782 (80) |
| Glyphosate 60 + $K_2HPO_4$ | 25 (13) | 0 (0) | 0 | 2396 (639) | 2381 (716) |
| Glyphosate 60 + $(NH_4)_2SO_4$ + $K_2HPO_4$ | 40 (0) | 0 (0) | 0 | 1938 (273) | 2103 (204) |
| Infested check | 0 | 19 (1) | 173 (77) | 1681 (342) | — |
| Noninfested check | 0 | 0 (0) | 0 | — | 3015 (577) |

† Standard deviations are shown in parentheses.

It has been repeatedly reported that weed control from glyphosate plus ammonium sulphate is more efficient than the herbicide alone, at rates from 0.5 to 2 kg/ha (Turner 1985). However, no reports, to our knowledge, exist on similar effects at lower rates, except for the one previously mentioned (Nassib et al. 1990).

The advantage of the addition of $(NH_4)_2SO_4$ or $K_2HPO_4$ to glyphosate for the control of broomrape in faba bean lies solely in the reduction of the rate of the herbicide needed to reach a certain level of control of the parasitic weed. However, since the rate of glyphosate is very low (60 g/ha) and the herbicide is inexpensive (about USD 4 at 1991 prices), the addition of N alone or N, P and K is not really an appreciable advantage. Moreover, it must be pointed out that the addition of $(NH_4)_2SO_4$ to given rates of glyphosate also increased its toxicity.

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# *Pleospora herbarum* and Some Other Fungi on Faba Bean Stalks

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## Abstract

***Stemphylium botryosum*** **Wallroth was observed causing leaf spot and seed or seedling damage in Hungary, and the development of its sexual stage *Pleospora herbarum* (Fries ex Fries) Rabenhorst was studied on overwintered faba bean stalks. Immature perithecia formed early on the dead stems, but did not maturate until after frost had occurred in December. Germinable ascospores were developed from January on, and cultures were successfully developed from ascospores. The fungus from these cultures was pathogenic on faba bean plants in a greenhouse. Overwintering of the pathogen *Botrytis cinerea* Persoon also was detected, and some saprophytic fungi were identified that showed the decomposition of plant material.**

# ظهور الفطر *Pleospora herbarum* وبعض الفطور الأخرى على سوق الفول (*Vicia faba* L.)

## ملخص

لوحظ الفطر *Stemphylium botryosum* Wallroth على الفول في هنغاريا مسبباً الإصابة بتبقع الأوراق والبذور أو تعريض البادرات للضرر؛ وقد تمت دراسة طوره الجنسي *Pleospora herbarum* (Fries ex Fries) Rabenhorst على سوق الفول على مدى فصل الشتاء. تشكلت الحاملات الزقية غير الناضجة على السوق الميتة ولكنها لم تنضج إلا بعد حدوث الصقيع في كانون الأول/ ديسمبر. وبدءاً من كانون الثاني/يناير أخذت الأبواغ الزقية/الأسكية القابلة للإنبات في النمو وتطورت عنها بنجاح مستنبتات فطرية، كانت فطورها عاملاً ممرضاً لنباتات الفول في الدفينة. كما تم أيضاً رصد العامل الممرض *Botrytis cinerea* Persoon على مدى فصل الشتاء،وتم التعرف على بعض الفطور الرِمية التي تُظهر تحلل المادة النباتية.

## Introduction

*Stemphylium botryosum* Wallroth, the asexual stage of *Pleospora herbarum* (Fries ex Fries) Rabenhorst, is a widespread but rather minor pathogen of *Vicia faba* L. (Gaunt 1983). It was reported from Hungary where it caused leaf spot (Simay 1988), and was isolated from both seeds and plant residues attached to seeds (Simay 1990, 1991). The fungus is well known from other, different substrates (Domsch et al. 1980; Corlett et al. 1982) and was reported as a widespread saprophytic fungus by Vörös and Husz (1965) from Hungary. The aim of our study was to check the development of perithecium on faba bean stalks and the pathogenicity of the fungus in its sexual form.

## Materials and Methods

The development of perithecia of *P. herbarum* during overwintering was studied on faba bean stalks collected from experimental plots of the Research Centre for Agrobotany, and the overwintering of fungi was studied by laying the stalks on to a field. Although we concentrated on pathogens, other fungi were identified. The stalks were sampled from the first frost continuously for identification of the fungi pathogenic to faba bean.

Preparates of the fungi occurring on stalks were made for microscopic study, and pure cultures of known pathogens were developed from these preparates made in sterilized distilled water. The identification of fungi was carried out according to Arx (1981), Bánhegyi et al. (1985), Corlett et al. (1982), Domsch et al. (1980) and Shoemaker (1976). The pathogenicity of fungi was tested from pure cultures on plants grown in a greenhouse.

## Results and Discussion

The perithecia of *P. herbarum* remained immature and stromatic before the first frost. The differentiation of asci was observed during December in the perithecia and some immature ascospores were developed. Yellow brown, well-septated ascospores were observed in January but were not yet germinating. The other pathogenic fungi observed in January 1988 were *Alternaria alternata* (Fr.) Keissler and *Botrytis cinerea* Persoon. *Alternaria alternata* was well sporulated on stalks and pure cultures were made from the spores successfully; *B. cinerea* formed sclerotia only. Pure cultures of *B. cinerea* were made by placing the sclerotia onto agar media.

Mature, germinable ascospores of *P. herbarum* were observed from the end of January, and pure cultures were made successfully from them. The cultures observed were typical for *Stemphylium botryosum* and the fungus was pathogenic to healthy faba bean plants in the greenhouse, causing leaf spots on them. The re-isolation of fungus from artificially infected plants was successful. Pathogenicity of *B. cinerea* isolated from overwintered sclerotia was confirmed. Occurrence of leaf spots caused by *A. alternata* remained sporadic.

The formation of mature ascostromata of *P. herbarum* at low temperature was reported earlier (Domsch et al. 1980). However, to the author's best knowledge no data are available on its overwintering on faba bean. Among the other pathogens mentioned, *A. alternata* is well known from different substrates, which could serve as an alternate source for the infection of susceptible plants. The weak pathogenicity of this fungus was considered earlier (Simay 1987a). The overwintering of *B. cinerea* by sclerotia or mycelia in plant residues was reported earlier (Domsch et al. 1980) but the primary source of fungus detected earlier in Hungary was the infected seed only (Simay 1987b). The other *Botrytis* species pathogenic to faba bean, *B. fabae* Sard., was able to survive in plant residues (Harrison 1979).

Some known saprophytic fungi were also identified during these trials. These were *Cladosporium herbarum* (Pers.) Link ex Gray and *Epicoccum purpurascens* Enrenberg ex Schelchtendahl in January, and *Torula herbarum* Persoon ex Gray in May. After May most of the perithecia of *Pleospora herbarum* were empty, and sclerotia of *B. cinerea* became severely contaminated with known mycoparasites like *Gliocladium, Penicillium* and *Trichoderma* species.

Empty perithecia also were observed during the following autumn and winter, but perithecia with mature asci were not. However, ascomatas of some other fungi were developed on the stalks in the second year. The identified species were *Leptosphaeria* sp., *Ophiobolus mathieui* (West.) Saccardo and *Ophiobolus rubellus* (Pers. ex Fries) Saccardo, represented by ascomatas. The other frequent saprophytes were *Dendryphion comosum* Wallr., *D. nanum* (Nees ex Gray) Hughes and *T. herbarum*. Germinable sclerotia of *B. cinerea* were not observed in the second year, and the *Didymella fabae* Jellis et Punithalingam teleomorph reported recently for *Ascochyta fabae* Speg. (Jellis and Punithalingam 1991) was not identified during the 2 years of trials.

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# Results of Seed Tests. III. Occurrence of Some Pycnidial Fungi on Faba Bean Seeds

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## Abstract

**In the course of pathological testing of faba bean seed samples, four *Phoma*-like pycnidial fungi were identified. The most prevalent species was *Ascochyta fabae*; the others were *Phoma glomerata, Ph. herbarum* and *Ph. pinodella. Ascochyta fabae* and *Ph. pinodella* were pathogens on adult plants, while *Ph. glomerata* could cause infection on plants infested with red mites (*Tetranichus urticae*) simultaneously. Diagnostic characters of species are also described.**

# نتائج اختبارات البذور 111. ظهور بعض الفطور البيكنيدية على بذور الفول

## ملخص

خلال القيام باختبارات مرضية لعينات بذرية من الفول تم تحديد أربعة أنواع من الفطور البيكنيدية الشبيهة بالفوما *Phoma*. وكان النوع *Ascochyta fabae* الأكثر انتشاراً بين أنواع الفطور الأخرى، وهي: *Phoma glomerata, Ph. herbarum* و *Ph. pinodella*. ويعتبر الفطران *Ascochyta fabae* و *Ph. pinodella* عاملين ممرضين على النباتات الكاملة، في حين أن الفطر *Ph. glomerata* يستطيع أن يسبب إصابة النباتات المصابة بالعُثة الحمراء (*Tetranichus urticae*) بشكل متزامن. وقد تم أيضاً وصف الخصائص التشخيصية لهذه الأنواع من الفطور.

## Introduction

Pycnidial fungi are frequently occurring saprophytic or parasitic organisms found on plant materials, including seeds (Rádulescu and Negru 1971; Neergaard 1979; Agarwal and Sinclair 1987). When occurring on leguminous seeds, some of these fungi cause several diseases. *Ascochyta fabae* Speg. is one of the most important pathogens of faba bean (*Vicia faba* L.) (Gaunt 1983). Some *Phoma* species also are reported from seeds of legumes (Neergaard 1979). *Phoma pinodella* (L.K. Jones) Morgan-Jones et Burch is a well-known pathogen of species of *Fabaceae* (Boerema et al. 1965; Punithalingam and Gibson 1976) and was identified from plant residues from faba bean seeds (Simay 1992). Because *Phoma* species may be misidentified without pure cultures (Boerema et al. 1965; Boerema 1976), this study aimed to identify these fungi by culturing.

## Materials and Methods

The seed material tested was harvested from the experimental field of the Research Centre for Agrobotany (Lókút village). The seeds were germinated under sterile conditions both with and without surface sterilization. The pycnidial fungi were observed by stereomicroscope on seed coat or cotyledons. Microscopic preparates were made from pycnidia in droplets of sterilized physiologic salt solution and pure cultures were made from these preparates after microscopic examinations. The pure cultures were tested for identification on Leonian's malted agar (LA), oatmeal agar (OMA) and two agars containing cellulose (CMA) and glucose (GMA) for carbon source, respectively (Simay 1991).

## Results and Discussion

During the survey of fungi developing *Phoma*-like pycnidia, *A. fabae* was the predominant fungus. It is a well-known seed-transmissible pathogen of faba bean (Gaunt 1983). Its colonies are rather moderate in growth, reaching 20–32 mm diameters after 7 days. The fungus sporulated well on OMA and CMA, but pycnidia were developed only in old cultures on LA and sporadically on GMA; however, significant differences were not registerable on the tested media. Pycnidia were 270–300 $\mu$m diameter and conidia were mainly two-celled, 19.2–26.8 × 3.6–4.8 $\mu$m (Fig. 1). These characters were similar to those earlier observed on field isolates (Simay 1988a). The pathogenicity of seed isolates was confirmed on greenhouse-grown five-leaved faba bean (cv. Bakony I) plants.

**Fig. 1.** Two- and three-celled conidia of *Ascochyta fabae.*

Among *Ascochyta* species, *A. boltschauseri* Sacc., *A. fabae*, *A. pinodes* Jones and *A. pisi* Lib. were reported from Hungary (Podhradszky 1960; Békési 1965; Lenti 1988; Simay 1988a). However, the report of *A. boltshauseri* may be based on a misidentification of *A. fabae* because of symptoms, conidia demonstrated by Békési (1965) and the observed restricted host range (French bean and pea were immune to artificial inoculation). Lenti's (1988) report of *A. fabae* is also doubtful as he reported diameters of 55–87.5 × 55–80 $\mu$m for pycnidia and 8.61 × 3.8 $\mu$m (weighted from his data) for conidia. These parameters and the demonstrated symptoms and culture characters suggest that his fungus was *Ph. exigua* var. *exigua* Desm. (Sutton and Waterston 1966; Boerema and Höwler 1967).

Another identified known pathogen of faba bean was *Ph. pinodella*, which can infect numerous leguminous plants (Punithalingam and Gibson 1976). It was observed in field blight on *V. faba* in Hungary (Simay 1988b), and was identified from plant residues on seeds (Simay 1992).

**Fig. 2. Chlamydospores of *Phoma pinodella*.**

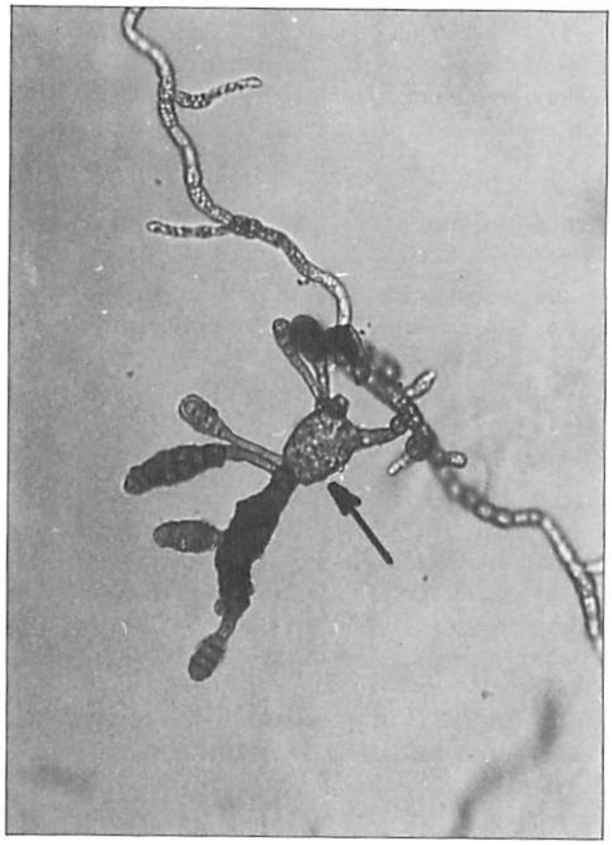

**Fig. 3. Dictyochlamydospores of *Phoma glomerata* with a developing micropycnidium formed from a chlamydospore (arrow).**

During the seed tests *Ph. pinodella* was identified from 2 of 105 samples tested in 1989. The fungus rapidly spread in cultures and the cultures became dark by the well-developed chlamydospores (Fig. 2). Its pycnidia were 80–160 $\mu$m in diameter and the conidia 5.4–9.6 × 3.6 $\mu$m. In greenhouse tests, the fungus caused small reddish leaf spots, which grew slowly on leaves. Long blackening lesions on stems also were observed.

The other chlamydospore-forming *Phoma* species was *Ph. glomerata* (Corda) Wollenw. et Hochapf. This fungus also rapidly grew on the investigated media, but typical dictyochlamydospores (Fig. 3) developed on LA and OMA media only. It formed abundant aerial mycelia, and pycnidia were occasionally produced directly from a dictyochlamydospore in the aerial mycelium. However, sectors lacking aerial mycelium were often observed and agaric pycnidia were more numerous in these sectors. The measurement of pycnidia varied between 90 and 180 $\mu$m diameter; conidia were 4–7.8 × 2.4 $\mu$m.

*Ph. glomerata* was reported from Hungary under synonymous names from different hosts (Bánhegyi et al. 1985), but we do not have the date of pathogenicity on these plants. In our trials the fungus caused blackening spots and top rot on plants infected artificially. These symptoms were not observed on healthy plants, but were on plants simultaneously infested with red mite (*Tetranichus urticae*). Its secondary or weak pathogenicity has been reported on other hosts (Vaartaja and Cram 1956; Boerema and Kesteren 1962; Picco 1962; Venn 1983).

Among *Phoma* species, *Ph. herbarum* also was identified. This fungus is well known from different substrates and seeds (Neergaard 1979; Domsch et al. 1980). Its colony was moderate in growth and was highly stromatic on agar surfaces, but chlamydospores were not observed. The pycnidia developed on this stromatic surface were 150–270 $\mu$m diameter. The conidia were 3.6–7.2 × 2–3 $\mu$m, oozing from pycnidia.

*Ph. herbarum* was reported earlier from different hosts from Hungary (Bánhegyi et al. 1985), in some cases under synonyms discussed by Boerema (1970). Typical discoloration of fungus by NaOH may be detected only by culturing the fungus. Its pathogenicity was not observed.

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# Results of Seed Tests. IV. Fungi on Seeds in Single-Seed Tests of Faba Bean

# نتائج اختبارات البذور V1. فطور على بذور الفول في اختبارات بذور إفرادية

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## Abstract

***Vicia faba* L. seeds were tested for fungi in single-seed tests of faba bean by germinating 150 and 100 seeds on 2,4D-water agar and on a moistened blotter, respectively. The fungi appeared in single and multiple infections. *Alternaria alternata*, *Ascochyta fabae* and *Penicillium* sp. were the predominant species on both agar and blotter. Some known pathogenic *Fusarium* ssp. also were identified, and *Neocosmospora vasinfecta* was observed for the first time in Hungary from a faba bean host. This fungus was identified from a single infection on one blotter.**

## ملخص

اختبرت بذور الفول *Vicia faba* L. لكشف إصابتها بالفطور في اختبارات بذور فول إفرادية، وذلك عن طريق إنبات ١٥٠ و ١٠٠ بذرة على ٢,٤د- آجار مائي وعلى ورق نشاف رطب على التوالي. ظهرت الفطور على شكل إصابات منفردة ومركبة . وكانت الأنواع *Alternaria alternata, Ascochyta fabae* و *Penicillium* sp. هي السائدة في كلا الآجار وورق النشاف. تم أيضاً تحديد بعض الممرضات المعروفة كالفيوزاريوم *Fusarium* ssp. . كما تمت ملاحظة *Neocosmospora vasinfecta* على عائل الفول لأول مرة في هنغاريا علماً أن هذا الفطر قد تم تحديده من بين الإصابات المنفردة على ورق النشاف.

## Introduction

Faba bean (*Vicia faba* L.) is widely cropped as a protein source, but numerous diseases limit the production. Some pathogens infect the seeds, and data about seed-transmitting fungi in Hungary have been published (Lenti 1986, 1990; Simay 1986, 1987a, 1987b, 1990a). Some saprophytes were also reported (Simay 1990a), and in vivo hyperparasitism of some pathogens was observed earlier (Simay 1988a, 1990b). This report presents data collected during single-seed tests of a faba bean seed sample.

## Materials and Methods

Seeds of faba bean cv. Bakony I tested in this study were harvested from the experimental field of the Research Centre for Agrobotany in Lókút village. The seeds were tested without surface sterilization before germination. Seeds were germinated on agar plates of water agar containing 100 ppm 2,4-dichloro-phenoxy-acetic-acid (2,4D) as sodium salt and on moistened blotters; 150 and 100 seeds, respectively. The number of moldy seeds on both media was recorded. Identification of fungi was carried out from sporulations developed on seeds and from representative cultures. Identifications were based mainly on Arx (1981), Bánhegyi et al. (1985), Booth (1971) and Domsch et al. (1980).

## Results and Discussion

The number of moldy seeds was 76 (50.7%) on agar and 47 (47%) on blotter, respectively, after 14 days. The fungi identified from seeds are shown in Table 1. The same fungi were predominant on both media, but the range of fungi was wider on agar. Infections were generally mixed, but in some cases single infections were observed. The fungi identified alone on seeds were *Ascochyta fabae*, *Fusarium equiseti*, *Fusarium oxysporum* and *Papulaspora* sp. on both media, *Fusarium culmorum* and *Penicillium* sp. on agar and *Neocosmospora vasinfecta*, *Rhizopus stolonifer* and *Trichotecium roseum* on blotters. Among them was *Neocosmospora vasinfecta*, first identified in Hungary on this host as causing seed rot. The fungi identified in multiple infections are presented in Table 2.

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Table 1. Number of faba bean seeds infected with fungi in single-seed tests on 2,4-D agar and blotting ggpaper.

| Fungus | On agar | | On paper | |
|---|---|---|---|---|
| | Total | One fungus only | Total | One fungus only |
| *Acremonium fusidioides* | - | - | 1 | - |
| *Acremonium* sp. | 1 | - | 2 | - |
| *Alternaria alternata* | 15 | - | 10 | - |
| *Ascochyta fabae* | 14 | 2 | 8 | 2 |
| *Aspergillus flavus* | 3 | - | - | - |
| *Aspergillus niger* | - | - | 1 | - |
| *Aureobasidium pullulans* | 1 | - | - | - |
| *Botrytis cinerea* | 4 | - | 4 | - |
| *Botrytis fabae* | 1 | - | - | - |
| *Ceratocystis fimbriata* | - | - | 1 | - |
| *Ceratocystis* sp. | 2 | - | 3 | - |
| *Cladosporium cladosporioides* | 4 | - | 2 | - |
| *Cladosporium herbarum* | 3 | - | 4 | - |
| *Cladosporium* sp. | 6 | - | 5 | - |
| *Fusarium avenaceum* | 1 | - | - | - |
| *Fusarium culmorum* | 3 | 1 | - | - |
| *Fusarium equiseti* | 6 | 1 | 2 | 1 |
| *Fusarium oxysporum* | 6 | 2 | 4 | 2 |
| *Fusarium poae* | 1 | - | - | - |
| *Fusarium semitectum* | 1 | - | - | - |
| *Fusarium solani* | 2 | - | - | - |
| *Fusarium verticillioides* | - | - | 1 | - |
| *Fusarium* sp. | 1 | - | 1 | - |
| *Gliocadium catenulatum* | 9 | 1 | - | - |
| *Gliocadium roseum* | 3 | - | - | - |
| *Gliocadium viride* | 1 | - | - | - |
| *Gliocadium* sp. | 4 | - | 3 | - |
| *Gonatobotrys simplex* | 1 | - | 1 | - |
| *Harzia acremonioides* | 7 | - | 7 | - |
| *Mucor hiemalis* | 2 | - | 2 | - |
| *Neocosmospora vasinfecta* | - | - | 1 | 1 |
| *Papulaspora* sp. | 3 | 1 | 4 | 1 |
| *Penicillium* sp. | 51 | 6 | 27 | - |
| *Pestalozia* sp. | 1 | - | - | - |
| *Phoma exigua* | 1 | - | - | - |
| *Phoma glomerata* | 1 | - | - | - |
| *Rhizoctonia solani* | - | - | 1 | - |
| *Rhizopus stolonifer* | 1 | - | 5 | 1 |
| *Stemphylium botryosum* | 1 | - | 1 | - |
| *Trichotecium roseum* | 4 | - | 2 | 1 |

**Table 2. Fungi in multiple infections observed on blotting paper (above diagonal) and on agar (below diagonal).**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 389 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | · | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| 2 | | · | | 1 | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | 1 | 1 | | | | | | |
| 3 | | | · | 2 | | | | | | | | | 4 | 1 | | | | | | | | | | | | | | | 1 | | 1 | 8 | | | | | 1 | |
| 4 | | | 3 | · | | 1 | | | | | | | | | | | | | | | | | | | | | | | 1 | | | 3 | | | | 1 | | |
| 5 | | | | | · | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | · | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | · | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | 1 | | | | | · | | | 2 | 1 | | | | | | | | | | | | | | | | | 1 | | | 4 | | | | | | |
| 9 | | | | | | | | | · | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | · | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | 1 | | | | | | | | · | | | | | | | | | | | | | | | | | | 1 | | | 1 | | | | | | |
| 12 | | | | | | | | | | | | · | | | | | | | | | | | | | | | | | | | | 1 | | | | | | |
| 13 | | | 1 | | | | | | | | | | · | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | | | 1 | 1 | | | | | | | | | | · | | | 1 | | | | | | | | | | | | | | 1 | 4 | | | | | | |
| 15 | | | 1 | | | | | | | | | | | | · | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | | | 1 | | | | | | | | | | | | | · | | | | | | | | | | | | | | | | | | | | | | |
| 17 | | | 1 | 1 | | | | 1 | | | | 1 | | | | | · | | | | | | | | | | | | | | | | | | | | | |
| 18 | | | 1 | | | | | | | | 1 | | | | | | | · | | | | | | | | | | | 1 | | | 1 | | | | | | |
| 19 | | | | 1 | | | | | | | | | | | | | | | · | | | | | | | | | | | | | | | | | | | |
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1 *Acremonium fusidioides*
2 *Acremonium* sp.
3 *Alternaria alternata*
4 *Ascochyta fabae*
5 *Aspergillus flavus*
6 *Aspergillus niger*
7 *Aureobasidium pullulans*
8 *Botrytis cinerea*
9 *Botrytis fabae*
10 *Ceratocystis fimbriata*
11 *Ceratocystis* sp.
12 *Cladosporium cladospor*
13 *Cladosporium herbarum*
14 *Cladosporium* sp.
15 *Fusarium avenaceum*
16 *Fusarium culmorum*
17 *Fusarium equiseti*
18 *Fusarium oxysporum*
19 *Fusarium poae*
20 *Fusarium semitectum*
21 *Fusarium solani*
22 *Fusarium verticillioides*
23 *Fusarium* sp.
24 *Gliocadium catenulatum*
25 *Gliocadium roseum*
26 *Gliocadium viride*
27 *Gliocadium* sp.
28 *Gonatobotrys simplex*
29 *Harzia acremonioides*
30 *Mucor hiemalis*
31 *Papulaspora* sp.
32 *Penicillium* sp.
33 *Pestalozia* sp.
34 *Phoma exiqua*
35 *Phoma glomerata*
36 *Rhizoctonia solani*
37 *Rhizopus stolonifer*
38 *Stemphylium botryosum*
39 *Trichotecium roseum*

Some pathogens observed in this study were reported earlier in Hungary (Lenti 1986, 1987, 1990; Simay 1986, 1987a, 1987b, 1988b, 1990a). Lenti (1988) reported a disease of *V. faba* as Ascochytosis caused by *Ascochyta fabae*, but his fungus developed a whitish to brown culture forming small pycnidia (75.5 x 74.5 $\mu$m) and conidia (weight 8.61 x 3.79 $\mu$m), indicating it to be *A. fabae* Speg. According to Lenti's (1988) data this fungus is rather similar to *Phoma exigua*; however, an alkalinic reaction was not demonstrated. *Phoma exigua* also was observed in our present work on a seed germinated on agar.

Some of the identified fungi are known storage fungi on other hosts (Christensen 1972) belonging to genera of *Aspergillus* and *Penicillium* especially. These fungi could cause deterioration of the seeds (Halloin 1986). Some others are mycoparasitic organisms (Vajna 1987), and *Gliocladium catenulatum* was observed earlier to be parasitic to *Botrytis cinerea* in vivo on faba bean seeds (Simay 1988a).

Because seed transmission of the pathogens may serve as an initial source for an epidemic, further investigations need to state the pathogenicity of identified fungi. Some others identified from multiple infections could be useful in integrated disease (pest) management.

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# Effect of Phyllody on Growth and Grain Yield of Faba Bean

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## Abstract

**Phyllody disease was recorded on faba bean during the 1990/91 season in Wadi Hadramout, where infestation reached as high as 69% in early sown faba bean. The objective of this study was to determine yield loss and changes in yield attributes caused by phyllody infection. The results showed that the infection significantly decreased the grain yield, 1000-grain weight and number of mature pods by 95, 84 and 88%, respectively, but infection significantly increased dry weight of plants, plant height and number of immature pods by 63, 5 and 407%, respectively, compared with healthy plants.**

# تاثير الفيلودي (التورق الزهري) على نمو الفول وغلته الحبية

## ملخص

سُجِل مرض الفيلودي على الفول خلال الموسم الزراعي ١٩٩٠-٩١ في وادي حضرموت، حيث وصلت نسبة إصابة الفول المزروع في وقت مبكر إلى ٦٩٪. وتهدف هذه الدراسة إلى تحديد الفاقد في الغلة والتغييرات في خصائص الغلة الناجمة عن الإصابة بالفيلودي. أظهرت النتائج أن الإصابة قد خفضت بشكل كبير الغلة الحبية ووزن الألف حبة وعدد القرون الناضجة بنسب ٩٥ . ٨٤ . ٨٨٪ على الترتيب غير أنها زادت إلى حد كبير من الوزن الجاف للنباتات وطول النبات وعدد القرون غير الناضجة بنسب ٦٣ . ٥ و٤٠٧٪ على الترتيب مقارنة بالنباتات السليمة.

## Introduction

In an effort to identify high-yielding faba bean lines for release, research trials were conducted at Wadi Hadramout in Yemen. In the 1990/91 season, the crop was infected by phyllody disease caused by mycoplasma-like organisms (Bernier et al. 1985). This infection spreads on the sesame crop in Wadi Hadramout and on some grass species.

The host range of susceptible plants is wide for each mycoplasma and corresponds to the host range of the vector (Belai et al. 1988). In 1984, ICARDA indicated that leafhoppers are the vectors of phyllody disease on faba bean. Belai et al. (1988) reported that the incubation periods of different mycoplasma in their vectors, i.e., hoppers, range from 2 weeks to 1.5 months depending on the vector and the weather conditions at the time of infestation. They also indicated that there was no evidence of seedborne mycoplasma; this may be because the formation of seeds on the infected plants often occurs prior to infestation or on infestation-free shoots. However, results of some research (Vlasov and Larina 1984) show that mycoplasma may, to a lesser extent, be transferred either by grafting or mechanically. Regarding the control of this disease, some references (Hartmut et al. 1986) show that there is no known method for phyllody control, but it is possible to limit its spread by controlling leafhoppers. Other studies (Belai et al. 1988) indicate that all antibiotics in the tetracycline group are effective in fully controlling mycoplasma but their actual usage is limited.

Faba bean's susceptibility to phyllody disease may become a limiting factor to the expansion of this crop because of the presence of alternative hosts such as sesame crop, perennial and annual grasses, and insect vectors.

By reducing the losses resulting from the disease incidence, farmers will be more likely to adopt the crop and expand its growing areas. This study was conducted to determine the effects of phyllody disease on faba bean yield components and yield loss in different sowing dates.

## Materials and Methods

In the yield and sowing date trial, carried out at Swayri experimental farm in a split-plot design with four replications, the incidence of phyllody was studied. One late-sown (15 November 1990) cultivar, IB 2785, was selected and a sample of five healthy plants and five infected plants was taken from each replication when harvested on 20 March 1991. Data concerning disease incidence severity and yield traits for each individual plant were taken from the sample, and the phyllody incidence level was assessed on a 0–4 scale, where: 0 = free of disease, healthy plant; 1 = slight incidence at infection, 1–25% of flowers; 2 = moderate incidence of infection, 26–50% of flowers; 3 = severe incidence, 51–75% of flowers; and 4 = very severe incidence with 76–100% of flowers infected.

Plants were placed in an oven at 80°C for 48 hours to obtain the dry weight. The correlation coefficient (r) between incidence of phyllody and yield of faba bean plants was calculated. Data of this study were statistically analyzed after they had been subjected to $\sqrt{x}$ transformation.

## Results and Discussion

The appearance of phyllody on faba bean plants started at the anthesis stage, i.e., 2.5 months after sowing. In the early sown crop, incidence reached as high as 69%. Incidence was characterized when one or more of the flower parts changed into green leaf-like structures with vegetative growth. The diseased flowers had pedicels that varied in length between 1 and 6 cm. Basal shoots proliferated and branched excessively, leading to a characteristic Witches-broom growth. Early incidence changed all the flowers into foliage.

In the case of severe incidence, pods did not set. It was also observed that one shoot might be infected while the others remained healthy. Plants that were severely infected in the field stayed green when others matured, indicating the effect of the disease incidence in prolonging the growth of the plants.

The incidence of phyllody had a significant effect on growth and yield of faba bean plants (Table 1). Infected plants in the field were significantly taller than the noninfected plants by 5.7 cm. In addition to the multiplication of shoots near the plant base and the increase in petiole length, the vegetative growth of infected plants increased causing a subsequent increase in dry weight of 63% in comparison with the healthy plants. It seemed that a large part of nutritive materials formed by the infected plant helped in forming these growths, leading finally to a 63.4% reduction in pods in contrast to the healthy plants; pod weight was reduced by 67.5%. Disease incidence inhibited pod setting in faba bean plants and the number of immature pods increased by 407%. These overall effects were reflected in seed yield, which was only 5% of that in healthy plants. The number of seeds/plant was reduced by 67.5% in diseased plants compared with healthy ones.

It was found that there was good correlation between the incidence of phyllody and the yield of faba bean plants (Table 2). The ability of infected plants to produce seeds decreased as the severity of phyllody increased. Yield loss was 82% when the degree of incidence was scored as 2 and yield loss was maximum (98%) when the disease rating score was 4 (Table 2).

**Table 1. Effect of phyllody disease incidence on faba bean yield traits.**

| Traits | Healthy plants | Infected plants | Coefficient of variation | Standard error | % change |
|---|---|---|---|---|---|
| Shoots/plant | 5.7a† | 6.7a | 2.02 | 0.05 | +17.5 |
| Dry weight/plant (g) | 33.6a | 54.8b | 1.77 | 0.70 | +63.0 |
| Plant height (cm) | 102.2a | 107.9b | 1.20 | 1.27 | +5.2 |
| No. immature pods | 4.1a | 20.8b | 6.30 | 0.20 | +407.0 |
| No. mature pods | 35.0a | 12.8b | 3.80 | 0.17 | -63.4 |
| Mature pod weight (g) | 68.1a | 8.1b | 13.00 | 4.90 | -88.1 |
| 1000-seed weight | 653.7a | 104.7b | 29.00 | 123.00 | -84.0 |
| Seeds/plant | 79.4a | 25.8b | 1.05 | 0.07 | -67.5 |
| Seed yield/5 plants (g) | 397.0a | 19.0b | 17.80 | 0.02 | -95.2 |
| Average pod weight (g) | 1.6a | 0.5b | 15.30 | 0.19 | -66.8 |

† Means with same letters do not significantly differ at 5% probability level in Duncan's test.

**Table 2. Relationship between faba bean seed yield and degree of disease incidence of phyllody.**

| Level of infection | Infection score | Mean seed yield/plant | Seed loss (%) |
|---|---|---|---|
| Healthy | 0 | 51 | 0 |
| Moderate | 2 | 9 | 82 |
| Severe | 3 | 3 | 94 |
| Epidemic | 4 | 1 | 98% |

Further studies are needed to investigate the mode of transmission of the disease and the environmental factors that help its spread, to develop techniques for inhibiting its prevalence and to develop disease-resistant varieties.

## Acknowledgement

I would like to extend my sincere thanks to Dr Gaafar Hussein Mohamed Ali for his revision of the manuscript.

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# News

In 1993, the first annual supplement of FABIS, containing faba bean references for 1991, will be published. This publication replaces Faba Bean in AGRIS, previously published by ICARDA. All entries will be extracted from AGRIS and AGRICOLA databases (CD-ROM) in the ICARDA holdings. The supplement will be distributed to recipients of the FABIS newsletter.

## *Conferences*

**1993**

***10th Australian Plant Breeding Conference*, Gold Coast, Queensland, 19—23 April.** Contact: Australian Convention and Travel Services Pty Ltd., GPO Box 2200, Canberra, ACT 2601, Australia.

***1st Crop Science Conference for Eastern and Southern Africa*, Kampala, Uganda, 14—18 June.** Contact: Dr Adipala Ekwamu, Makere University, P.O. Box 7062, Kampala, Uganda [Phone 256-041-531152, Fax 256-041-531641].

***7th International Symposium on Iron Nutrition and Interactions in Plants*, Zaragoza, Spain, 27 June—2 July.** Contact: Sr D. Jesus Gascon, Secretary, 7th Int. Symp. Iron Nutrition and Interactions in Plants, Aula Dei Experimental Station, CSIC Apdo, 202, 50080 Zaragoza, Spain.

***14th North American Symbiotic Nitrogen Fixation Conference*, St. Paul, Minnesota, USA, 25-30 July.** Contact: Nancy Harvey, Program Coordinator, Educational Development System, 405 Coffey Hall, 1420 Eckles Ave., Univ. of Minnesota, St. Paul, MN 55108-6068, USA [Phone-USA only-612-625-8215, 800-367-5363; Fax 612-625-2207, E-mail INTERNET:nh@esp.mes.umn.edu].

***6th International Congress of Plant Pathology*, Montreal, Canada, 28 July—6 August.** Contact: Managing Editor, Bureau of Crop Protection, CAB International, Wallingford, Oxon, OX10 8DE, UK.

***10th Australian Nitrogen Fixation Conference*, Brisbane, Australia, September.** Contact: H.V.A. Bushby, 306 Carmody Road, St. Lucia, Queensland 4067, Australia [Phone (07) 377-0209, Fax (07) 371-3946].

***15th Congress of the International Commission on Irrigation and Drainage*, The Hague, Netherlands, 6—11 September.** Contact: Prof W.A. Segeren, Chairman, Organizing Committee, Secretariat ICID, PO Box 82000, 2508 EA, The Hague, The Netherlands.

***XII International Plant Nutrition Colloquium/Symposium — Zinc in Soils and Plants*, Perth, Western Australia, 21—28 September.** Contact: Plant Nutrition Secretariat, The Conference Office, University of Western Australia, Nedlands, WA 6009, Australia.

***Second International Symposium on Pesticide Application*, Strasbourg, France, 22—24 September.** Contact: Conference Associates & Services Ltd., BCPC Enquiries, Congress House, 55 New Cavendish Street, London W1M 7RE, UK. [Phone 44-71-486-0531; Fax 44-71-935-7559].

***Opportunities for Molecular Biology in Crop Protection*, Cambridge, UK, 27—29 September.** Contact: Conference Associates & Services Ltd., BCPC Enquiries, Congress House, 55 New Cavendish Street, London W1M 7RE, UK. [Phone 44-71-486-0531; Fax 44-71-935-7559].

***Brighton Crop Protection Conference: Weeds*, Brighton, UK, 22—25 November.** Contact: Conference Associates & Services Ltd., BCPC Enquiries, Congress House, 55 New Cavendish Street, London W1M 7RE, UK. [Phone 44-71-486-0531; Fax 44-71-935-7559].

*2nd International Workshop on Antinutritional Factors (ANFs) in Legume Seeds,* **Wageningen, The Netherlands, 1—3 December.** Contact: Dr J. Huisman, TNO-Institute of Animal Nutrition and Physiology (ILOB), P.O. Box 15, 6700 AA Wageningen, The Netherlands [Phone 31-8370-99460; Fax 31-8370-99463].

*International Symposium on Pulses Research,* **Kanpur, India, 4—8 December.** Contact: Dr A.N. Asthana, Organizing Secretary, International Symposium ISPRD, Directorate of Pulses Research, Kanpur 208 024, India.

1994

*British Crop Protection Council: Seed Treatment,* **Surrey University, UK, 4—6 January.** Contact: Conference Associates & Services Ltd., BCPC Enquiries, Congress House, 55 New Cavendish Street, London W1M 7RE, UK. [Phone 44-71-486-0531; Fax 44-71-935-7559].

*7th International Congress of Bacteriology, Applied Microbiology and Mycology,* **Prague, Czechoslovakia, 3—8 July.** Contact: Dr B. Sikyta, Institute of Microbiology, Czechoslovak Academy of Sciences, Videnska 1083, CS-142 20, Prague 4, Czechoslovakia.

1995

*American Phytopathological Society Annual Meeting,* **Pittsburgh, PA, USA.** Contact: APS Headquarters, 3340 Pilot Knob Road, St. Paul, MN 55121, USA.

Visuals

ICARDA has produced three slide/tape modules dealing with legume hybridization techniques. The three programs, *Hybridization Techniques in Chickpea, Hybridization Techniques in Lentil,* and *Hybridization Techniques in Faba Bean,* discuss the morphology of the flowers, crossing block layout, and emasculation and pollination techniques. The programs are designed as introductory material for junior scientists.

To purchase the modules, send a check for US$50 payable to ICARDA for each program to the Training Coordination Unit. Each slide set includes 80 slides, a cassette tape and an accompanying resource book.

# *International Symposium on Pulses Research*

## *4—8 December 1993, Kanpur, India*

The program of the Symposium will cover cool-season (chickpea, lentil, dry peas, grasspea, kidney bean and faba bean) as well as warm-season (pigeonpea, mungbean, urdbean, cowpea, horsegram, mothbean and ricebean) grain legumes.

The topics will cover a wide range of subjects:

- enhancement of genetic resources
- breeding for resistance (biotic and abiotic stress) and productivity
- genetics
- cytogenetics
- physiology
- biotechnology
- disease and pest management
- production technology (legume-based cropping systems, fertility management including biological nitrogen fixation, weed management and sustainable agriculture)
- grain quality
- post-harvest technology
- developmental strategies

**Organized by:** Indian Society of Pulses Research and Development (ISPRD)
Directorate of Pulses Research
Kanpur 208 024, India

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New Delhi, India

**Contact:** Dr A.N. Asthana, Organizing Secretary
International Symposium, ISPRD
Directorate of Pulses Research
Kanpur 208 024, India

*First circular is being distributed*

# Agricultural libraries receiving ICARDA publications

ICARDA publications are deposited in agricultural libraries throughout the world to make them available to other users under normal interlibrary loan and photocopy procedures. These depository libraries are located in the countries listed. Readers requiring information on the library nearest to them should address inquiries to: Library, ICARDA, P.O. Box 5466, Aleppo, Syria.

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# *ICARDA publications and services*

**ICARDA Publications**
Request your list of all currently available publications from the Communication, Documentation and Information Services (CODIS).

**FABIS**
FABIS is the newsletter of the Faba Bean Information Service. Produced biannually, it publishes short scientific papers on the latest research results and news items related to faba bean research. The newsletter is available free to faba bean researchers. For further information or to subscribe, write to: FABIS/CODIS.

**LENS**
LENS, the newsletter of the Lentil Experimental News Service, is produced twice a year at ICARDA in cooperation with the University of Saskatchewan, Canada. Short research articles provide rapid information exchange, and comprehensive reviews are invited regularly on specific areas of lentil research. The newsletter is available free to lentil researchers. For further information or to subscribe, write to: LENS/CODIS.

**RACHIS**
This publication is aimed at cereal researchers in the Near East and North Africa region and Mediterranean-type environments. It publishes 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 or to subscribe, write to: RACHIS/CODIS.

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The ICARDA library maintains bibliographic databases for the use of researchers at the center and elsewhere. FABIS, LENS and BARLEY databases contain 5000, 1500 and 60 000 references, respectively, extracted from AGRIS. Literature searches can be conducted by the library staff and results downloaded to diskette or hard copy. Photocopies of articles identified in a literature search can be provided to users, if available. Researchers can request a literature search by letter or telex to: Library.

**A Directory of Faba Bean and Lentil Research Workers** is being compiled for publication, and will soon be available.

**To Obtain Information**
Address requests for publications or services to the specific department cited above, at: ICARDA, P.O. Box 5466, Aleppo, Syria.

## Contributors' Style Guide

The FABIS newsletter publishes the results of recent research on faba bean, in English with Arabic abstracts. Articles should be brief, confined to a single subject and be of primary interest to researchers, extension workers, producers, administrators and policy makers in the field of faba bean research. Articles submitted to FABIS should not be published or submitted to other journals or newsletters.

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### Manuscript

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Include the authority name at the first mention of scientific names.

Present measurements in metric units, e.g., t/ha, kg, g, m, km, ml. Where other units are used (e.g., quintal), the metric equivalent should be provided in parentheses.

Define in footnotes or legends any unusual abbreviations or symbols used in the text or figures.

Provide the full name of journals and book titles. Use the following formats for references.

> **Journal article:** Schubert, I. and R. Rieger. 1990. Alteration by centric fission of the diploid chromosome number in *Vicia faba* L. *Genetica* 81:67-69.
>
> **Article in book:** Bos, L. 1982. Virus diseases of faba beans. Pages 233-242 *in* Faba Bean Improvement (G. Hawtin and C. Webb, eds.). Martinus Nijhoff Publ., The Hague.
>
> **Article in proceedings:** Montoya, J.L. 1988. The production of seed of leguminous crops in Spain. Pages 136-142 *in* Seed Production in and for Mediterranean Countries. Proceedings of the ICARDA/EC Workshop, 16-18 Dec 1988, Cairo, Egypt (A.J.G. van Gastel and J.D. Hopkins, eds.). ICARDA, Aleppo, Syria.
>
> **Book:** Agarwal, V.K. and J.B. Sinclair. 1987. Principles of Seed Pathology. CRC Press, Boca Raton, Florida, USA.
>
> **Thesis:** El-Hosary, A.A. 1981. Genetic studies of some strains of field beans (*Vicia faba* L.). Ph.D. Thesis. Menoufia University, Egypt.

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