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Faba Bean Information Service

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(ICARDA)

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FABIS

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COVER: Independent vascular supply (IVS) trait is currently available only in small-seeded faba bean. Research at Douyet, Morocco is aiming to combine IVS trait with large seed size.

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Breeding and Genetics

Studies on Mutations Induced by EMS and DES in Faba Bean. II. Vital Mutations Affecting Vegetative Organs

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Abstract

The frequency of different mutations induced by varying doses of EMS and DES affecting vegetative plant parts in *Vicia faba* L. was determined. DES was more effective than EMS. Mutations affecting shape and size of cotyledonary leaves, plant height, branching, leaves, bristle color and texture of plant surface and their M_3 breeding behavior are described here. A dose-dependent increase in the frequency of such mutations was noted for both mutagens.

دراسات على الطفرات المستحدثة بواسطة سلفونات إتيل ميتان (EMS) وسلفات ثنائي الإتيل (DES) في الفول II. الطفرات الحيوية المؤثرة على الأعضاء الخضرية

الملخص

تم تحديد تكرار مختلف الطفرات المستحدثة بجرعات مختلفة من EMS و DES المؤثرة على الأجزاء الخضرية في نبات الفول *Vicia faba* L. وتبين أن DES كانت أكثر فعالية من EMS . ويرد في هذا البحث وصف الطفرات المؤثرة على شكل وحجم الورقات الجنينية، وطول النبات، وتشكل الفروع، والأوراق، ولون الشعرات الشوكية وقوام سطح النبتة وسلوكها في التربية في الجيل الثالث. وقد لوحظ ازدياد في عدد هذه الطفرات وفقاً للجرعة من كلا المطفّرين.

Introduction

Induction of mutations is of considerable value in comprehending evaluation and accelerating the process of plant improvement. In a study on mutagenesis in *Vicia faba* L. following treatment with varying doses of ethyl methane sulphonate (EMS) and diethyl sulphate (DES), a wide spectrum of mutations was isolated (Vandana 1990). The mutants isolated could be grouped into three categories, i.e., chloromutants, sterile mutants and vital mutants. Frequency and spectrum of chlorophyll mutations and sterile mutations have been reported elsewhere (Vandana 1991). The vital mutations could be further grouped into those affecting vegetative organs and those affecting reproductive organs. This paper describes the mutants affecting vegetative organs.

Materials and Methods

Details of seed treatment with mutagens and layout of M_1 and M_2 experiments were reported earlier (Vandana 1991). The M_2 populations were screened for mutations at regular intervals from seedling stage until maturity of the crop. Various macromutants were identified and tagged for separate harvesting. The frequencies of those mutants affecting vegetative organs were determined in terms of mutants per 1000 M_2 plants. Seeds of isolated mutants were sown in separate rows to raise the M_3 families. The M_3 breeding behavior of selected mutants was studied.

Results

The frequencies of various mutations affecting vegetative parts of the plants isolated in various mutagenic treatments are summarized in Table 1. The total frequency of such mutations in the EMS treatments

Table 1. Frequency (per 1000 M_2 plants) of mutations affecting vegetative parts in M_2 generation of mutagen-treated faba bean.

	Treatment					
	EMS (%)			DES (%)		
Mutant type	0.05	0.125	0.25	0.25	0.50	0.75
Seedling						
Large cotyl. leaves	—	—	—	1.05	—	—
Small cotyl. leaves	1.01	2.06	3.63	2.06	3.67	4.89
Height						
Stunted	3.03	4.13	4.84	4.21	6.10	7.34
Very dwarf	5.06	7.22	18.15	9.49	13.43	30.60
Dwarf	2.02	1.03	2.42	1.05	1.22	3.67
Tall	1.01	—	1.21	1.05	—	—
Very tall	1.01	2.06	1.21	1.05	12.21	1.22
Giant	1.01	2.06	3.63	3.16	3.66	13.49
Branching						
Unbranched	1.01	—	—	1.05	—	—
Bushy dwarf	—	—	—	6.32	10.99	19.58
Bushy tall	4.04	—	—	4.21	1.22	—
Bushy very tall	9.10	8.25	5.47	3.16	7.33	6.12
Leaf						
Hexafoliate	—	—	3.63	7.38	—	—
Small	1.01	1.03	1.21	—	—	1.22
Oval	6.07	—	—	—	—	—
Curled	—	5.15	—	—	7.33	—
Bristle						
Enlarged	3.03	—	—	—	—	—
Reduced	—	1.03	2.42	—	3.67	4.84
Plant color and texture						
Hairy	3.03	11.35	16.94	7.38	6.10	4.89
Pale green	2.02	9.28	13.11	4.21	13.43	12.24
Leathery	—	—	—	—	2.44	2.45
Dark green	1.01	1.03	1.21	1.05	3.67	3.64
Total frequency	44.47	55.68	82.28	57.89	96.47	116.14

ranged from 44.5 to 82.3 per 1000 M_2 plants among the EMS treatments. DES treatments induced much higher mutation frequencies, ranging from 57.9 to 116.1 per 1000 M_2 plants. The mutation frequencies increased with an increase in the concentration of each mutagen. Vegetative mutations were grouped into six categories.

Seedling mutants

Viable mutants showing alterations in the size and color of cotyledonary leaves on the seedlings were induced under this category. These included the 'large cotyledonary leaf' and 'reduced cotyledonary leaf' mutants. The cotyledonary leaves in the former were remarkably large and dark green, whereas in the latter they were smaller than the control and pale green. Among the seedling mutants, all the large cotyledonary leaf mutants bred true for the character in the M_3 generation; the reduced cotyledonary leaf mutants segregated into normal and mutated types.

Height mutants

The plant height in the control variety ranged from 19 to 29 cm. Mutants showing remarkable variation from the normal plant height could be grouped into the following categories: stunted mutants, not exceeding 5 cm; very dwarf mutants, 5–10 cm; dwarf mutants, 10–18 cm; tall mutants, 30–35 cm; very tall mutants, 35–50 cm, and giant mutants, exceeding 50 cm. Plant height mutants of all six types bred true to their types in the M_3 generation.

Branching mutants

In the parent variety two to three branches arise from the base of the plant only and no secondary branching occurs above this level. Among the treated M_2 progenies, 'unbranched' mutants showing no branching at all as well as those showing an increased number of basal branches leading to a bushy appearance of the plants were recovered. The bushy mutants could be further categorized as 'bushy dwarf,' 'bushy tall' and 'bushy very tall,' depending upon the plant height. Among the branching mutants, all three bushy types bred true in the M_3 generation while the unbranched mutants segregated into normal and unbranched types.

Leaf mutants

The leaf in faba bean is compound with the number of leaflets varying from two to five. Among the M_2 progenies there were remarkable variations in the shape, size and number of leaflets. The isolated mutants included the hexafoliate, small leaf, oval leaf and curled leaf types. Different leaf mutants did not show a similar trend of inheritance in the M_3 generation. Hexafoliate, curled and oval leaf mutants produced chimeric progenies, while the small leaf mutants bred true to their type.

Bristle mutants

Normally, in the leaf of faba bean the tip of the rachis extends beyond the level of insertion of the last leaflet in the form of a thin, tender, bristle-like structure, 0.5 to 1.0 cm long. The enlarged-bristle mutants had bristles 2-3 cm long, which in some cases were ribbed, whereas bristles in the reduced-bristle mutants were only rudimentary. Both bristle mutants bred true in the M_3 generation.

Mutants for plant color and texture

Mutations causing alterations in the texture of plant surface and color of plant body were included in this category. These included hairy mutants characterized by conspicuous epidermal hairs on the surfaces of leaves and stems; leathery mutants with thick and leathery leaves; pale green mutants, lacking proper chlorophyll content, and dark green mutants apparently rich in chlorophyll content. All the mutants for plant color and texture maintained their mutated characteristics in the M_3 generation.

Discussion

Enhancement of the frequency and spectrum of mutation in a predictable manner and consequent achievement of desirable plant characteristics is an important goal of current mutation research (Gustafsson 1941, 1947, 1955; Auroback 1967; Swaminathan 1969). Spectra of vital mutations are the most important considerations for isolating desirable mutant types. Although high seed yield is often the ultimate goal for legume breeders, yield is a composite character and therefore can be manipulated through the various components characteristics. Thus manipulation of plant structural components to induce desirable alterations in the yield components provides invaluable material for the breeders.

In *V. faba* a limited range of variation for some characters and little prospect of introduction of new variations from other species have led to many attempts at mutagenesis. Among these, dwarf mutants isolated by Filippetti and Marzano (1984) and mutants affecting leaves, stems and floral parts induced by El-Shouny and El-Hosary (1983) deserve special mention. A wide range of vital mutations was induced in the present study, several of which are useful from a breeder's point of view because of their high yield capacity. With increases in the concentration, the two mutagens induced increasing frequencies of mutations. DES was more effective than EMS.

Among the mutants for plant height the tall, very tall and giant types have better yield potential because of their greater number of nodes and consequently an increased number of fruits and seeds. Similarly, different categories of bushy tall mutants characterized by increased branching also hold promise, as do hexafoliate mutants with increased leaf area and resultant better photosynthesizing ability.

Besides the desirable mutations mentioned above, a number of mutants of academic interest were induced, such as those showing variation in cotyledonary leaf size, stunted or dwarf characteristics, small or curled leaf and variations in bristle size and plant texture. Further cytogenetical analysis of these mutants is expected to throw new light on the genetics of the traits involved in these mutations.

Acknowledgements

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Studies on Mutations Induced by EMS and DES in Faba Bean. III. Vital Mutations Affecting Maturity Period and Reproductive Parts

دراسات على الطفرات المستحدثة بواسطة EMS و DES في الفول (III). الطفرات الحيوية المؤثرة على فترة النضج والأجزاء التكاثرية

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الملخص

تم تحديد تكرار مختلف الطفرات التي تؤثر على فترة النضج وخصائص الأوراق والبذور المستحدثة بجرعات مختلفة من EMS و DES في الفول. ويرد في هذه الدراسة الطفرات التي تؤثر على عدد الأيام حتى الإزهار، وحجم ولون عدد الأزهار في كل عقدة؛ وشكل وحجم وقوام القرون والبذور وسلوكها في التربية عند الجيل الثالث. وقد لوحظ أن زيادة تكرر هذه الطفرات يعتمد على الجرعة من كلا المطفّرين.

Abstract

The frequency of different mutations affecting maturity period and floral and seed characteristics induced by varying doses of EMS and DES in *Vicia faba* L. was determined. Mutations affecting days to flower, size, color and number of flowers per node; shape, size and texture of pods and seeds, and their M_3 breeding behavior are reported. A dose-dependent increase in the frequency of such mutations was observed for both mutagens.

Introduction

In a study on mutagenesis in *Vicia faba* L. following treatment with various doses of ethyl methane sulphonate (EMS) and diethyl sulphate (DES), a wide spectrum of mutations was isolated. The frequency and spectrum of chloromutations and sterile mutations as well as vital mutations affecting vegetative organs have been reported elsewhere (Vandana 1991; Vandana 1992). This paper describes the mutants affecting maturity period and floral and seed characteristics.

Materials and Methods

Details of seed treatment with mutagens and layout of M_1 and M_2 experiments were reported earlier (Vandana 1991). The M_2 populations were screened for mutations at regular intervals from first flowering until maturity of the crop. Mutants for maturity period and floral and seed characteristics were tagged for separate harvesting. The frequencies of various mutants isolated were determined in terms of mutants per 1000 M_2 plants. The isolated mutants were carried to M_3 generation to study the breeding behavior of mutated characteristics.

Results and Discussion

The frequencies of various mutations affecting maturity period and reproductive parts of the plants, isolated in different mutagenic treatments, are summarized in Table 1. The total frequency of such mutations in EMS treatments ranged from 19.2 to 43.6 per 1000 M_2 plants, whereas in the three DES treatments it ranged from 23.2 to 45.3 per 1000 M_2 plants. Within each mutagen, the mutation frequency increased with an increase in the concentration. DES induced higher mutation frequencies than EMS. The various mutants isolated are described here briefly.

Mutants for maturity period

Days taken to flower were taken as an index of maturity because variations in actual time to maturity are obscured by high temperature-induced crop drying at the end of the crop season. Plants in the control flowered 79–83 days after sowing (DAS). Remarkable variations in time taken to flower were induced among the M_2 populations. Based on DAS to flower, three distinct categories of mutants were isolated. These included 'early flowering mutants' blooming 75–78 DAS, 'late flowering mutants' flowering 84–89 DAS and 'very late flowering mutants' flowering 90–93 DAS. The various mutants for maturity period bred true in the M_3 generation.

Floral mutants

The flowers in the control plants had a typical papilionaceous corolla with standard, white keel petals; the two wing petals had a black blotch toward the tip. Normally only two flowers were borne at each node. Mutants showing alterations in size, color and number of flowers per node were isolated. These included the 'small flowered,' 'brown flowered,' 'yellowish-white flowered' and 'triflorate' mutants. The small-flower mutants had reduced size of various floral parts. In the brown-flower mutants, the blotches on the wing petals were brown instead of dark black, whereas in the yellowish-flower mutant the normally white portions of the corolla were light yellow and the blotches on the wings were the normal black. Triflorate mutants had three flowers per node instead of the normal two; all three flowers blossomed normally and developed into healthy fruits. The brown and yellowish-white floral mutants segregated into mutated and normal progenies in the M_3 generation, but triflorate mutants produced chimeric progenies.

Pod mutants

The mature pods in control plants prior to drying were shiny green, 2 to 4 cm in length, with one to four seeds. The mutants for pod characteristics included the 'leathery pod,' 'small pod' and 'large pod.' The fruit wall in the leathery pod mutants was thick, leathery and dark green. The size of the pod was slightly reduced. Pod length in the small pod mutants was only 2.0 to 2.5 cm with one seed per pod. Pod length in the 'large pod mutants' ranged from 4.0 to 5.5 cm, and the number of seeds per pod varied from three to five. These mutants showed luxuriant growth with broad leaves and bold seeds. The various pod mutants bred true in the M_3 generation.

Table 1. Frequency (per 1000 M_2 plants) of mutations affecting reproductive parts in M_2 generation of mutagen-treated faba bean.

	Treatment					
	EMS (%)			DES (%)		
Mutant type	0.05	0.125	0.25	0.25	0.50	0.75
Floral						
Small flowered	—	—	—	—	2.44	—
Brown flowered	1.01	1.03	—	—	—	—
Yellowish flowered	—	—	1.21	—	—	—
Triflorate	6.07	5.15	7.26	4.21	7.33	4.89
Maturity period						
Early flowering	4.04	4.13	1.21	3.16	3.66	4.89
Late flowering	—	—	—	—	2.44	2.45
Very late flowering	3.03	4.13	4.84	4.21	4.88	3.67
Pod						
Leathery	—	—	3.63	—	—	3.67
Small	1.01	1.03	3.63	1.05	4.88	3.67
Large	—	1.03	—	7.38	—	1.22
Seed						
Dark brown	—	3.10	4.84	—	—	6.12
Light brown	1.01	3.10	4.84	—	—	4.89
Brown, wrinkled	—	—	4.84	—	1.22	—
Small, round	1.01	1.01	1.21	1.05	1.22	1.22
Black, wrinkled	2.02	4.13	6.05	2.11	4.88	8.57
Total frequency	19.20	27.84	43.56	23.17	32.95	45.26

Seed mutants

The seeds in the control plants were dark black with a somewhat cylindrical shape, compressed at the ends and on the sides. The seed coat was smooth and seed length varied from 5 to 7 mm. Among the various seed mutants, remarkable variations in shape, size and color were observed. The five prominent seed mutants were 'dark brown seeded,' 'brown seeded,' 'black wrinkled seeded,' 'brown wrinkled seeded' and 'small round seeded' types. Seed size and shape were normal in the dark brown and brown seed mutants. The small round seed mutants had normal black seeds with a reduced length (4.0 to 4.5 mm) and appeared to be somewhat round in shape because they were less compressed. The seed coat in both the wrinkled mutants was conspicuously wrinkled and the length of the seeds was only 3 to 4 mm. The 'dark brown', 'small round' and 'black wrinkled' mutants were true breeding whereas the 'light brown' and 'brown wrinkled' types segregated into normal and mutated types in the M_3 generation.

Some of the mutants reported here hold promise for breeders. Triflorate mutants are of considerable value as their increased sink size will have a direct bearing on yielding ability. Similar multiflorate mutants were recorded earlier in lentil by Sharma and Sharma (1977, 1980) and Dixit and Dubey (1983, 1984). Mutants with early maturity and large pod were the other promising types obtained in this study.

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Genetical Studies of some Egyptian and Imported Varieties of Faba Bean

دراسات وراثية حول بعض أصناف الفول المصرية والمستقدمة

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Abstract

The objectives of this investigation were to study the genetic behavior of yield and its components and to furnish information on the nature of associations between pairs of characters in a faba bean seven-parent diallel cross, without reciprocals. The results showed that both additive and nonadditive genetic effects controlled the genetic systems of all the studied traits. Additive gene effects had the main effect in inheritance of height to the first pod, but dominance gene effects played the major role in seed yield/plant. Moreover, epistatic gene effects were found in the inheritance of plant height, number of pods/plant and seed yield/plant. The parents showed unequal frequencies of dominant and recessive alleles in all traits studied. Narrow-sense heritability values were 0.41 for seed yield/plant, 0.46 for height to the first pod, 0.55 for plant height, 0.52 for number of pods/plant and 0.85 for 100-seed weight. Accordingly, selection could be effective in the segregating generations for improving these traits. Correlations among characters differed according to the population under consideration. On the other hand, both the parents and F_1 hybrids showed that number of pods/plant gave the highest genotypic and phenotypic correlations with seed yield/plant.

الملخص

يتوخى هذا البحث دراسة النظام الوراثي للغلة ومكوناتها وتوفير معلومات حول طبيعة الإرتباط بين أزواج من الصفات المختلفة باستخدام سبعة أصناف من الفول ثنائية الأليل بدون تهجينات عكسية. وأظهرت النتائج أن تأثير المورثات ذات الأثر المتجمع وغير المتجمع قد تحكمت في الأنظمة الوراثية لجميع الصفات المدروسة. وكان للتأثيرات الوراثية ذات الأثر المتجمع الدور الرئيسي في توريث صفة الإرتفاع حتى أول قرن، في حين كان للتأثيرات الوراثية السائدة ذلك الدور في غلة البذور/نبات. كما وجدت تأثيرات التفوق الوراثي في توريث طول النبات وعدد القرون/نبات وغلة البذور/نبات. وقد أظهرت الآباء تكرارات غير متساوية للأليلات السائدة والمتنحية في جميع الصفات المدروسة. وكانت قيم التوريث الخاصة 0.41 لغلة البذور/النبات، و0.46 للإرتفاع حتى أول قرن، و0.55 لطول النبات و 0.52 لعدد القرون/النبات و 0.85 لوزن المئة بذرة. بناء على ذلك يمكن أن يكون الإنتخاب فعالاً في الأجيال الإنعزالية لتحسين هذه الصفات. وقد تباينت الإرتباطات بين الصفات حسب العشائر موضوع الدراسة. ومن الناحية الأخرى، أظهرت كل من الآباء وهجن الجيل الأول أن عدد القرون/النبات أعطى أعلى الإرتباطات الطرازية والشكلية مع غلة البذور/النبات.

Introduction

Faba bean (*Vicia faba* L.) is a protein crop for temperate regions. In Egypt, there is little possibility of increasing the cultivated area. Therefore, it is important to obtain higher-yielding varieties through breeding programs. Selection for increased seed yield from the Egyptian faba bean varieties alone would not be effective (Ibrahim 1963), but crossing Egyptian and introduced faba bean varieties could increase genetic variability. The breeder should know the type of gene action of the quantitative traits because this is the main determinant in the choice of selection and breeding procedures. Contradictory results were obtained by many authors with respect to the genetic systems governing yield and its components. Nassib (1982) stated that the nonadditive genetic variance was more important than additive genetic variance in controlling inheritance of pods/plant, whereas the reverse was true for seed weight. El-Hosary (1981) found partial dominance for 100-seed weight and overdominance for number of pods/plant. Mahmoud (1968) found incomplete dominance of lighter over heavier seeds.

This work was carried out to (1) study the genetic behavior of yield and its components and other important characteristics, and (2) furnish information on the nature of the association between pairs of characters of faba bean in each of the parents and F_1 hybrids.

Materials and Methods

The work was conducted at Assiut University, Experimental Farm of the Agronomy Department during the two successive seasons of 1985/86 and 1986/87. Seven genotypes of faba bean of diverse origin were used as parental lines. The common names and origin are presented in Table 1.

Table 1. Name and origin of the parental varieties.

Parent	Variety	Origin
1	Reina Blanca	Spain
2	Giza 402	Egypt
3	Syria local	Syria
4	Rebaya 40	Egypt
5	Lippoi	Hungary
6	Kobrosi	Cyprus
7	Aquadulce	Spain

Diallel crosses among the parents, excluding reciprocals, were made. In the second season the 7 parents and their 21 possible F_1 hybrids were grown in a randomized complete block design with three replications. Each entry was represented by a single-row plot 3 m long with 60 cm between rows. Seeds were spaced 15 cm apart with three seeds/hill. After full emergence the plants were thinned to one plant/hill. The recommended cultural practices for faba bean production were adopted throughout the growing season. At harvest, 10 competitive plants were randomly sampled from each plot to provide measurements for plant height, height to the first pod, number of pods/plant, seed yield/plant and 100-seed weight.

The data obtained were subjected to genetic analysis of the diallel table as described by Hayman (1954a, b) and Mather and Jinks (1971). The phenotypic and genotypic correlations were estimated according to Miller et al. (1958).

Results and Discussion

The average plant height, height to the first pod, number of pods/plant, seed yield/plant and 100-seed weight for the seven parents and their F_1 hybrids are presented in Table 2. The cultivar Reina Blanca had the lowest number of pods/plant (31.3) and seed yield/plant (59.3 g). However, the local cultivar Rebaya 40 gave the highest number of pods/plant (71.0) and seed yield/plant (93.3 g) and the lightest 100-seed weight (45.7 g) along with the other local parent Giza 402 (43.0 g). In general, hybrids that had Aquadulce as a common parent produced the heaviest seed weight. Likewise, hybrids with Giza 402 as a common parent produced the highest grain yield/plant and the lightest 100-seed weight.

Highly significant differences among the entries were obtained for all the studied traits (Table 3). Separate analysis of variance for each of the parents, F_1 hybrids and the two combined showed nonsignificant differences among the parents and F_1 hybrid block interactions. Therefore, experimental error of the parents could be considered equal to F_1 hybrid error, and both equal to the total block interaction mean square of the parents + F_1 hybrids. Consequently, the total block interaction mean square was considered an estimate of the environmental variance in computing the genetic parameters for all the studied traits.

The diallel analyses of variance for the studied traits are given in Table 3. The a and b mean squares were significant for all traits, indicating that the additive and nonadditive genetic effects were important in the inheritance of those traits. These results are in line with those reported by Hanna and Hayes (1966), Lawes and Newaz (1979), El-Hosary (1981, 1983), and Abo-El-Zahab et al. (1984).

The mean deviation of the F_1s from their midparental values was small for height to the first pod. This was confirmed with the nonsignificance of b_1 mean square (Table 3). However, this item was significant for the other traits indicating the presence of a unidirectional trend of dominance in these traits. Furthermore, the b_2 and b_3 mean squares were highly significant for the studied traits. This indicates unequal frequencies of dominant and recessive genes among the parents and the existence of some specific combinations. Similar results were obtained by Khalil (1969), Mahmoud (1977) and Habetinek (1982).

Diallel-cross analysis suggested by Hayman (1954a,b) is based on several assumptions. Failure of one or more of these assumptions invalidates to some degree the inferences derived by means of the analysis. Therefore, two tests of the assumptions were employed to screen the traits for such failures. The first was the analysis of variance of the quantity (W_r-V_r). This value is expected to be constant over arrays if the assumptions are valid (Hayman 1954a,b). The results (Table 4) showed that the differences between arrays of the (W_r+V_r) values for height to the first pod, number of pods/plant and 100-seed weight were highly significant. These indicate the presence of nonadditive effects. However, these values

Table 2. Mean plant height, height to the first pod, number of pods/plant, seed yield/plant and 100-seed weight of the parents and F_1 hybrids.

	Plant height (cm)	Height to first pod (cm)	No. pods/ plant	Seed yield/ plant (g)	100-seed weight (g)
P_1 (Reina Blanca)	133.3	41.0	31.3	59.3	75.0
$P_1 \times P_2$	151.3	35.3	66.0	104.7	55.7
$P_1 \times P_3$	152.7	37.7	78.7	110.0	60.3
$P_1 \times P_4$	146.0	40.3	71.3	98.7	64.7
$P_1 \times P_5$	155.0	35.0	51.7	69.7	52.3
$P_1 \times P_6$	153.0	35.0	56.0	93.0	70.7
$P_1 \times P_7$	139.7	33.3	46.7	98.7	89.3
P_2 (Giza 402)	140.0	28.7	62.3	70.0	43.0
$P_2 \times P_3$	151.0	38.3	79.7	106.3	51.3
$P_2 \times P_4$	146.3	33.0	66.7	89.3	46.0
$P_2 \times P_5$	164.3	36.0	80.3	75.3	40.0
$P_2 \times P_6$	143.3	32.3	65.3	108.0	52.3
$P_2 \times P_7$	152.0	33.3	53.3	96.0	80.7
P_3 (Syria local)	142.0	51.3	37.7	63.7	72.3
$P_3 \times P_4$	150.3	39.7	58.0	107.3	72.3
$P_3 \times P_5$	157.7	37.7	50.0	73.0	60.0
$P_3 \times P_6$	144.7	40.0	52.7	95.3	71.7
$P_3 \times P_7$	130.0	32.0	27.7	55.7	86.7
P_4 (Rebaya 40)	145.7	32.7	71.0	93.3	45.7
$P_4 \times P_5$	164.0	38.0	60.0	93.3	48.0
$P_4 \times P_6$	147.3	37.7	70.3	103.0	63.3
$P_4 \times P_7$	142.7	32.3	35.3	62.7	77.3
P_5 (Lippoi)	158.0	34.7	54.7	60.3	53.3
$P_5 \times P_6$	159.3	38.7	63.7	70.0	51.7
$P_5 \times P_7$	143.7	34.7	27.0	48.0	66.7
P_6 (Kobrosi)	143.3	29.7	47.3	82.7	93.0
$P_6 \times P_7$	141.7	32.7	27.7	56.7	96.0
P_7 (Aquadulce)	132.0	27.7	37.3	73.7	110.3
P	142.1 ± 1.1	35.1 ± 0.6	48.8 ± 1.2	71.9 ± 1.7	70.4 ± 1.1
F_1	149.3 ± 0.6	35.9 ± 0.4	56.6 ± 0.9	86.4 ± 1.2	64.6 ± 0.5

Table 3. Mean squares of the F_1 hybrids for plant height, height to the first pod, number of pods/plant, seed yield/plant and 100-seed weight of the 7-parent diallel cross of faba bean.

Source of variation	df	Plant height (cm)	Height to first pod (cm)	No. pods/ plant	Seed yield/ plant (g)	100-seed weight (g)
Block	2	193.3**	41.4**	73.9	47.0	10.6
Genotypes	27	217.8**	46.4**	791.3**	1108.2**	829.9**
a	6	1103.3**	223.7**	3892.6**	4203.8**	5886.2**
b	21	181.7**	42.1**	693.5**	1331.8**	251.1**
b_1	1	932.7**	10.5	1084.5**	3813.6**	597.6**
b_2	6	93.9**	90.5**	1055.6**	1708.0**	259.5**
b_3	14	165.7**	23.7**	514.9**	993.4**	168.7**
Error	54	19.5	7.7	37.7	82.6	13.3

** Significant at P≤01.

Table 4. Analysis of variance for ($W_r + V_r$) and ($W_r - V_r$) values for plant height, height to the first pod, number of pods/plant, seed yield/plant and 100-seed weight.

Source of variation	df	Plant height (cm)	Height to first pod (cm)	No. pods/ plant	Seed yield/ plant (g)	100-seed weight (g)
			($W_r + V_r$)			
Block	2	1036.2	529.3	19939.6	2080.5	3425.5
Arrays	6	1393.1	1617.1**	67999.5**	79895.5	73058.9**
Error	12	1356.4	250.9	12170.8	47411.1	4506.6
			($W_r - V_r$)			
Block	2	6577.3	198.1	19446.9	12032.6	275.0
Arrays	6	498.7	74.5	21052.0**	48026.3	462.9
Error	12	471.9	70.3	4408.6	32874.5	850.9

** Significant at P=≤0.01.

were not significant for plant height and seed yield/plant, thus failing to confirm the existence of a nonadditive effect for these two characters. The variation of W_r-V_r over arrays was significant only for number of pods/plant, indicating that the data do not obey the model for this character only. The nonsignificance of W_r-V_r is indicative of the absence of deviation from the basic dominance/additivity model for the other four characters.

The second test is an analysis of the W on V regression. This regression provides a geometric presentation of the degree of dominance. The regression coefficient is expected to deviate significantly from zero but not from unity if the assumptions are valid. The W_r/V_r graphs (Fig. 1) showed the presence of nonallelic gene interaction for plant height, number of pods/plant and seed yield/plant. The slope of the regression lines was above the origin point for all traits, confirming the presence of partial dominance.

It should be noted that, in the presence of epistasis, we cannot test for multiple allelism or gene correlation. The estimates of the genetic parameters for the characters that exhibited a partial failure of the assumptions are still possible, but the estimators are less reliable than when all the assumptions have been fulfilled (Hayman 1957).

Estimates of the genetic components and their corresponding standard errors are presented in Table 5. The results showed that the magnitude of additive effect D was significant for plant height, height to the first pod, number of pods/plant and 100-seed weight, but insignificant for grain yield/plant. The H_1 and H_2 estimates were significant and greater than D, indicating that the dominance gene effects play a major role in the inheritance of plant height, number of pods/plant and seed yield/plant. The $H_2/4H_1$ values were less than 0.25, indicating unequal distribution of dominant and recessive alleles among the parents for all traits. The quantities of $(H_1/D)^{½}$, a weighted measure of the average degree of dominance at each locus, were found to be more than unity for plant height, number of pods/plant and seed yield/plant, indicating the presence of overdominance. This contradicts the conclusion derived from the W_r/V_r graphs, which indicated partial dominance for all traits. Hayman (1957) stated that epistasis can decrease or increase the average degree of dominance. Moreover, Mather and Jinks (1971) noted that the most important shortcoming of estimating D and H is that unless $u = v = ½$ at each locus, D does not contain only additive genetic effects and H contains less than the whole of the dominance effects, with the consequence that the ratio of H to D is not a measure of the degree of dominance. Consequently, the overdominance obtained for plant height, number of pods/plant and seed yield/plant from the ratio $(H/D)^{½}$ is not reliable. Hence, the graphical analysis which indicated partial dominance for these traits could be accepted.

Broad- and narrow-sense heritability estimates were 0.78 and 0.55 for plant height, 0.62 and 0.46 for height to the first pod, 0.88 and 0.57 for number of pods/plant, 0.82 and 0.41 for seed yield/plant and 0.96 and 0.86 for 100-seed weight. Accordingly, selection could be effective in the segregating generations for improving these traits. These findings were in agreement with those obtained by Ibrahim (1972), Yassin (1973), Poulsen (1977) and Mahmoud and Ibrahim (1978).

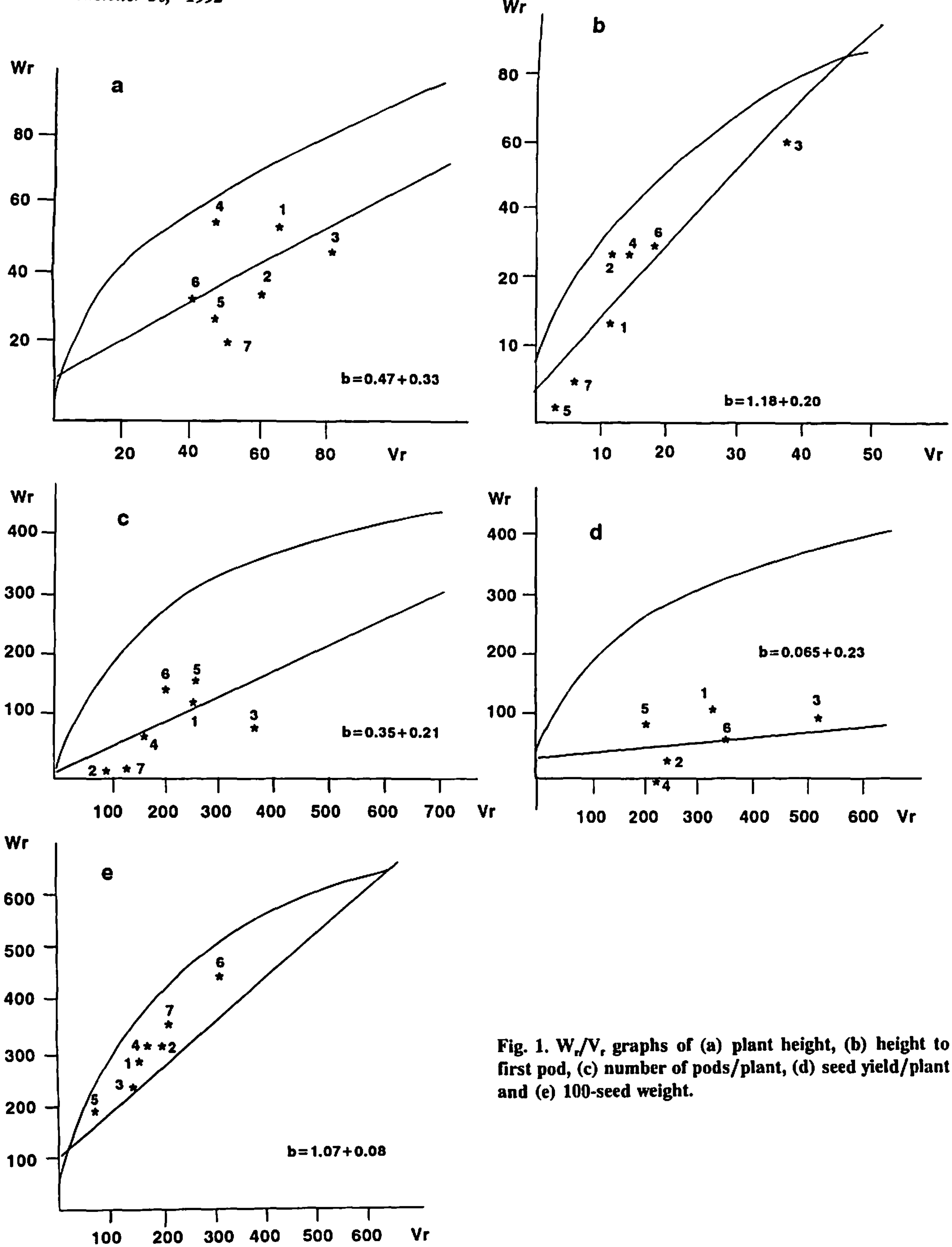

Fig. 1. W_r/V_r graphs of (a) plant height, (b) height to first pod, (c) number of pods/plant, (d) seed yield/plant and (e) 100-seed weight.

Table 5. Estimates of components of genetic variation and their ratios in a 7 × 7 diallel cross.

Components	Plant height (cm)	Height to first pod (cm)	No. pods/ plant	Seed yield/ plant (g)	100-seed weight (g)
D	55.54 ± 13.41	64.08 ± 5.17	174.49 ± 40.98	74.37 ± 111.91	617.38 ± 18.00
F	35.54 ± 32.16	61.03 ± 12.41	38.94 ± 98.31	45.30 ± 268.47	112.88 ± 43.19
H_1	90.54 ± 32.28	28.78 ± 12.45	613.38 ± 98.66	1070.50 ± 269.42	169.09 ± 43.34
H_2	82.91 ± 28.44	13.03 ± 10.97	390.51 ± 86.93	726.16 ± 237.39	117.34 ± 38.19
E	19.52 ± 4.74	7.69 ± 1.83	37.69 ± 14.49	82.56 ± 39.57	13.30 ± 6.37
Proportional values					
$(H_1/D)^{½}$	1.28	0.67	1.88	3.79	0.52
$H_2/4H_1$ = UV	0.23	0.11	0.16	0.17	0.17
$\frac{(4D\ H_1)^{½} + F}{(4D\ H_1)^{½} - F}$	0.60	5.91	1.13	1.18	1.42
Heritability:					
broad sense	0.78	0.62	0.88	0.82	0.96
narrow sense	0.55	0.46	0.57	0.41	0.86

Table 6. Phenotypic (P) and genotypic (G) correlation coefficients among pairs of characters of the seven parents (above diagonal) and their F_1 hybrids (below diagonal) for the diallel cross in faba bean.

		Plant height	Height to first pod	No. pods/ plant	Seed yield/ plant	100-seed weight
Plant height (cm)	P	—	0.02	0.54	0.02	0.99
	G	—	0.05	0.59	-0.01	0.99
Height to first pod	P	0.48	—	-0.45	-0.50	0.03
	G	0.59	—	-0.46	-0.55	0.06
No. pods/plant	P	0.57	0.57	—	0.60	0.54
	G	0.59	0.74	—	0.68	0.59
Seed yield/plant	P	0.19	0.45	0.74	—	0.01
	G	0.22	0.64	0.76	—	-0.02
100-seed weight	P	-0.69	-0.49	-0.72	-0.27	—
	G	-0.72	-0.40	-0.74	-0.25	—

Phenotypic and genotypic correlation coefficients among pairs of traits for the parents and their F_1 hybrids are presented in Table 6. Genotypic correlations were in general slightly higher than phenotypic correlations as reported by Singh et al. (1985). This similarity was probably due to the relatively small error variances and covariances.

Comparing the correlations among characters in the parents and F_1 hybrids, it is apparent that the correlation between any two pairs of characters differed according to the population under consideration. For example, the phenotypic correlation coefficients for the parents were positive between 100-seed weight and each of the following: plant height, height to the first pod, number of pods/plant and seed yield/plant. However, in the F_1 hybrids the phenotypic and genotypic correlations were negative between 100-seed weight and each of the other ones. The observed changes in the genotypic and phenotypic correlation coefficients could be due to the nature of the two populations studied. Parents are in the equilibrium state, while the linkage complexes in the segregating population could be a source of difference in correlations among characters (Miller and Rawlings 1967). On the other hand, in both parents and F_1 hybrids, the number of pods/plant gave the highest genotypic and phenotypic correlations with seed yield/plant. Similar results were concluded by Salem (1982), Huang and Jiang (1983) and Sindhu et al. (1985).

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Shambat 75, a Faba Bean Cultivar for El Rahad Area of Sudan

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Abstract

When faba bean production extended further south into central Sudan to the El Rahad area, producers faced the problem of shorter, warmer seasons, which reduced yields and made the crop more susceptible to the root rot/wilt complex. Line 0070 was higher yielding than the check (BF 2/2) by an average of 7.6% for the period 1983 to 1988. The line had a lower percentage of hard and defective seeds than any other line, including the check, and had a much higher hydration coefficient. When these quality parameters were taken into account, line 0070 was more than 24% higher yielding than other lines in the trials. Therefore, the Agricultural Research Corporation of Sudan released 0070 as Shambat 75 for the El Rahad area of Sudan.

شمبات 75، صنف فول ملائم لمنطقة الرهض في السودان

الملخص

مع التوسع في زراعة الفول جنوباً إلى المنطقة الوسطى من السودان حتى منطقة الرهض، واجه المزارعون مشكلة المواسم الأقصر والأكثر دفئاً مما أدى إلى انخفاض الغلة وتعرض المحصول لفرصة أكبر للإصابة بالمرض المركب تعفن الجذور/الذبول. وتفوقت السلالة 0070 في الغلة على الشاهد (BF2/2) بمتوسط قدره 7.6٪ خلال الفترة من 1983 وحتى 1988. وكان للسلالة أدنى نسبة مئوية من البذور الصلدة وغير السليمة مقارنةً بأي سلالة أخرى من ضمنها الشاهد، وكان لها معامل تميؤ أعلى بكثير. وعندما أخذت معايير الجودة هذه في الحسبان، أعطت السلالة 0070 غلة أعلى من السلالات الأخرى في التجربة بنسبة 24٪. لذلك اعتمدت هيئة البحوث الزراعية في السودان السلالة 0070 باسم الصنف شمبات 75 لمنطقة الرهض في السودان.

Introduction

Evaluation of faba bean utilization in Sudan for the last 20 years revealed that the crop forms an important component of the Sudanese diet and thus its consumption and prices are steadily increasing. In some years the domestic supply falls short of the demand and consequently the balance must be imported. The total production is usually low because of limited cultivable land in the traditional faba bean growing regions and the low yields obtained by farmers. Extension of faba bean production to central Sudan in the Gezira and further south to El Rahad and New Halfa agricultural production schemes seems to be logical since land and water are adequate. However, in these new areas the winter season is short and hot. Hence, suitable genotypes should be early in flowering and maturing, tolerant or resistant to the root rot/wilt disease complex and potentially high yielding.

Breeding programs initiated for this crop in 1980 at Shambat Research Station included a short-term program for genetic stock screening and variety tests at Shambat, Gezira, El Rahad and New Halfa Research Station. The results submitted below cast some light on the varietal aspects of this crop's yield under El Rahad conditions.

Materials and Methods

For five consecutive seasons (1983-1988), 12 faba bean breeding lines from the Sudanese collection, developed over the years since 1960 at Hudeiba Research Station, were planted at El Rahad Research Station. The tested lines were arranged in a randomized complete block design with four replications. Planting dates were 22 October 1983, 23 October 1984, 28 October 1985, 3 November 1986 and 1 November 1987, at an inter-row spacing of 20 cm on ridges 60 cm wide, with two seeds per hole. Sowing was on both sides of the ridge. The trials were irrigated every 7-10 days.

Superphosphate (P_2O_5) at 43 kg/ha and urea (N) at 86 kg/ha were applied at sowing. Danitol-S was sprayed to protect against leaf miner; weeding and other cultural operations were done as necessary.

The pedigrees of the breeding lines tested are shown in Table 1.

Two stability statistical tests were computed for each genotype. The first is the linear regression coefficient (b), obtained by regressing genotypes mean yields on the seasonal (environmental) index obtained as the difference between the marginal means and the overall mean (Eberhart and Russell 1966). The second is Wricke's ecovalence (W^2) cited in Lin et al. (1986).

Results and Discussion

Seed yield (t/ha) is shown in Table 1 for the seasons 1983/84 to 1987/88. Differences among the tested lines in seed yield were significant in 1983/84, 1985/86 and 1987/88 seasons.

The combined analysis of the seed yields of the 12 genotypes in the five seasons showed that the differences among the seasons and lines were highly significant. Similarly, the interaction of lines × seasons was highly significant. The highest yields in the overall average of the five seasons were obtained from line 0071, followed by 0070 and 0075, and their yields gave increases of 14.4%, 11.2% and 7.6%, respectively, over BF 2/2.

Stability tests for seed yield using the same subset of seasons (environments) are shown in Table 2. On the basis of both statistical tests, lines 0071, 0070 and 0075 were judged to be more stable than the rest of the tested breeding lines. The regression coefficient of line 0035 was close to 1.0, but its seed yield did not increase in favorable seasonal conditions.

Table 2. Stability statistics for seed yield.

Breeding line	Regression coefficient	Stability parameter R^2	Equivalence
0071	1.13 ± 0.25	0.87	1.14
0070	1.14 ± 0.14	0.96	0.41
0075	1.19 ± 0.08	0.99	0.30
00656	1.04 ± 0.13	0.96	0.28
0072	1.24 ± 0.04	1.00	0.35
BF 2/2	1.27 ± 0.22	0.92	1.21
007	0.39 ± 0.28	0.38	3.67
00633	0.94 ± 0.24	0.83	1.01
0035	1.01 ± 0.06	0.99	0.10
00634	1.11 ± 0.14	0.96	0.38
00532	0.86 ± 0.10	0.96	0.29
0080	0.75 ± 0.24	0.76	1.39

Quality assessment was done once for all lines in the 1987/88 season. It can be seen from Table 3 that line 0075, which had the third highest seed yield among the tested lines, had the best quality attributes in comparison

Table 1. Seed yield (t/ha) of 12 genotypes of faba bean grown in the El Rahad area for five seasons.

Breeding line	Cross pedigree	Season 1983-84	1984-85	1985-86	1986-87	1987-88	5-season mean
0071	Bulk of the cross (Giza 2 × Giza 1)	2.47	1.32	2.91	1.44	2.55	2.14
0070	Bulk of the cross (BF289 × BM 9/3)	1.73	1.30	2.91	1.71	2.66	2.06
0075	Bulk of the cross (Hudeiba 72 × Giza 1)	1.75	1.24	2.80	1.46	2.66	1.98
00656	Bulk of the cross (Selaim × Giza 1)	1.69	1.38	2.68	1.45	2.60	1.96
0072	Bulk of the cross (Giza 2 × Hudeiba 72)	1.85	1.03	2.78	1.36	2.48	1.90
BF 2/2	Inbred line from the Baladi	1.35	1.02	2.68	1.44	2.68	1.83
007	Bulk of the cross (188 × RB 30)	2.19	1.26	2.06	1.82	1.77	1.82
00633	Bulk of the cross (Salaim × Giza 1)	1.29	1.29	2.45	1.50	2.47	1.80
0035	Bulk of the cross (NEB 423 × NE B425.S)	1.69	1.13	2.55	1.31	2.23	1.78
00634	Bulk of the cross (Rebaya 30 × Giza 1)	1.67	1.10	2.64	1.12	2.18	1.74
00532	Rebaya 40	1.72	1.08	2.18	1.39	2.31	1.74
0080	Bulk of the cross (Salaim × Giza 1)	2.02	0.95	1.98	1.30	2.08	1.67
S.E. ±		0.13	0.09	0.21	0.07	0.10	0.06
Mean		1.78	1.17	2.55	1.44	2.39	1.87

Table 3. Some yield components and seed quality attributes of 12 faba bean genotypes grown in the El Rahad area in the 1987/88 season.

Breeding line	No. pods/ plant	1000-seed weight (g)	Total defective seeds (%)	Hard seed (%)	Hydration coefficient (%)	Cookability (%)	Tannic acid (%)	Crude protein (%)
0071	19.1	443	11.3	10.9	173.9	37.2	0.05	27.35
0070	15.5	413	11.9	11.3	174.4	35.2	0.06	27.78
0075	18.4	417	5.9	4.7	192.5	30.5	0.06	28.00
00656	18.6	413	10.4	9.6	173.4	31.8	0.04	27.13
0072	15.5	423	12.6	11.0	179.2	31.8	0.07	28.06
BF 2/2	18.4	390	13.4	12.7	174.6	27.8	0.07	28.99
007	18.1	407	10.2	9.6	174.4	35.2	0.05	27.93
00633	20.2	424	11.9	10.9	172.2	36.0	0.04	27.83
0035	15.6	420	16.7	16.1	167.4	42.5	0.06	26.18
00634	18.2	415	12.8	12.4	168.0	41.0	0.06	29.40
00532	19.2	395	6.2	6.0	180.0	35.5	0.04	29.00
0080	17.2	433	13.1	12.0	177.7	28.2	0.07	29.99
S.E. ±			1.00	0.93	30.5	2.27	0.00	0.45
Mean	17.8	416	11.4	10.6	175.7	34.4	0.06	28.14

with the other lines, specifically the first and the second highest seed yielding lines (0071 and 0070, respectively). Although line 0075 had a 1000-seed weight of 417 g, less than that of 0071 by 5.9%, it had the highest percentage of hydration coefficient and the lowest percentages of hard seed and defective seeds.

The hard seed percentage in 0075 was low (4.7%) compared with lines 0071 and 0070. The difference in hard seed was as high as 6.2 and 6.6% for 0071 and 0070, respectively. Consequently the effective seed yields of lines 0070 and 0071 were less by 0.133 and 0.136 t/ha, respectively, than that of line 0075.

The hydration coefficient percent showed a very high value for line 0075 (192.5%) compared with lines 0070 and 0071 (174.4 and 173.9%). The resulting differences in the yields of 0070 and 0071 amounted to 0.398 and 0.373 t/ha, respectively. If the differences in hard seed and hydration coefficient for lines 0070 and 0071 are considered as qualities not available for immediate utilization, then their actual yields will be less than the seed yield of 0075 by 26.2 and 23.7%, respectively.

Conclusion

Based on the above results and discussions on 6 May 1991, the variety release committee of the Agricultural Research Corporation approved the release of line 0075 under the name Shambat 75 for the El Rahad area of the Sudan.

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Shambat 104, a New Faba Bean Cultivar for the Gezira, Sudan

شمبات 104، صنف فول جديد لمنطقة الجزيرة بالسودان

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Abstract

With the extension of faba bean cultivation to central Sudan, problems were faced with shorter and warmer growing seasons, which reduced yields and made the crop more susceptible to disease. Quality, particularly hardseededness, also was a problem. Line 00104 was found to have yield advantages of 17.2 to 19.6% over the local checks BF 2/2 and Hudeiba 72 for the period 1981 to 1990. The line also had acceptable quality traits and showed a good tolerance to the root rot/wilt complex, the major disease in the new areas. For this reason, 00104 was released by the Agricultural Research Corporation of Sudan as Shambat 104 for use in the central region of Sudan.

الملخص

مع التوسع في زراعة الفول إلى المنطقة الوسطى من السودان، واجه المزارعون مشكلات تتعلق بالمواسم الزراعية الأقصر والأكثر دفئاً مما أدى إلى انخفاض الغلة وتعريض المحصول على نحو أكبر للإصابة بالأمراض. كما شكلت الجودة ولاسيما صلادة البذور مشكلة أخرى. ووجد أن السلالة 00104 تتفوق في الغلة بنسبة تتراوح بين 17.2 و 19.6٪ على أصناف الشاهد المحلية BF 2/2 وحديبة 72 خلال الفترة الممتدة بين 1981 و 1990. كما كان لتلك السلالة صفات جودة مقبولة وأظهرت قدرة جيدة على تحمل المرض المركب تعفن الجذور/الذبول الذي يعتبر المرض الرئيسي في المناطق الجديدة. ولهذا السبب اعتمدت هيئة البحوث الزراعية بالسودان السلالة 00104 باسم شمبات 104 لزراعتها في المنطقة الوسطى من السودان.

Introduction

Faba bean is the most important food legume in the Sudan. It is increasingly becoming popular with many of the Sudanese people. Recently the demand for this commodity has outstripped local production and as a result prices have sharply increased.

Faba bean is traditionally grown on small irrigated holdings with lift irrigation along the banks of the Nile in the northern region. Horizontal expansion of faba bean production in that area is limited by a shortage of suitable land and irrigation water. In addition, cost of production is rising because of large increases in cost of agricultural inputs and marketing facilities.

As part of the efforts of the Nile Valley Project to make this essential food commodity available to the consumer at a reasonable price, serious research attempts have been made during the last 10 years to extend faba bean cultivation to irrigated schemes of central Sudan (Gezira, El Rahad and New Halfa) where land, water and agricultural services are reasonably adequate.

The extension of faba bean cultivation to central Sudan was not without problems. The growing season is shorter (90-110 days) and warmer and soils (Vertisols) are heavier than in traditional areas (Northern Region). The effect of these factors on faba beans has been production of smaller plants, with fewer pods and inferior quality. The crop is more susceptible to disease, mainly the root rot/wilt disease complex, which is enhanced by relatively warmer climates.

Materials and Methods

The majority of the genotypes included in the executed trials were bulks of F_1 crosses made at Hudeiba Research Station between 1968 and 1975. They were evaluated for seed yield at Shambat Research Station, Gezira, El Rahad and New Halfa Schemes for eight seasons in 24 yield trials. The tested inbred lines were compared with either or both of the standard varieties Hudeiba 72 and BF 2/2 in a randomized complete block design with four replicates. Inter- and intra-ridge spacing was 0.6 and 0.2 m, respectively. The trials were planted in the last week of October or the first week of November.

The attributes measured included seed yield, 100-seed weight, number of pods per plant and some quality characters.

Results and Discussion

Seed yield

In 18 out of 24 experiments, line 00104 was the best in nine cases, the second in five cases, the third in two cases and the fifth in two cases. It outyielded BF 2/2 or Hudeiba 72, the traditionally grown varieties (Table 1), with yield advantages averaging 17.2 to 19.6%. Line 00104 has given comparatively high, consistent and stable yields throughout the 8 years of testing. It also has proved to be an early flowering and early maturity genotype which fits well with the short growing period of the new areas south of Khartoum, and has fairly good tolerance to the root rot/wilt complex.

Table 1. Line 00104 and mean of Hudeiba 72 and BF 2/2 (checks) yields in different experiments and seasons (kg/ha).

	Genotype		
Season†	00104	Checks	Increase (%)
1981/82	1831	1070	+ 71.1
1982/83	3183	2456	+ 29.6
1983/84‡	2679	2214	+ 21.0
1983/84‡	1761	1550	+ 13.6
1984/85	1308	1389	- 6.1
1986/87	2079	1709	+ 21.6
1987/88	2073	1942	+ 6.3
1988/89	3245	3054	+ 6.7
1989/90	3183	2825	+ 12.7
Mean	2371	2023	+ 17.2-19.6

† Results from 1985/86 not available.
‡ Two separate trials were executed in 1983/84, one at Shambat, the other at Wad Medani. In both trials, the genotypes were different except for a few common genotypes.

Quality assessment

This was done only once for the seven genotypes included in the national verification trial in 1989/90. Line 00104 gave the third lowest percentage of hard seed (unsoaked seeds), the lowest percentage of defective seeds and the lowest percentage of toxic acid content in the seed (Table 2). It also showed the second highest percentage of cookability and the third highest percentage of hydration coefficient. Line 00104 had the third largest seed size and this renders it more preferable for consumers than the small-seeded types like BF 2/2 and BF 2/2/8/1.

Table 2. Faba bean, some yield components and some seed quality attributes of the genotypes included in the national verification trial, 1989/90 season.

Breeding line	Testa fraction (%)	Defective seeds (%)	Hard seeds (%)	Tannic acid (%)	H.C. (%)†	Cookability (%)	No. pods/ plant	100-seed weight (g)	Crude protein (%)
00104	13.4	2.2	7.63	0.11	181.8	33.7	15.0	46.0	33.94
H.72/7	12.4	2.8	7.30	0.15	189.3	33.7	15.1	48.1	31.83
00654	13.1	2.5	11.00	0.13	176.4	30.4	17.5	44.3	28.70
00634	13.0	3.4	10.20	0.13	178.6	32.8	16.2	43.3	32.84
Sm-L	12.7	5.4	2.28	0.13	199.4	27.7	14.9	66.6	34.40
BF 2/2	13.5	4.3	8.30	0.12	181.1	30.8	16.9	41.4	22.94
BF 2/2/8/1	12.7	5.2	3.50	0.15	201.8	35.6	19.2	41.7	30.87
SE±	0.10	—	—	—	—	—	0.49	0.67	—
Mean	13.0	3.7	7.17	0.13	186.9	32.1	16.4	47.7	30.79

† H.C. = Percentage of hydration coefficient.
All values included in this table are averages of five locations.

Conclusion

On 6 May 1991, the variety release committee of the Agricultural Research Corporation approved the release of line 00104 as a commercial cultivar for the central region of Sudan, especially the Gezira, under the name of Shambat 104.

Pedigree of cultivar Shambat 104

It is a bulk of an F_1 cross, NEB 133.S × NEB 425, made in Hudeiba Research Station in the 1975/76 season. Both entries included in the cross were received from the ALAD Organization. The cross was registered in the records of the plant breeding section of Shambat Research Station under the designation 00104.

Description of variety Shambat 104

The variety has a vigorous growth habit with a tall (90-117 cm), indeterminate stem. Stem thickness ranges between 8 and 10 mm. The plants are resistant to lodging and have basal branching of nearly 3-4 branches per plant. Its leaf is formed from 4-6 leaflets. The leaflet shape is intermediate (subelliptic) and of medium size. Inflorescences are multiflowered and the majority have three flowers formed in the axils of the leaves. The flowers have white petals with dark purple spotted wings. The genotype takes an average of 42 days to flowering and 105 days to maturity and hence could be classified as of medium maturity. The mature pods are erect, flattened, constricted, dark (brown/black) in color and with a matted surface. The pod length is about 6.5 cm and each pod has 3-4 seeds. The majority of the pod-bearing nodes have 2-3 pods. The 100-seed weight ranges from 42 to 48 g. Seeds are angular in shape, mostly with light brown testa and black hilum.

Agronomy and Mechanization

Seedling Emergence in Inbred Lines of Faba Bean in Three Agroecological Zones of Ethiopia

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Abstract

Seedling emergence in 23 inbred lines of faba bean from England and Ethiopia was studied across three different agroecological zones in Ethiopia. The zones—Holetta, Debre Zeit and Nazreth—differ from each other in soil texture and temperature regimes. The influences of soil temperature and soil texture on the rate of seedling emergence were apparent. The highest seedling emergence was observed in the sandy clay loam soils of Nazreth, where the daily mean air and soil temperatures were relatively higher than at the other two sites. The rate of seedling emergence at Debre Zeit was second highest, but not significantly higher than that at Holetta. The best initial plant stand of the three would be expected at Nazreth.

تكشف البادرات في سلالات الفول النقية في ثلاث مناطق بيئية زراعية في إثيوبيا

الملخص

تمت دراسة تكشف البادرات في 23 سلالة فو ل نقية من إنكلترا وإثيوبيا في ثلاث مناطق بيئية زراعية مختلفة في إثيوبيا. وتختلف المناطق الثلاث (هوليتا ودبرزيت ونازريت) عن بعضها بعضاً في قوام التربة ونظام الحرارة، وكانت تأثيرات درجة حرارة التربة وقوام التربة على معدل تكشف البادرات واضحاً. ولوحظ أعلى تكشف للبادرات في التربة الطمية الرملية في نازريت حيث كان متوسط درجات حرارة الهواء والتربة أعلى نسبياً مما هي في الموقعين الآخرين. وكان معدل تكشف البادرات في دبرزيت في المرتبة الثانية إلا أنه لم يكن أعلى معنوياً مما هو عليه في هوليتا. ويتوقع أن تتمتع نازريت بأفضل كثافة محصولية مبدئية بين المناطق الثلاث.

Introduction

Faba bean (*Vicia faba* L.) is extensively grown both in the mid-altitude (Wynadega, 1850–2200 m) and high-altitude (Dega, 2200–3000 m) zones of the Ethiopian plateau (Amare and Beniwal 1988). However, faba bean grain yield suffers from extreme temperatures prevailing in these zones. In Wynadega zone, high daytime temperatures that fluctuate between 25 and 30°C at the prime morphological and reproductive phases interfere with normal growth, development and fertilization processes. Coupled with moisture stress, this results in excessive flower drop as observed in the 1987 crop season.

Likewise in the Dega zone, daytime temperatures from 18 to 22°C and night temperatures from -5 to 5°C adversely affect normal growth and development of faba bean with the fertilization process and seed development suffering the most. For this zone, the situation is very serious, particularly from early August to early October, when prevalence of low temperatures is common. To overcome these difficulties, a screening program of a geographically wide diversity of inbred faba bean genotypes was initiated. The zones selected were Holetta, representing the Dega zone; Debre Zeit, representing the Wynadega zone, and Nazreth, the lowland zone. The results of a study on the effect of location environment on the seedling emergence of 23 faba bean inbred genotypes are reported here.

Materials and Methods

Twenty-three inbred faba bean lines were selected for the study. These included 9 inbred lines (selfed for eight or nine generations) from the University of Durham, England, with origins from a wide geographical diversity, and 14 Ethiopian selections (selfed for four generations), some of which were ICARDA-originated selections. All 23 genotypes were planted at Holetta Research Center (HRC), about 45 km west of Addis Ababa, Debre Zeit Research Center (DZRC), 45 km southeast of Addis Ababa and Nazreth Research Center (NRC), 120 km southeast of Addis Ababa. Soil types were red clay (Nitosols), silt loam and sandy loam, respectively.

At all three sites, the method of seedbed preparations was similar. The soil after disc-plowing was immediately followed by disc-harrowing and leveling. Any large, leftover soil clods were further broken down manually. After preparation of a fine seedbed, ridges at 40-cm spacing were made. At NRC the ridges were made 60 cm apart with a tractor ridger. The approximate height of the ridges was 15 cm. Just prior to sowing, diammonium phosphate (DAP) was incorporated into each ridge at the rate of 100 kg/ha. Also prior to sowing, five seeds from each genotype were soaked overnight in tap water at room temperature (24, 26.5 and 26°C at HRC, DZRC and NRC, respectively).

Seeds were sown by placing them 25 cm apart at an average depth of 3 cm. At HRC, sowing was done on 11 November 1987 on the top of ridges; at DZRC and NRC, seeds were sown along the sides of the ridges on 11 December and 26 November, respectively. Sowing was immediately followed by irrigation until the top of each ridge was soaked with water. Irrigation was done every 4th day at DZRC and NRC and once every week at HRC. Weeding and intercultivation, done after second irrigation, prevented undesirable crust formation at the surface (Kanemasu et al. 1975) and facilitated good water penetration and normal air circulation. Seedling emergence was recorded at 10 and 15 days after seeding.

Results and Discussion

A minimum air temperature of -3°C was observed at Holetta 5 days after seeding, and of 3.9°C at Nazreth 20 days after seeding (Fig. 1). Maximum air temperature of 24.5°C at Holetta was observed at 13 days after seeding, while at Nazreth it reached 30.5°C on the first day of seeding. Soil temperatures at 5 and 10 cm depth for Holetta, and on the surface and at 10-cm depth for Nazreth did not show much variation (Fig. 1). Relative humidity at Holetta varied from 37 to 57%, while at Nazreth it varied from 40 to 64%. A slightly higher humidity at Nazreth than at Holetta was expected because of its proximity to the Awash River.

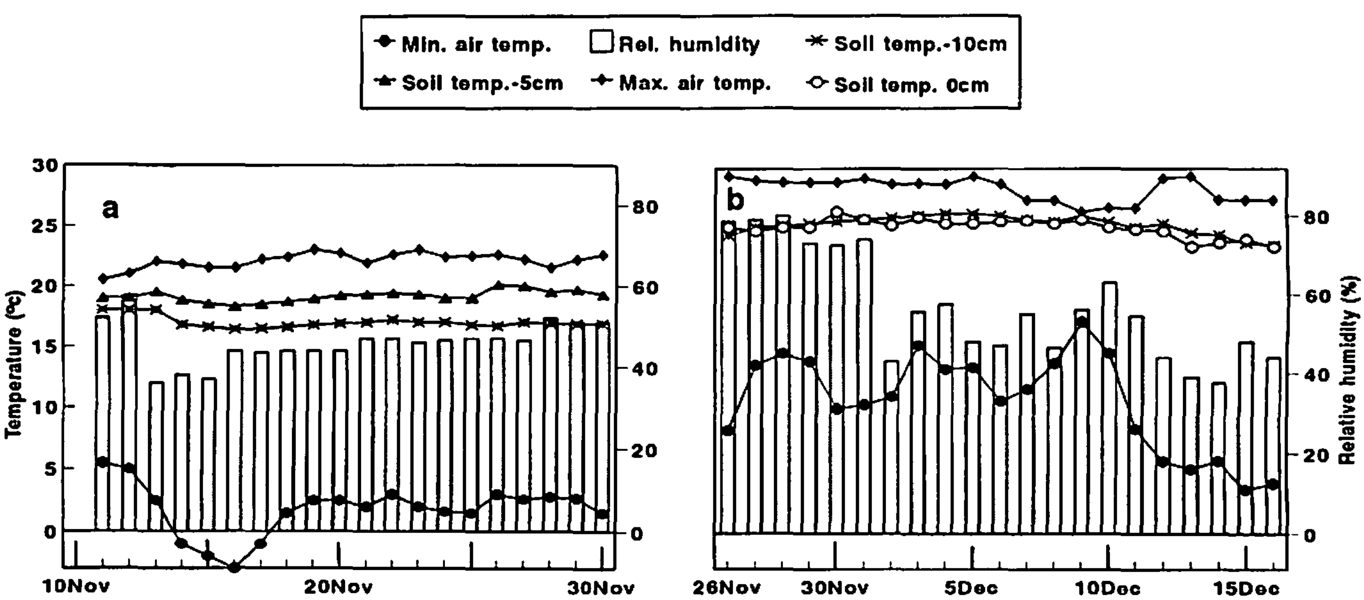

Fig. 1. Trends in temperature and relative humidity from the first day of planting to the last day of emergence count of faba bean seedlings, 1987: (a) Holetta Research Center and (b) Nazreth Research Center.

The seedling emergence was higher at Nazreth (significant at 5%) than at Holetta and Debre Zeit, where differences in seedling emergence were nonsignificant (Table 1). The location differences might be due to temperature and soil type differences at the three sites (Singh and Dhaliwal 1972; Kanemasu 1975; Fakorede and Ojo 1981). The soil is red clay at Holetta, silt clay loam at Debre Zeit and sandy clay loam at Nazreth, the latter known to encourage better crop emergence (Singh and Dhaliwal 1972). Nazreth also had higher soil and air temperatures, known to affect crop emergence favorably (Singh and Dhaliwal 1972).

Table 1. Seedling emergence in two types of inbred faba bean lines at three locations in Ethiopia recorded at 10 days (P_1) and 15 days (P_2) after seeding, 1987 season.

Genotypes†		HRC	DZRC	NRC	Mean	Genotype mean
I	P_1	2.6‡	2.6‡	3.1‡	2.8	3.48
	P_2	4.6	3.3	4.7	4.2	
II	P_1	2.8	2.3	3.0	2.7	3.37
	P_2	3.0	4.3	4	4.0	
Mean		3.25	3.13	3.9*		

† Genotypes in group I are the inbred lines from the University of Durham; genotypes in group II are from Ethiopian selections.
‡ Out of five seeds seeded.
* Significantly different at $P<0.05$.

The rate of seedling emergence also was significantly higher at Nazreth than at the other two sites, which had similar rates of emergence. This again could be attributed to light soils and higher soil and air temperatures at Nazreth than at Holetta and Debre Zeit. The mean number of seedlings emerged at 10 days was 2.73 and at 15 days 4.15. The difference was significant at 1% probability level. This is expected because the second count (period II) is the sum of the first and the second count. However, the seedling emergence in the first period was higher (2.75) than that of the second period (1.35) (Table 1). Differences in the two groups of genotypes from England and Ethiopia were not apparent.

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Seeding Date Effects on Faba Bean Yields in Two Agroecological Areas of Southern Chile

تأثير موعد الزراعة على غلة الفول في منطقتين بيئيتين زراعيتين في جنوبي تشيلي

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Abstract

The effects on faba bean yields of four planting dates, with and without fungicide protection to control *Botrytis vicie fabae*, were studied in two agroecological areas of southern Chile in 1990. In both locations yields of green pods, dry matter and dry grain were significantly higher from crops with early winter planting dates. The increased yields in the early sowing dates were associated with increased numbers of pods/plant and mean seed weight.

الملخص

تمت دراسة تأثير أربعة مواعيد لزراعة الفول على الغلة باستخدام وبدون استخدام مبيدات فطرية لمكافحة التبقع الشوكولاتي *(Botrytis vicie fabae)* في منطقتين بيئيتين زراعيتين بجنوب تشيلي عام 1990. وفي كلا المنطقتين كانت غلة القرون الخضراء والمادة الجافة والحب الجاف أعلى معنوياً من المحاصيل التي زرعت في أوائل الشتاء. وقد ارتبطت زيادة الغلة في مواعيد الزراعة المبكرة بازدياد عدد القرون/النبات ومتوسط وزن البذور.

Introduction

Faba bean (*Vicia faba* var. *major*) in Chile is used almost exclusively as green beans for human consumption and less often is mixed with oats for silage. The area dedicated to the crop is around 5000 ha, concentrated in Central and South Chile (Krarup 1984). Recently, Chilean farmers have demonstrated an interest in the production of dry grains for external markets. However, information on sowing dates and other aspects of management is scarce, especially in the central-south zone where soils and climate conditions would be suitable for the development of this crop. For this reason the Food Legume Program of the Estación Experimental Quilamapu (INIA), Chile initiated preliminary trials on the effect of sowing date on yield in 1990. The results of those experiments are reported here.

Materials and Methods

Four planting dates with and without fungicide use to control *Botrytis vicie fabae*, were studied in Yungay, in the Andes foothill region (37° 09' S, 72° 02' W; 530 m a.s.l.) and at Chillan in the Central Valley region (36° 03' S, 72° 06' W; 144 m a.s.l.) under rain-fed conditions. Total rainfall was 518 and 691 mm during the crop period at Chillan and Yungay, respectively. The soil type was an Andept in both locations. In Chillan the soil pH was 6.2 with 6.0% organic matter. At Yungay the soil had a pH of 5.8 with 8.0% organic matter.

A population of 25 plants/m^2 was established in 5-row plots, each 5 m long, with a distance of 40 cm between rows and 10 cm between plants. A split-plot design with four replications was used with planting dates as main plot and fungicide protection as subplot. Benoyml 75%, at a rate of 50 g/100 L water plus adherents, was applied in the subplot as fungicide protection approximately 60 days after sowing and subsequently every 15 days until pods filled. To avoid fungicide drift, barley was planted to separate the subplots. The faba bean cultivar used was LPH-28, a large-seeded type of unknown origin. In both locations the trials were fertilized with P_2O_5 as triple superphosphate at 90 kg/ha and the seed was inoculated with a *Rhizobium* sp. One row was sampled to measure green pod yield and dry matter determination and two rows were harvested for dry seed yield.

Results and Discussion

In both locations yields of green pods, dry matter and dry grain were significantly higher in early winter than at later sowing dates (Tables 1, 2). There were no significant effects of either the fungicide protection or the interaction of sowing dates × fungicide protection on yield. The

Table 1. Green pod, dry matter and dry grain yields of faba bean cv. LPII-28, at different sowing dates, with and without foliar fungicide protection at Chillan and Yungay, Chile in 1990.

	Green pods† (t/ha)			Dry matter† (t/ha)			Dry grain† (t/ha)		
Sowing date	FF	WF	Mean	FF	WF	Mean	FF	WF	Mean
Chillan									
26 June	19.5	23.3	21.4	8.3	8.3	8.3	5.2	5.2	5.2
19 July	19.4	18.9	19.2	6.1	6.0	6.1	3.4	3.8	3.6
10 August	18.4	19.0	18.7	5.3	5.4	5.4	3.5	3.3	3.4
24 August	12.7	21.1	12.4	5.0	4.9	5.0	3.3	3.0	3.2
LSD (0.05)			1.1			0.2			0.4
CV (%) Sowing date		27.8			19.0			19.6	
Fungicide		3.0			15.1			14.1	
Yungay									
26 June	12.1	11.8	12.0	3.6	3.1	3.4	2.3	2.2	2.3
19 July	10.0	9.5	9.8	3.6	3.6	3.6	1.6	1.8	1.7
10 August	7.8	6.6	7.2	2.7	2.3	2.5	1.1	1.0	1.1
24 August	6.1	4.7	5.4	1.8	1.7	1.8	0.7	0.7	0.7
LSD (0.05)			0.5			0.1			0.1
CV (%) Sowing date		26.6			13.2			18.9	
Fungicide		14.8			14.4			10.3	

FF = foliar fungicide; WF = without fungicide.
† Average of four replications. Significant only for sowing dates at P ≤0.01.

Table 2. Pods per plant and 1000-seed weight of faba bean cv. LPII-28 at different sowing dates, with and without foliar fungicide protection at Chillan and Yungay, Chile in 1990.

	Pods/plant†			1000 seed-weight†(g)		
Sowing date	FF	WF	Mean	FF	WF	Mean
Chillan						
25 June	4.9	5.1	5.0	1991.4	1915.7	1953.4
15 July	4.2	4.5	4.4	1697.8	1630.7	1664.3
9 August	3.8	3.5	3.7	1665.0	1718.8	1691.9
24 August	3.5	3.3	3.4	1637.0	1543.1	1590.0
LSD (0.05)			0.8			430.0
CV (%) Sowing date		17.6			7.3	
Fungicide		7.1			7.8	
Yungay						
26 June	2.8	2.5	2.7	1746.4	1703.2	1724.8
19 July	1.8	2.1	2.0	1662.8	1582.0	1622.4
10 August	1.6	1.5	1.6	1430.9	1423.4	1427.1
24 August	1.3	1.3	1.3	1342.8	1254.7	1298.7
LSD (0.05)			0.4			325.3
CV (%) Sowing date		18.9			6.3	
Fungicide		5.2			8.6	

FF = foliar fungicide; WF = without fungicide.
†Average of four replications. Significant only for sowing dates at P (≤0.01).

incidence of *Botrytis* disease was very low in both Yungay and Chillan.

The increase in yields in the early sowing dates was because of an increased number of pods/plant and higher mean seed weights (Table 2). The results of these experiments suggested that, among rain-fed crops in Central-South Chile, faba bean has a higher yield than either lentil (1.0-2.5 t/ha at Chillan and 1.0-1.8 t/ha at Yungay), or pea (2.5-4.0 t/ha at Chillan and 2.0-3.8 t/ha at Yungay). However, improved cultivars need to be evaluated with different seeding rates in spring sowing, with irrigation and at different fertilization rates.

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Performance of Faba Bean Varieties at Different Plant Densities

الكفاءة الإنتاجية لأصناف الفول عند كثافات نباتية مختلفة

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Abstract

An experiment to study the effect of variety and plant density on growth and yield of faba bean was conducted during the *rabi* (winter) season of 1980/81 and 1982/83 at the Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar. This study included two varieties (UPS 1 and BS 1) and five plant densities (12.5, 25, 50, 100 and 200 plants/m^2). Differences in grain yield, number of grains/pod, 100-grain weight and number of nodes/plant due to variety and variety × density interaction were not significant. Grain yield increased with increasing plant density up to 100 plants/m^2. Number of nodes/branch and plant height increased, but number of pods/branch, pods/plant, branches/plant and nodes/plant decreased with increase in plant density.

الملخص

أجريت تجربة لدراسة تأثير الصنف والكثافة النباتية على نمو وغلة الفول خلال فصلي الشتاء في 1980/81 و 1982/83 في مركز بحوث المحاصيل في جامعة جوفيند بالابه بانت للزراعة والتكنولوجيا في بانتاناجر. وشملت الدراسة صنفين (UPS 1 و BS 1) وخمس كثافات نباتية (12.5 و 25 و 50 و 100 و 200 نبتة/م^2). ولم تكن الفروقات في غلة الحب وعدد الحبات/القرون ووزن المئة حبة وعدد العقد/النبات والناجمة عن الصنف وتفاعل الصنف x الكثافة معنوية. وازدادت الغلة الحبية مع تزايد كثافة النبات حتى 100 نبتة/م^2 كما ازداد عدد العقد/الفرع وطول النبات. إلا أن عدد القرون/الفرع و القرون/النبات و الفروع/النبات و العقد/النبات انخفضت مع ارتفاع الكثافة النباتية.

Introduction

The response of faba bean to different agronomic inputs in different areas of India has yet to be investigated. Among the factors affecting growth and yield, variety and plant density are of paramount importance. Varieties not only possess substantially different growth patterns, they also differ in inherent yield potential. Planting too densely or too sparsely may result in suboptimal yields. High plant density, in general, adversely affects the plant's growth and development. Suboptimal plant density, on the other hand, results in high yield per plant but lower yield per unit area. Thus, an experiment was conducted to identify high-yielding varieties and optimal 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. The experimental soil during 1980/81 was low in organic carbon and high in available phosphorus and potassium; in 1982/83 the soil was high in organic carbon and available potassium and medium in available phosphorus. Soils of both fields were neutral in reaction. A uniform basal application of diammonium phosphate (18% N and 46% P_2O_5) was made at the rate of 100 kg/ha. The crop was sown during the first week of November and harvested during the first week of April in both years.

The treatments, consisting of two varieties (UPS 1 and BS 1) and five plant densities (12.5, 25, 50, 100 and 200 plants/m^2), were laid out in a randomized block design with four replications. Seed was placed 5 cm deep in furrows at a constant spacing of 20 cm. Two seeds per hill were put at a distance of 2.5, 5, 10, 20 and 40 cm and only one plant/hill was allowed to grow. Data were recorded on yield and its attributes at maturity.

Table 1. Characters as affected by varieties and plant densities.

	Varieties			Plant densities (plants/m²)					
Characters	UPS 1	BS 1	LSD†	12.5	25	50	100	200	LSD†
Grain yield (kg/ha)									
1980–81	3449	3527	NS	3421	3312	3765	3593	3849	NS
1982–83	3349	3430	NS	2109	3265	3593	3952	4030	351
Pooled	3499	3478	NS	2665	3288	3679	3772	3939	163
No. pods/plant									
1980–81	18.3	19.0	0.7	44.3	25.3	13.2	6.8	3.5	1.2
1982–83	16.7	16.2	NS	37.1	22.8	13.5	6.0	3.1	0.6
No. grains/pod									
1980–81	2.8	2.8	NS	2.6	2.7	2.8	2.9	2.9	0.05
1982–83	2.7	2.7	NS	2.5	2.6	2.9	2.8	2.8	0.05
100-grain weight (g)									
1980–81	26.4	26.1	NS	25.5	26.0	26.5	26.1	27.2	1.0
1982–83	25.4	26.5	NS	25.6	26.0	26.3	26.9	27.5	0.4
Plant height (cm)									
1980–81	107	103	1.0	94	101	107	111	113	1.0
1982–83	77	79	1.0	69	72	76	81	93	1.6
No. branches/plant									
1980–81	3.5	3.7	NS	6.7	4.7	3.2	2.3	1.1	0.3
1982–83	3.3	3.6	0.2	6.5	4.7	3.2	1.9	1.0	0.3
No. nodes/plant									
1980–81	37.4	37.7	NS	57.0	48.9	36.3	28.9	16.7	2.5
1982–83	44.5	43.7	NS	71.2	59.3	43.6	29.1	17.2	4.1
No. nodes/branch									
1980–81	11.4	11.4	NS	8.4	10.4	11.3	12.4	14.5	0.4
1982–83	14.2	12.9	0.3	10.9	12.6	13.6	14.7	15.9	0.5
No. pods/branch									
1980–81	4.3	4.3	NS	6.5	5.2	4.1	2.9	2.9	0.3
1982–83	4.3	3.4	0.3	4.7	4.8	4.2	3.1	2.9	0.3

NS = nonsignificant.
† P = 0.05.

Results and Discussion

Varieties

The interaction between varieties and plant densities for all characters being nonsignificant, main effects of varieties and plant densities are presented here. Differences in grain yield/ha due to variety were not significant in either year (Table 1). Differences in number of grains/pod, 100-grain weight and nodes/plant were unaffected by variety. Average number of grains/pod is a relatively stable character in faba bean varieties (Chapman 1981). The most important yield-attributing characters—number of pods/plant (Table 1), which was higher in BS 1 during the first year, and number of pods/branch (Table 1), which was higher in UPS 1 during the second year—did not lead to a significantly different grain yield between varieties. The trend in plant height of these two varieties was not consistent during 2 years of experimentation.

Plant densities

Grain yield/ha in both years increased with the corresponding increase in plant density, although differences were significant only in 1982/83. Grain yield increased significantly with increases in plant density up to 100 plants/m^2 in 1982/83 and up to 200 plants/m^2 for pooled yield. Differences between 100 and 200 plants/m^2 were not significant during 1982/83. The increase in yield on a pooled basis over 12.5 plants/m^2 was 19, 33, 36 and 42% with 25, 50, 100 and 200 plant/m^2, respectively. The positive effect of plant density in enhancing grain yield of faba bean has been widely reported (Hodgson and Blackman 1956; Sprent et al. 1977; Thompson and Taylor 1977).

Yield attributes showed that the number of grains/pod increased up to 50 plants/m^2 and 100-grain weight up to 200 plants/m^2, whereas the number of pods/plant decreased consistently with increasing plant density even up to 200 plants/m^2. Reduction in number of pods/plant with increasing density confirmed the findings of Hodgson and Blackman (1956), Kambal (1969) and Salih (1981). Fewer branches/plant and pods/branch with increasing plant density might be responsible for a lower number of pods/plant at higher plant densities. However, the decreasing trend of these parameters was well compensated by the increased plant density (pods per unit area) up to 100 plants/m^2 in terms of grain yield/ha. There is evidence that populations are largely self-balancing over a range of 5- to 6-fold variation in population density with respect to yield (Hodgson and Blackman 1956).

Secondary characters for yield attributes, i.e., number of nodes/plant and nodes/branch (Table 1), also significantly influenced yield. Nodes/branch increased significantly with increasing density, although branches/plant decreased with higher plant density, leading to a net effect of a total reduction in nodes/plant with increasing plant density. Thompson and Taylor (1977) reported that yield differences in response to changes in density were particularly due to changes in the number of pod-bearing nodes/plant. Plants at increasing densities were significantly taller in both years. Hodgson and Blackman (1956), Sprent et al. (1977) and Witty et al. (1980) also reported similar observations due to an increase in internode length, not in the number of nodes/plant.

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Pests and Diseases

Efficacy of Some Insecticides Used in Coating Faba Beans to Control Pea and Bean Weevil (*Sitona lineatus*) and the Relation between Yield and Attack

فعالية بعض المبيدات الحشرية المستخدمة في تغليف بذور الفول لمكافحة سوسة ورق البازلاء (*Sitona lineatus*) والعلاقة بين الغلة والإصابة

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Abstract

Pea and bean weevil is a serious pest of faba bean in the Netherlands, causing yield reduction when infestation reaches >2 larvae or pupae/plant. Eight field experiments were conducted from 1987 to 1989, at four locations throughout the country, to determine how effectively insecticide-coated seed controls adults and larvae of pea and bean weevil in faba bean crops. The efficacy of coating seed with different doses of carbofuran, benfuracarb, furathiocarb, fonofos, methiocarb or tefluthrin was compared with foliar application of pesticides: parathion (ethyl) at 375 ml (a.i.)/ha in 1987 and 1988, and deltamethrin at 7.5 ml (a.i.)/ha in 1989. Seed coating either with benfuracarb (1 g a.i.), furathiocarb (1 g a.i.) or carbofuran (1 ml a.i.)/kg seed gave better control than the spray treatment and resulted in bean yields that were 10–20% higher on average.

الملخص

تعتبر سوسة ورق البازلاء، آفة خطيرة على الفول في هولندا، إذ تسبب انخفاضاً في الغلة عندما تصل درجة الإصابة إلى 2 < يرقة أو عذراء/النبات. لقد أجريت ثماني تجارب حقلية، من 1987 وحتى 1989 في أربعة مواقع في أنحاء البلاد لتحديد مدى فعالية البذور المغلفة بالمبيد الحشري في مكافحة الحشرات الكاملة من سوسة ورق البازلاء، ويرقاتها في محاصيل الفول. وقد قورنت فعالية تغليف البذور بجرعات مختلفة من كاربوفيوران و بينفيوراكارب و فيوراثيوكارب و فونفوس و ميثوكارب أو تفليوثرين بفعالية رش الأوراق بالمبيدات الحشرية : باراثيون (إتيل) بمعدل 375 مل (مادة فعالة)/هـ في 1987 و 1988 ومبيد دلتامثيرين بمعدل 7.5 مل (مادة فعالة)/هـ في 1989. وقد أدى تغليف البذور بالمبيد بينفيوراكارب (1غ مادة فعالة) أو فيوراثيوكارب (1غ مادة فعالة) أو بالمبيد كاربوفيوران (1 مل مادة فعالة)/1 كغ إلى حدوث مكافحة أفضل من معاملة الرش وإعطاء غلة أعلى من الفول تراوحت نسبتها في المتوسط بين 10 و 20٪.

Introduction

Sitona lineatus L. is a threat to many leguminous crops such as clover, lucerne and common vetch. Pea (*Pisum sativum* L.) and faba bean (*Vicia faba* L.) are the preferred food plants of the adult and larval stages of *S. lineatus*, although clover (*Trifolium repens*), lucerne (*Medicago sativa*), common vetch (*Vicia sativa*) and other leguminous crops also are attacked (Hans 1959). Bardner et al. (1979) and Griffiths et al. (1986) found that faba bean yields were 150–500 kg/ha higher when this pest was controlled.

The need to reduce costs in agriculture and increasing concern about environmental pollution make it necessary to use agricultural chemicals more economically and efficiently (Karlberg 1976; Ester and Floot 1990). Foliar application of chemicals may be inefficient because of wastage by dripping from sprayed surfaces and the exposure of nontarget organisms. If the weevil is prevented from attacking the plant, the risk of wastage is reduced. Applying insecticides to the seed is one way of controlling the pea and bean weevil. This paper describes experiments on coating seed with insecticides to control *S. lineatus* in the faba bean.

Materials and Methods

The experiments were done in three seasons (1987–89) at four locations in the Netherlands. Two of the locations (Nieuw-Beerta in Groningen and Colijnsplaat in Zeeland) have high densities of pea and bean weevils, because the pest's winter host (lucerne) is grown there; the other two locations (Valthermond and Rolde, both in Drenthe) have a lower density of the pest, as lucerne crops are not grown in those areas. The soil at Nieuw-Beerta and Colijnsplaat is clay; at Valthermond and Rolde it is sandy peat. The experiments were randomized in three replicates, with plots 100 m^2. The control (untreated) plots consisted of nine replicates in 1987 and 1988, and six replicates in 1989.

Seed of the field bean cultivar Alfred was sown in April. The 1000-kernel weight of the seed was about 572 g and the moisture content was 18.3%. A Miniair sowing machine was used. The rows were 10 cm apart and the seeding rate was approximately 20 seeds/m^2.

The insecticide treatment recommended for Dutch growers of faba bean was applied to one plot of each replicate, to provide a benchmark. In 1987 and 1988 this was parathion (ethyl) sprayed at a rate of 375 ml (a.i.)/ha, and in 1989 deltamethrin sprayed at a rate of 7.5 ml (a.i.)/ha. These treatments were applied after the leaves had been slightly attacked; immediately afterward, two tents of polyethylene netting gauge (1.35 × 1.35 mm) with a floor area of 1 m^2 were placed above the crop to prevent immigration of the pea and bean weevil.

Seed treatments

In 1987 and 1988, the seeds were treated with the fungicides thiram, carbendazim and fosetyl-aluminium at rates of 1.3, 2 and 3.2 g (a.i.)/kg seed, respectively. In 1989 carbendazim/copperoxychinolate was used at a standard rate of 0.3 g (a.i.)/kg seed. The 'untreated' seed used in the control was not coated, or was coated with the polymer without insecticides in all the years except in 1987 when only 'uncoated' seed was used.

Table 1 shows the insecticides and doses used in 1987, 1988 and 1989. In 1988, in addition to the same doses of benfuracarb 40% WP, fonofos 250 EC and methiocarb FS 500 used in 1987, half doses of each of these compounds were tested (Table 1). In addition, furathiocarb 50% DS (powder for dry seed treatment), carbofuran 500 SC (suspension concentrate) and tefluthrin 20% CS (capsule suspension) were used.

In 1989 the doses of benfuracarb, furathiocarb and carbofuran were reduced, and the doses of methiocarb and tefluthrin were increased.

Assessments

The percentage of leaves attacked was assessed in the last week of May and the number of larvae on the roots was determined once between mid-June and the beginning of July. In 1987 and 1988 the crops were harvested in September. In 1989 the crops at Nieuw-Beerta and Rolde were harvested in August; those at Colijnsplaat were harvested in September.

The crop damage in each plot was assessed by estimating the percentage of leaves of 45 plants attacked by adult pea and bean weevils. To do this, the number of leaves per leaf stage whose edges had been notched by

Table 1. Formulation and dosage of insecticides used to control pea and bean weevil (*Sitona lineatus*) in faba bean.

		Active ingredient doses in ml or g/kg seed				
Insecticide	**Formulation**	**1987**	**1988**		**1989**	
Untreated, no coating	—	+	+		+	
Untreated, plus coating	—	—	+		+	
Parathion (ethyl)	250 g/L	(375†)	(375†)		—	
Deltamethrin	25 g/L	—	—		(7.5‡)	
Benfuracarb	40% WP	4	2	4	1	2
Carbofuran	500 SC	—	2	4	1	—
Fonofos	250 EC	3.1	1.6	3.1	—	—
Furathiocarb	50% DS	—	2	4	1	2
Methiocarb	FS 500	2.5	2.5	5	5	7.5
Tefluthrin	20% CS	—	3	6	3	—

† Benchmark 375 ml (a.i.)/ha sprayed on the crop.
‡ Benchmark 7.5 ml (a.i.)/ha sprayed on the crop.

feeding of adult weevils was counted in 20 plants from each plot and averaged. The number of larvae or pupae feeding on the roots of the beans, especially on the nodules, was counted on 5 plants/plot, which were removed with roots and soil, using a core 12 cm long and 12 cm in diameter. The resulting rootball was plunged into a bucket containing about 2 L of a 10% saline solution. This dislodged most of the larvae and pupae, which then floated to the surface and were counted.

Results

Percentage of leaves attacked

In the trials at Nieuw-Beerta and Colijnsplaat a large percentage of leaves was attacked by the pea and bean weevil. However, in the trials at the other two locations the pest population was lower, because lucerne (a winter host) was not grown there.

Table 2 shows the percentage of leaves/plant attacked by the pea and bean weevil at the four sites about 5 weeks after sowing. In 1987 at Nieuw-Beerta and Colijnsplaat the plants grown from seed coated with benfuracarb 4 g, fonofos 3.1 ml and methiocarb 2.5 g/kg seed showed less damage than plants that had received a foliar application of parathion (ethyl) at 375 ml/ha. At Valthermond there was no difference between the efficacy of seed treatment and foliar application because the population of the pea and bean weevil was small. At Nieuw-Beerta there was no difference in leaf damage between the plants given a foliar application of parathion (ethyl) at 375 ml/ha and the plants grown from untreated seeds, perhaps because the spray was applied too late.

Table 2. Effect of different insecticide treatments on percentages of leaves/plant attacked by the pea and bean weevil, 5 weeks after sowing.

Treatment		Rate (a.i.)/kg of seed (g or ml)	1987			1988		1989		
			Nw-B	C	V	Nw-B	C	Nw-B	C	R
Untreated, no coating	Uo	—	99c	99d	32b	100d	77cf	91b	99d	99d
Untreated, plus coating	Uf	—	—	—	—	96d	98g	99b	98d	100d
Parathion (ethyl) 250 g/L	P	(375†)	100c	63c	5a	99d	42b	—	—	—
Deltamethrin 25 g/L	D	(7.5†)	—	—	—	—	—	87b	98d	57c
Benfuracarb 40% WP	B_1	1	—	—	—	—	—	83b	28bc	14ab
	B_2	2	—	—	—	4a	1a	60a	20ab	5a
	B_4	4	11a	8a	3a	5a	1a	—	—	—
Carbofuran 500 SC	C_1	1	—	—	—	—	—	63a	18a	6a
	C_2	2	—	—	—	5a	1a	—	—	—
	C_4	4	—	—	—	3a	1a	—	—	—
Fonofos 250 EC	F_1	1.6	—	—	—	53c	67de	—	—	—
	F_3	3.1	19ab	31b	5a	14ab	14a	—	—	—
Furathiocarb 50 DS	F_0	1	—	—	—	—	—	82b	31c	37bc
	F_2	2	—	—	—	11ab	3a	57a	19ab	41bc
	F_4	4	—	—	—	23b	2a	—	—	—
Methiocarb FS 500	M_2	2.5	24b	43b	6a	69c	45bc	—	—	—
	M_5	5	—	—	—	58c	59cd	100b	93d	93d
	M_7	7.5	—	—	—	—	—	97b	93d	36bc
Tefluthrin 20% CS	T_3	3	—	—	—	99d	93fg	98b	98d	89d
	T_6	6	—	—	—	90d	85fg	—	—	—

Sites: Nw-B = Nieuw-Beerta; C = Colijnsplaat; R = Rolde; V = Valthermond.
† ml (a.i.)/ha sprayed on the crop (benchmark treatment).
Means followed by the same letter are not significantly different at the 5% probability level.

The lower rate of fonofos (1.6 ml/kg seed) in 1988 and all rates of methiocarb and tefluthrin in 1988 and 1989 gave insufficient protection to the leaves. Furathiocarb 2 and 4 g, carbofuran 2 and 4 ml and benfuracarb 2 and 4 g/kg seed gave good protection in 1988 and were similar in their efficacy.

At Nieuw-Beerta, where an extremely high percentage of leaves had been attacked in preceding years, the doses of the three successful compounds were halved again in 1989. In that trial only carbofuran (1 ml/kg seed) showed a significant positive effect, similar to that obtained in 1988 with benfuracarb 2 g and furathiocarb 2 g/kg seed. At Colijnsplaat the three compounds used (benfuracarb 1 and 2 g, carbofuran 1 ml, and furathiocarb 1 and 2 g/kg seed) resulted in a significantly smaller percentage of attacked leaves than the foliar application of deltamethrin at 7.5 ml/ha. For furathiocarb there was a clear effect of dose: the low dose (1 g/kg seed) was not sufficient.

At Rolde, however, benfuracarb, carbofuran and furathiocarb resulted in significantly lower percentages of attacked leaves, even at the lowest dose. Tefluthrin 3 ml and methiocarb 5 and 7.5 g/kg seed gave insufficient protection.

Number of notches per leaf stage

The average number of notches/leaf was plotted against the number of leaf stages at Nieuw-Beerta in 1988 (Fig. 1a). This figure showed that without insecticide treatment of seed (treatment Uf) the notching was quite high at the 1st leaf stage and increased up to the 5th leaf stage, after which it decreased because of the natural mortality of the adults. In the case of the conventional spray application with parathion (ethyl) (P) in the 2nd leaf stage, the number of notches decreased in the next stages. The fonofos treatment at the higher dose (F3) gave sufficient control and a low number of notches, while at a lower dose (F1) it only controlled until the 4th leaf stage, after which the number of notches per leaf stage increased. The methiocarb low-dose treatment (M2) only protected until the 3rd leaf stage, but the higher dose (M5) provided better protection, even at later stages.

At Colijnsplaat in 1988, the average number of notches/leaf was plotted against the number of leaf stages. Treatment Uf had an average of four notches in the 1st leaf stage, with the number increasing up to the 5th leaf stage, after which it decreased because of the natural mortality of the adults (Fig. 1b).

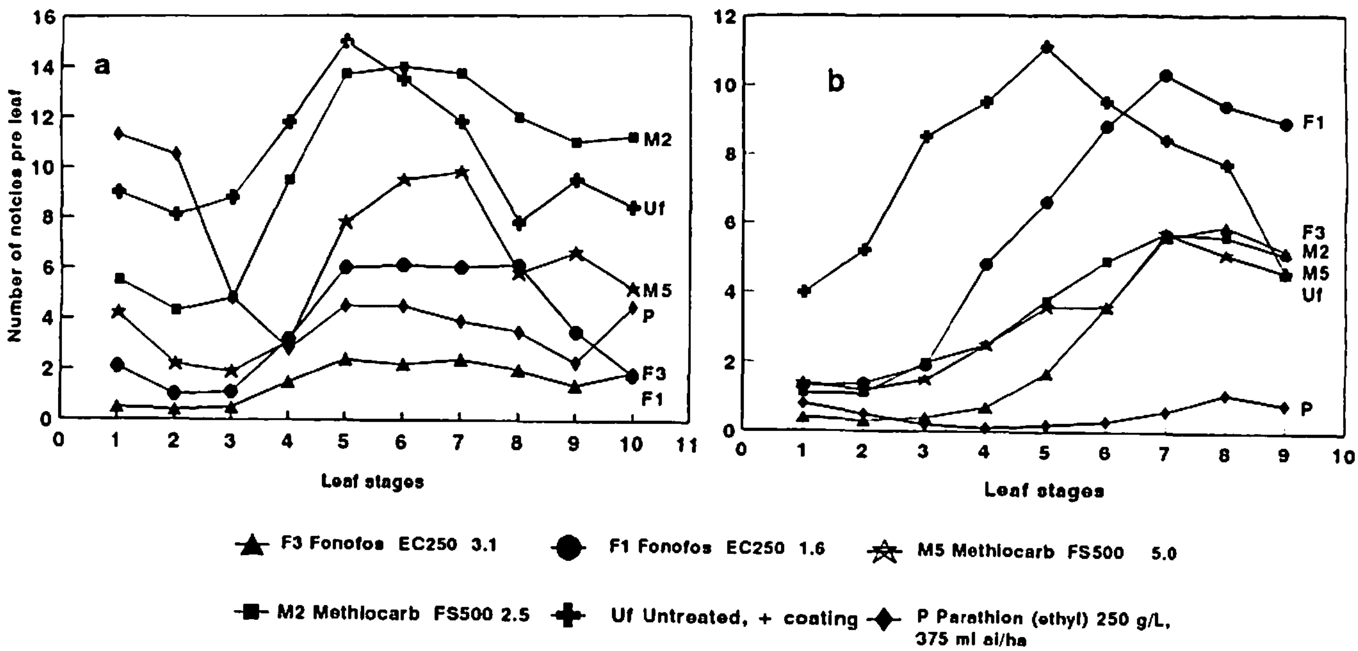

Fig. 1. Relation between average number of notches/leaf and number of leaf stages at (a) Nieuw-Beerta and (b) Colijnsplaat, 1988.

The conventional spraying application (P) had been applied adequately, which resulted in a low number of notches per leaf stage. Treatment F3 controlled until the 5th leaf stage, after which the number of notches increased. The fonofos low-dose treatment (F1) controlled until the 3rd leaf stage, and thereafter the number of notches per leaf stage increased. The methiocarb treatments (M2 and M5) controlled until the 3rd leaf stage and there was no dose effect.

Number of larvae or pupae

Table 3 shows the data on average number of larvae or pupae/5 plants 10 weeks after sowing. In 1987 at Nieuw-Beerta the seed coating with benfuracarb 4 g/kg seed resulted in satisfactory control of the larvae or pupae 10 weeks after sowing. Foliar application of parathion (ethyl) 375 ml/ha gave insufficient control of the larvae or pupae. In 1988 at Nieuw-Beerta benfuracarb 2 and 4 g, carbofuran 2 and 4 ml, fonofos 1.6 and 3.1 ml and furathiocarb 2 and 4 g/kg seed successfully controlled the larvae or pupae of the pea and bean weevil after 10 weeks. Tefluthrin 3 and 6 ml and methiocarb 2.5 and 5 g/kg seed gave good control and were significantly more effective than the foliar application; foliar application of parathion (ethyl) did not have any significant effect.

In the Colijnsplaat trials in 1987 the untreated plots had an average of 3 larvae or pupae/plant; foliar spray had no effect but seed treatment reduced the infestation significantly. In 1988, untreated plots had an average of 10 larvae or pupae/plant and benfuracarb 2 and 4 g, carbofuran 2 and 4 ml, fonofos 3.1 ml and furathiocarb 2

Table 3. Effect of insecticides on average number of larvae or pupae on the roots of five plants 10 weeks after sowing.

Insecticide	Rate (a.i.)/kg of seed (g or ml)	1987 Nw-B	1987 C	1988 Nw-B	1988 C	1989 Nw-B	1989 C	1989 R
Untreated, no coating	—	15b	15c	38g	52h	24d	17c	10c
Untreated, plus coating	—	—	—	37g	57h	49d	16c	9c
Parathion (ethyl) 250 g/L	(375†)	14b	9bc	34fg	16efg	—	—	—
Deltamethrin 25 g/L	(7.5†)	—	—	—	—	56d	11c	5bc
Benfuracarb 40% WP	1	—	—	—	—	1abc	0a	0a
	2	—	—	0a	2abcd	0a	2ab	0a
	4	0a	0a	0a	1abc	—	—	—
Carbofuran 500 SC	1	—	—	—	—	0a	0a	0a
	2	—	—	0ab	0a	—	—	—
	4	—	—	0ab	0ab	—	—	—
Fonofos 250 EC	1.6	—	—	2bcd	15fg	—	—	—
	3.1	0a	0a	0ab	6cdef	—	—	—
Furathiocarb 50% DS	1	—	—	—	—	1abc	0a	0a
	2	—	—	0abc	5bcd	2abc	0a	2a
	4	—	—	1abc	5bcde	—	—	—
Methiocarb FS 500	2.5	0a	2ab	21ef	35gh	—	—	—
	5	—	—	19e	19fg	6c	5d	2ab
	7.5	—	—	—	—	6c	2c	0a
Tefluthrin 20% CS	3	—	—	4cd	12def	3bc	2bc	1a
	6	—	—	5d	8def	—	—	—

Sites: Nw-B = Nieuw-Beerta; C = Colijnsplaat; R = Rolde.
† ml (a.i.)/ha sprayed on the crop (benchmark treatment).
Means followed by the same letter are not significantly different at the 5% probability level.

and 4 g/kg seed gave the best control of the larvae or pupae. The average number of larvae or pupae in the other seed treatments was similar to that of the conventional foliar application of parathion (375 ml/ha). Compared with the untreated plots the infestation of plants that received this foliar application was significantly lower.

In 1989, the results from all three locations were virtually identical. The foliar application of deltamethrin 7.5 ml/ha did not have any effect on the number of larvae or pupae, except some reduction at Rolde. Coating the seeds with benfuracarb 1 and 2 g, carbofuran 1 ml, furathiocarb 1 and 2 g and tefluthrin 3 ml/kg seed controlled the larvae and pupae. At Rolde, with a small population of larvae or pupae, the application of methiocarb at rates of 5 and 7.5 g/kg seed also gave sufficient control. At Nieuw-Beerta and Colijnsplaat, methiocarb applied at 5 and 7.5 g/kg seed resulted in significantly fewer larvae or pupae compared with the conventional foliar application, but at Colijnsplaat the number of larvae or pupae was significantly higher than with the other carbamates.

Yield of beans

The yield data for the six experiments are presented in Table 4. In 1987 only the trial at Nieuw-Beerta was harvested, because at that stage of the research we did not expect that coating the seed would have such a marked effect on yield.

Table 4. Effect of insecticides on the yield of faba bean (kg/100 m²).

Insecticide	Rate (a.i.)/kg of seed (g or ml)	1987	1988		1989		
		Nw-B	Nw-B	C	Nw-B	C	R
Untreated, no coating	—	27.4a	19.9ab	38.6a	28.6ab	58.0a	44.0a
Untreated, plus coating	—	—	16.8a	37.5a	29.6ab	57.0a	43.1a
Parathion (ethyl) 250 g/L	(375†)	27.4a	17.7a	39.6ab	—	—	—
Deltamethrin 25 g/L	(7.5†)	—	—	—	27 0.7ab	62.0b	37.1a
Benfuracarb 40% WP	1	—	—	—	30.9b	67.0c	40.5a
	2	—	35.4f	48.4ef	29.3ab	66.0c	41.5a
	4	36.7b	38.9f	49.2ef	—	—	—
Carbofuran 500 SC	1	—	—	—	31.8b	67.5c	39.9a
	2	—	33.8ef	51.0f	—	—	—
	4	—	38.7f	51.3f	—	—	—
Fonofos 250 EC	1.6	—	25.1bcd	42.2abc	—	—	—
	3.1	34.6ab	26.0cd	41.9abc	—	—	—
Furathiocarb 50% DS	1	—	—	—	31.7b	64.0bc	43.3a
	2	—	28.5de	47.1def	30.4ab	65.0bc	47.3a
	4	—	27.2cd	44.8cde	—	—	—
Methiocarb FS 500	2.5	28.2ab	21.7abc	37.5a	—	—	—
	5	—	25.2bcd	43.0bcd	30.6ab	62.0b	42.3a
	7.5	—	—	—	26.5a	61.5b	44.3a
Tefluthrin 20% CS	3	—	18.5a	40.3abc	31.9b	62.0b	38.6a
	6	—	19.5ab	41.5abc	—	—	—

Sites: Nw-B = Nieuw-Beerta; C = Colijnsplaat; R = Rolde.
† ml (a.i.)/ha sprayed on the crop (benchmark treatment).
Means followed by the same letter are not significantly different at the 5% probability level.

In 1987 there were no significant differences in yield between any of the treatments, except the seed treatment with benfuracarb 4 g/kg seed, which gave significantly larger yields than the untreated control and the foliar application of parathion (375 ml/ha).

In 1988 there were no significant differences in yield between the untreated control and the foliar application of parathion (ethyl) at both Nieuw-Beerta and Colijnsplaat. The seed treatment with the compounds fonofos 1.6 ml, methiocarb 2.5 and 5 g and tefluthrin 3 and 6 ml/kg seed did not show significant differences in yield compared with the yields of the untreated control or foliar application of parathion at both locations. Benfuracarb 2 and 4 g and carbofuran 2 and 4 ml/kg seed were effective, resulting in significantly higher yields. At these locations, furathiocarb 2 and 4 g gave a significantly higher yield than the foliar application and a lower yield than the seed treatment with benfuracarb and carbofuran. The same applied for fonofos 3.1 g and methiocarb 5 g/kg seed at Nieuw-Beerta.

In 1989 at Nieuw-Beerta and Rolde there were no significant differences in yield between the seed treatments and the foliar application of deltamethrin. At Colijnsplaat there was a significant difference in yield between the control (untreated) and foliar application. Here too, the yield from the plots where seed had been treated with benfuracarb 1 and 2 g or carbofuran 1 ml/kg seed was significantly higher than the yield from plots that received the foliar application of deltamethrin.

Relation between yield and attack

In Figure 2 the yield of beans/100 m² at Nieuw-Beerta in 1988 is plotted against the number of larvae or pupae. This figure shows that the insecticide treatments with an average of 0.5 larvae/5 plants had a higher yield than treatments with an average of 5 or more larvae per sample. If there were more than 5 larvae per sample the yield did not decrease further.

In Figure 3a the yield of beans/100 m² at Nieuw-Beerta in 1988 is plotted against the percentage of leaves attacked. The higher the percentage of leaves attacked, the lower the yield, but the decrease in yield became smaller once the proportion of leaves attacked exceeded 40%.

In Figure 4 the percentage of leaves attacked is plotted against the number of larvae or pupae per sample. Only when less than 40% of the leaves were attacked were there no larvae near the roots. When the percentage was 40% or more there were a few larvae (treatment F) or about 20 larvae (treatments M2 and M5). In Figure 2b the yield of beans at Colijnsplaat is plotted against the number of larvae or pupae. This figure shows that yield decreased markedly with increasing number until there were 10 larvae or pupae per five plants, then it leveled off, regardless of the number of larvae or pupae per sample. In Figure 3b the yield of beans at Colijnsplaat is plotted against the percentage of leaves attacked. The yield decreased sharply when less than 10% of the leaves

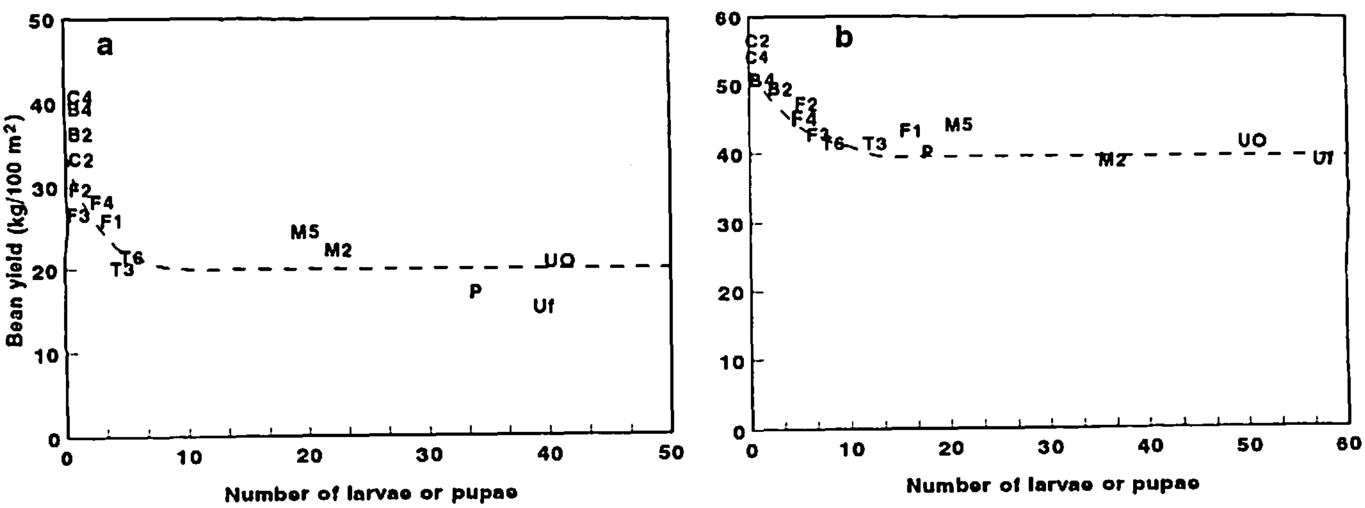

Fig. 2. Relation between bean yields and number of larvae or pupae at (a) Nieuw-Beerta and (b) Colijnsplaat, 1988. (See Table 2 for legend.)

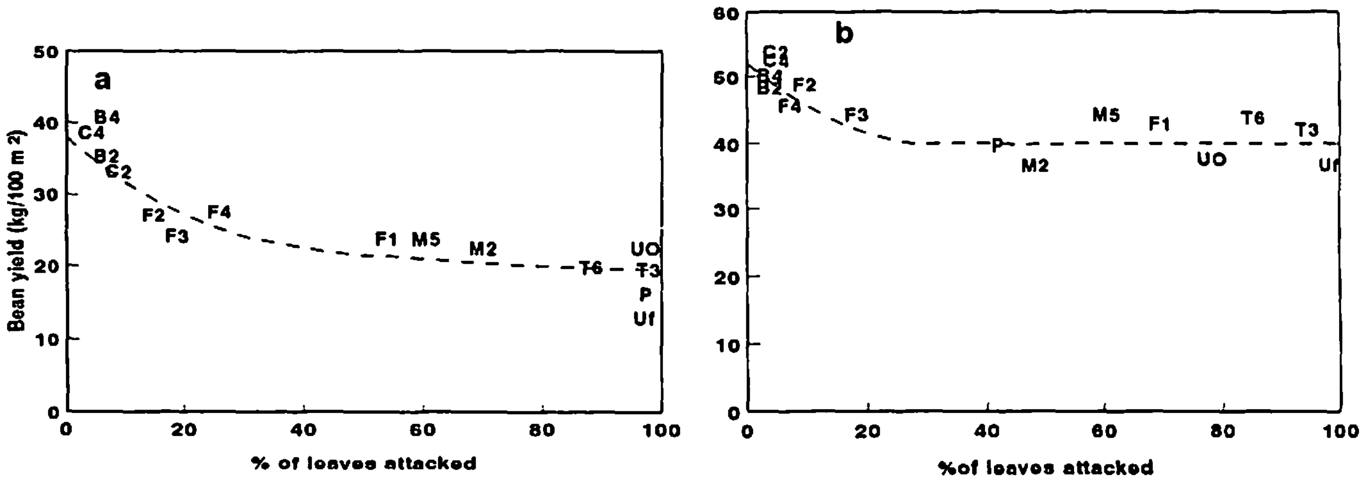

Fig. 3. Relation between bean yields and percentage of leaves attacked at (a) Nieuw-Beerta and (b) Colijnsplaat, 1988. (See Table 2 for legend.)

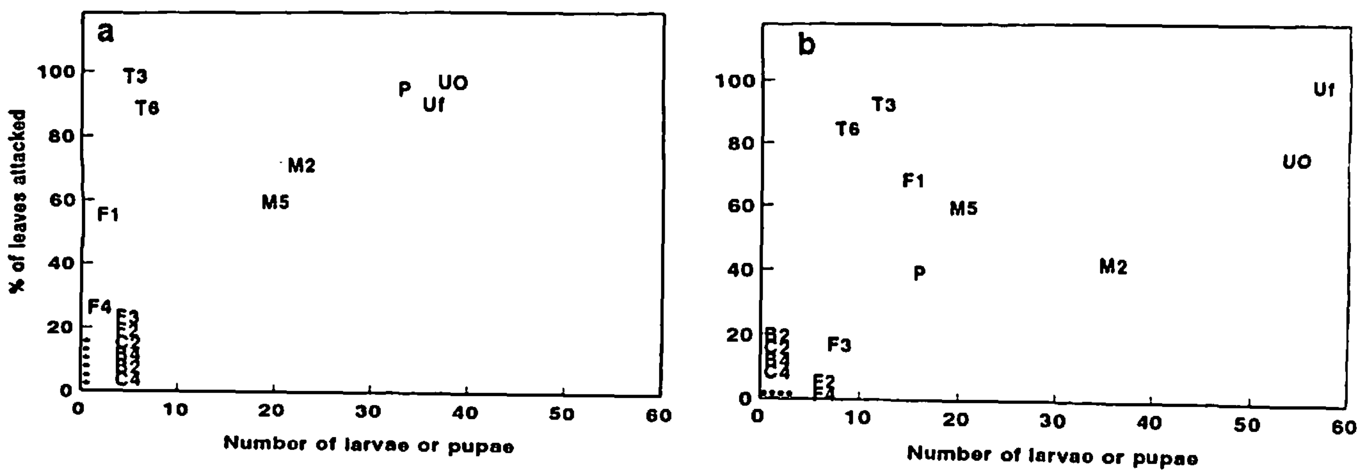

Fig. 4. Relation between percentage of leaves attacked and number of larvae or pupae at (a) Nieuw-Beerta and (b) Colijnsplaat, 1988. (See Table 2 for legend.)

were attacked, but thereafter it leveled out. In Figure 4b the percentage of leaves attacked at Colijnsplaat is plotted against the number of larvae or pupae/5 plants.

Discussion

Germination trials in the greenhouse (Nijënstein and Ester 1990) showed that the seed coatings used in this research are not phytotoxic.

The data obtained on pea and bean weevil damage to leaves and on the presence of larvae in the root nodules indicate that coating seed with benfuracarb 1 g, carbofuran 1 ml or furathiocarb 1 g/kg seed can provide good control of adult *Sitona*, thus reducing egg-laying and subsequent larval attack. (In 1989 the authors conducted pot experiments with coated seed, the results of which showed that a coating containing insecticide does not control larvae.)

King (1981) showed that in pea a foliar spray of insecticide is useful only if applied as soon as adult *Sitona* are found feeding on leaves. Our own experiments often have shown no differences between the foliar treatment and the control (untreated). Once adult *Sitona* are on the plants and in the soil it will be difficult to control them properly; hence, many adults will escape and continue to lay eggs, which means a large population of larvae on the roots later.

Bardner et al. (1983) reported that treating the seed of spring-sown beans with bendiocarb or phorate reduced the number of larvae found later. They also noted that this method is not very practical as it is unlikely that seed merchants will treat seeds for such a small market, and it might be hazardous for growers to treat their own seed. In conformity with this, only precoated seeds were used in these experiments to minimize the risk to the growers (Ester 1990). The advantage of coating is that it provides the seed with a total package of pesticides or biological compounds (Ester and Neuvel 1990). Bacon and Clayton (1986) discovered a filmcoating that has promise for use on nonhorticultural crops and is economically attractive.

In experiments at the locations with clay soil, large populations of adult *Sitona* were present; as a result, nearly 100% of the leaves were attacked. Fonofos at the lowest dose and methiocarb and tefluthrin at both doses gave insufficient protection against leaf attack by larvae or pupae in 1988 and 1989. However, Crowell (1975) reported that treating garden pea with methiocarb 1 g (a.i.)/kg seed reduced infestation with the larvae of the pea weevil.

In these experiments coating seed with benfuracarb 1 g, carbofuran 1 ml or furathiocarb 1 g/kg seed gave excellent control of adults, larvae and pupae of *S. lineatus* (Table 3). Vulsteke and Seutin (1985) achieved similar results. The seed treatment prevented the weevil from laying eggs, therefore no larvae infested the roots and the plants were protected against the weevil and the larvae. Vulsteke and Bockstaele (1984) obtained similar results using furathiocarb on pea seeds.

Bardner and Fletcher (1979) found that the use of insecticides nearly always increased yields, the mean increase for all treatments being 0.15 t/ha, although a maximum yield increment of >0.5 t/ha was achieved. Oschmann (1984) also found a yield increase of 8–31% when faba bean seed was treated.

The trial in 1987 with the insecticide benfuracarb 40% WP 4 g/kg seed boosted yield by nearly 34%/ha. In 1988 the average yield at Nieuw-Beerta achieved by using benfuracarb 2 g, carbofuran 2 ml or furathiocarb 2 g/kg seed was 83% higher than that of the foliar treatment, and in Colijnsplaat these insecticides resulted in an average of 23% higher yield than that of the foliar treatment.

From these experiments, it is clear that faba bean seeds coated with benfuracarb (40% WP) 1 g, carbofuran (500 SC) 1 ml and furathiocarb (50% DS) 1 g/kg seed are well protected against the weevil and larvae of *S. lineatus*. The relationship between larvae/pupae populations and yield has shown that 2 larvae or pupae/plant are sufficient to cause maximum yield reduction. The conventional insecticide spraying always resulted in more than 2 larvae or pupae/plant, so the yield was always the same as in the untreated plots. Coating the seeds of field beans (*V. faba*) with an insecticide is a better alternative than foliar application of parathion (ethyl) or deltamethrin for controlling adult and larval *Sitona*, and decreasing the amounts of insecticide used benefits the environment.

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Results of Seed Tests. II. Occurrence of some Pathogenic Fungi in Plant Residues on Faba Bean Seeds

نتائج اختبارات البذور. II. تفشي بعض الفطريات المرضة في الأجزاء النباتية المتبقية على بذور الفول

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Abstract

Seed decay of faba bean (*Vicia faba*) is caused by a complex of different fungi, some of them able to survive in plant residues. Material was scraped from seed surfaces and investigated in droplets of sterilized water to detect spores and hyphae. *Alternaria alternata* was the predominant fungus in residues represented by both mycelia and conidia. *Botrytis cinerea*, *B. fabae*, *Fusarium oxysporum*, *Phoma pinodella* and *Stemphylium botryosum* also were identified from the investigated plant material, and their pathogenicity to adult plants tested.

الملخص

ينجم تعفن بذور الفول (Vicia faba) عن مجموعة من الفطريات المختلفة، التي يكون لبعضها القدرة على الحياة في الأجزاء النباتية المتبقية على بذور الفول. وقد كشطت مادة من سطوح البذور وفحصت في قطيرات من المياه المعقمة للكشف عن الأبواغ والخيوط الفطرية. وكان فطر التبقع الألترناري Alternaria alternata الفطر السائد في تلك البقايا ممثلاً بالغصينات الفطرية (mycelia) والأبواغ الكونيدية. كما أمكن تحديد B fabae و Botrytis Cinerea و Stemphylium botryosum و Phona pinodella و Fusarium axysporum من المادة النباتية المدروسة، واختبرت قدرتها على إحداث المرض على النباتات البالغة.

Introduction

Faba bean (*Vicia faba* L.) is one of the most important protein sources in many countries. Productivity of the crop is affected by a number of different factors, including seed-transmissible pathogens, and numerous fungi are known to occur on seeds of faba bean (Agarwal and Sinclair 1987; Neergaard 1977; Rádulescu and Negru 1971; Simay 1991). Some of these fungi are well-known saprophytic organisms, but a number of other pathogens also can survive on dead plant materials (Bánhegyi et al. 1985; Domsch et al. 1980; Ubrizsy 1965). Some fungal organs were observed in our seed health tests in plant residues attached to seed surfaces. The aim of the trials was to identify the fungi and investigate their pathogenicity.

Materials and Methods

The seeds investigated were harvested from the experimental plots and the samples were handled as normal seed. Seeds were stored in paper bags after cleaning at room temperature; laboratory investigations were conducted 2 to 4 weeks after the cleaning.

We removed the plant material with a pick to detect fungal organs that had occurred in the plant tissues and remained on the seed surface. The preparates were then investigated by microscope in droplets of sterilized water. If typical spores were available, the fungi were identified from the preparates; otherwise, the fungi were identified from cultures. The cultures were made by placing the scraped plant residues onto plates of potato dextrose agar (PDA) and 2% malt extract agar (MEA). The pure cultures were typed and their pathogenicity tested from some representative cultures found either on germinating seeds or on five-leaved faba beans grown in a greenhouse; 41 preparates were investigated for contaminants. The identification of fungi was made according to Bánhegyi et al. (1985), Booth (1971), Domsch et al. (1980), Ellis (1971), and Ellis and Waller (1974 a,b).

Pathogenicity tests were conducted for eight known pathogens, i.e., *Alternaria alternata* (Fr.) Keissler, *Botrytis cinerea* Persoon, *Botrytis fabae* Sard., *Fusarium oxysporum* Schlecht., *Peronospora viciae* (Berk.) Casp., Monatsber. K. Preuss, *Phoma pinodella* (L.K. Jones) Morgan-Jones et Burch, *Stemphylium botryosum* Wallr. and *Uromyces viciae fabae* (Persoon) Schroeter. Pathogenicity of culturable conidial fungi was tested by spraying the conidial mass washed from pure cultures onto faba bean plants grown in a greenhouse. The conidial suspension was adjusted to 10^5 conidia and the infected plants were covered with polyethylene tents for 48 hours. Pathogenicity of *F. oxysporum* was investigated by soaking the seeds in the conidial suspension overnight. Plants were inoculated with *Peronospora* and *Uromyces* by taking the preparates containing the spores and placing them on the plants, then covering the plants with polyethylene tents for 48 hours.

Results and Discussion

Different fungal particles detected in the 41 preparates were grouped. The first group consisted of the three preparates containing oospores of *P. viciae*. The oospores were spherical and light brown with reticulations (Fig. 1a) developed singly or in clusters (Fig. 1b). Germination of oospores was not observed in the investigated preparates, but successful infections were made on two occasions using the preparates. Small yellowish spots were the first symptoms after the artificial infection; sporulation of fungus also was observed. Secondary infections were registered in the greenhouse. The fungus was identified by its characteristic sporangiophore branching and oospore structure (Mukerji 1975). Although the fungus is distributed on peas worldwide (Mukerji 1975), to the author's best knowledge only a few natural infections have been reported on *V. faba* (Blaeser-Dickmann 1982; Jamoussi 1968; Marras 1963; Sávulescu 1948). Rádulescu and Negru (1971) reported its seed transmission, and Jamoussi (1968) observed the occurrence of downy mildew on pods.

The second group of preparates contained the teleutospores of *U. viciae fabae*. This fungus is well known on faba bean (Gaunt 1983; Lelley 1964). Its occurrence on faba bean seeds was reported by Rádulescu and Negru (1971), but we do not have data on the economic importance of the seed transmissibility of *U. viciae fabae* in the case of *V. faba*. However, rust spores are a known primary source of infection on some other plants (Agarwal and Sinclair 1987; Emdal and Foldo 1979; Neergaard 1977). After the two preparates were placed on *V. faba* plants, development of aecia and, later, typical uredinia and telia were observed (Fig. 2a).

The third group of preparates also contained two samples in which chlamydospores were observed with some mycelia (Fig. 2b). *Phoma pinodella* was identified from pure cultures made from these preparates. The fungus sporulated well on both PDA and MEA media and the tests of pathogenicity resulted in symptoms similar to those observed earlier in this host-pathogen relationship (Simay 1988). *Phoma pinodella* is a well-known pathogen on different leguminous plants (Punithalingam and Gibson 1976) including faba bean (Bremer 1944; Hanounik and Maliha 1983; Simay 1988).

The other 34 preparates contained hyphae and mycelia. Some preparates were divided and plated onto agar media and stained with lacto-phenole-cottonblue to demonstrate the living parts (Fig. 3a,b). In pure isolates *A. alternata*, *B. cinerea*, *B. fabae*, *F. oxysporum* and *S. botryosum* were identified from 26, 3, 1, 1 and 3 preparates, respectively. The predominant *A. alternata* is distributed worldwide (Domsch et al. 1980), and is a known pathogen on numerous plants in addition to *V. faba* (Furgal-Wegrzycka 1984; Ibrahim and Michail 1968; Sumar et al. 1982). Its seed transmission is rather common on different plants (Neergaard 1977) and the seedborne nature of the pathogen was revealed in our earlier trials in the inner-seed tests (Simay 1987a). Isolates made from plant material harvested from the seed surface also were pathogenic on adult plants.

Fig. 1. (a) Oospore of *Peronospora viciae* in plant residue, (b) cluster of oospores of *Peronospora viciae*.

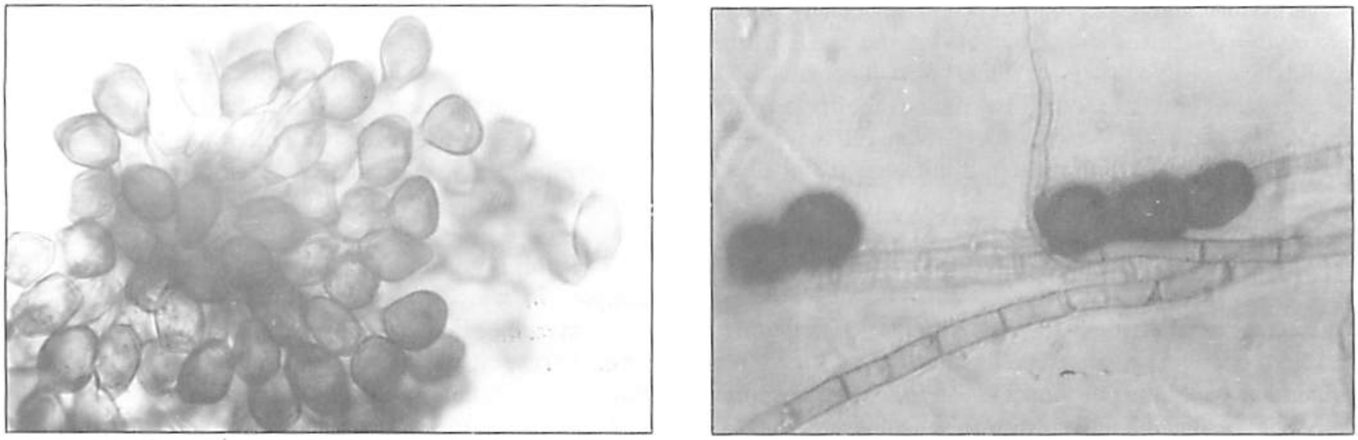

Fig. 2. (a) Teleutospores of *Uromyces viciae fabae*, (b) chlamydospores from seed surface.

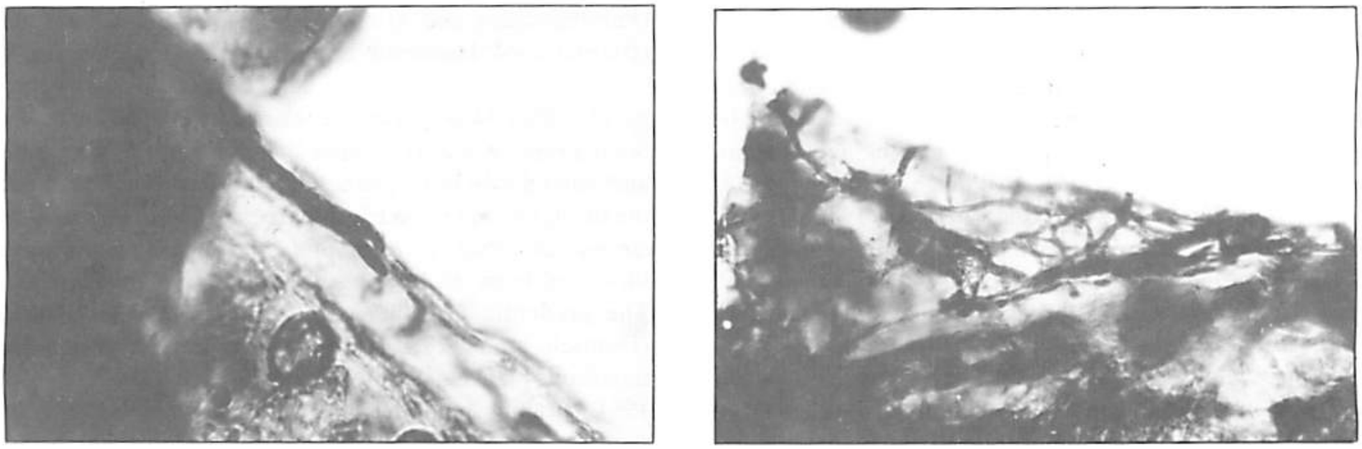

Fig. 3. (a) Hypha in plant material with cottonblue staining, (b) mycelium in plant material with cottonblue staining.

The two identified *Botrytis* spp. reported in Hungary (Simay 1987b) could cause serious damage to faba bean fields (Gaunt 1983). *Botrytis cinerea* is a polyphagous pathogen infecting different plants and fruits, while *B. fabae* can infect leguminous plants only (Ellis and Waller 1974 a,b). They both cause chocolate spot disease on leaves of *V. faba* (Gaunt 1983; Sundheim 1973). This disease also was observed on plants infected artificially by our isolates.

Fusarium spp. could cause root rot or wilt on faba bean (Salt 1983) and some may be seed transmitted (Simay 1991). *Fusarium oxysporum*, observed in dead plant material, caused wilt on different plants and on faba bean, while Singh and Singh (1986) claimed this fungus to be the most important of the seed-transmissible *Fusarium* spp.; it was observed on surface-sterilized seeds in our earlier tests (Simay 1986). The isolate made from plant residue caused no symptoms on leaves, but caused rot of primary roots. The germination of treated seeds was 13.5%, while it was 96% by treating the seeds with sterilized water, according to sowing tests using 50-50 seeds in two replicates.

Stemphylium botryosum is a widespread but rather minor pathogen of faba bean (Gaunt 1983), causing leaf spot on this host (Mansour 1980; Ruokola and Vestberg 1978; Simay 1988; Teuteberg 1980). Its seed transmission is common on different hosts (Neergaard 1977), but seed infection is not the most important source of infection as the fungus is known to occur on different substrates (Corlett et al. 1982; Domsch et al. 1980).

Other fungi, e.g., *Cladosporium* spp. and *Penicillium* sp., were observed from some preparates but determining their economic importance on this host requires further investigations.

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First Report of *Orobanche foetida* Poiret on Faba Bean in Tunisia

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Abstract

A preliminary survey was conducted in spring 1991 to delimit the zone of infestation by *Orobanche* in the main faba bean growing areas of Tunisia. Results revealed that faba bean was infested by *Orobanche foetida* and *O. crenata*. Zones infested by *O. foetida* were in the triangle formed by Qued Beja, Amdoun and Bou Salem, whereas *O. crenata* was observed in some areas of the eastern coast of the country.

أول تقرير عن الهالوك *Orobanche foetida* poiret على الفول بتونس

ملخص

أجري حصر أولي في ربيع 1991 لتحديد مناطق الإصابة بالهالوك في مناطق زراعة الفول الرئيسية في تونس. وأوضحت النتائج بأن الفول أصيب بنوعي الهالوك *Orobanche foetida* و *O. crenata* وكانت المناطق المصابة بالنوع *O. foetida* واقعة في المثلث الذي تشكله كد بيجة وعمدون وبوسالم في حين لوحظ النوع *O. crenta* في بعض مناطق الساحل الشرقي من البلاد.

Faba bean (*Vicia faba* L.) is the major food legume crop grown in Tunisia. About 86% of the total faba bean growing area is in the northern part of the country (Kharrat et al. 1991). One of the important constraints for the development of this crop is the infestation in some areas by *Orobanche* spp., obligate parasites of numerous wild and cultivated plants, mainly legumes. Of the Orobanchaceae family, *Orobanche crenata* Forsk. is considered one of the most important parasitic weeds in the Mediterranean and Middle East region. It prefers faba bean as a host, but also parasitizes other legumes, carrots, lettuce, clover, *Pelargonium* and many wild plants (Cubero 1983). In Tunisia, this holoparasite was reported in Tunis, Sousse, Menzel Temime and Kelibia area (Pottier-Alapetite 1981). However, in the food-legume belt of northern Tunisia, especially in the Beja area, the faba bean crop is attacked by a red-flowered *Orobanche*. This species was identified as *Orobanche foetida* Poiret at the National Agricultural Institute of Tunisia (INAT), the International Center for Agricultural Research in the Dry Areas (ICARDA) and the Botanical Garden of the University of Cordoba. This broomrape normally parasitizes *Medicago* spp., *Astragalus iusitanicus*, *Ononis natrix* L., *Ononis viscosa* L., *Lotus cytisoides* L., *Scorpiurus muricatus* L., *Scorpiurus vermiculatus* L. and *Calycotome spinosa* (L.) Link. (A. Pujadas Salvas, University of Cordoba, pers. comm.). In Tunisia, Pottier-Alapetite (1981) reported the rare occurrence of *O. foetida* on various legumes other than faba bean at Bordj Cedria, Hammam-Lif and in some areas of Korba and Menzel Temime.

This type of broomrape seems to be highly aggressive. Lines identified as resistant to *O. crenata* in Spain, Syria and Morocco have not shown any tolerance to *O. foetida* in fields infested with this parasite at Beja (Anonymous 1991).

To attempt to delimit the zone of infestation by *Orobanche* in the main faba bean growing area, a preliminary survey was undertaken in 1991. The route followed is shown in Figure 1. This survey revealed that *O. foetida* was present in many parts of Beja governorate. The infested zones were found in the triangle formed by Oued Beja, Amdoun and Bou Salem. During the same survey, *O. crenata* was observed in the areas of Tunis, Ras Jebel, Sfax and Cap-Bon. Figure 1 also shows the zones of infestation by *O. foetida* and *O. crenata*. The level of attack by both *Orobanche* spp. in infested fields varied from 1 to 5 on the 0 to 6 scale (Schmitt 1979).

Orobanche foetida also was seen on winter chickpea (*Cicer arietinum* L.), *Medicago ciliaris*, *M. doliata* and *Lathyrus odoratus* L., whereas *O. crenata* was found on pea (*Pisum sativum* L.) and on carrot (*Daucus carota* L.).

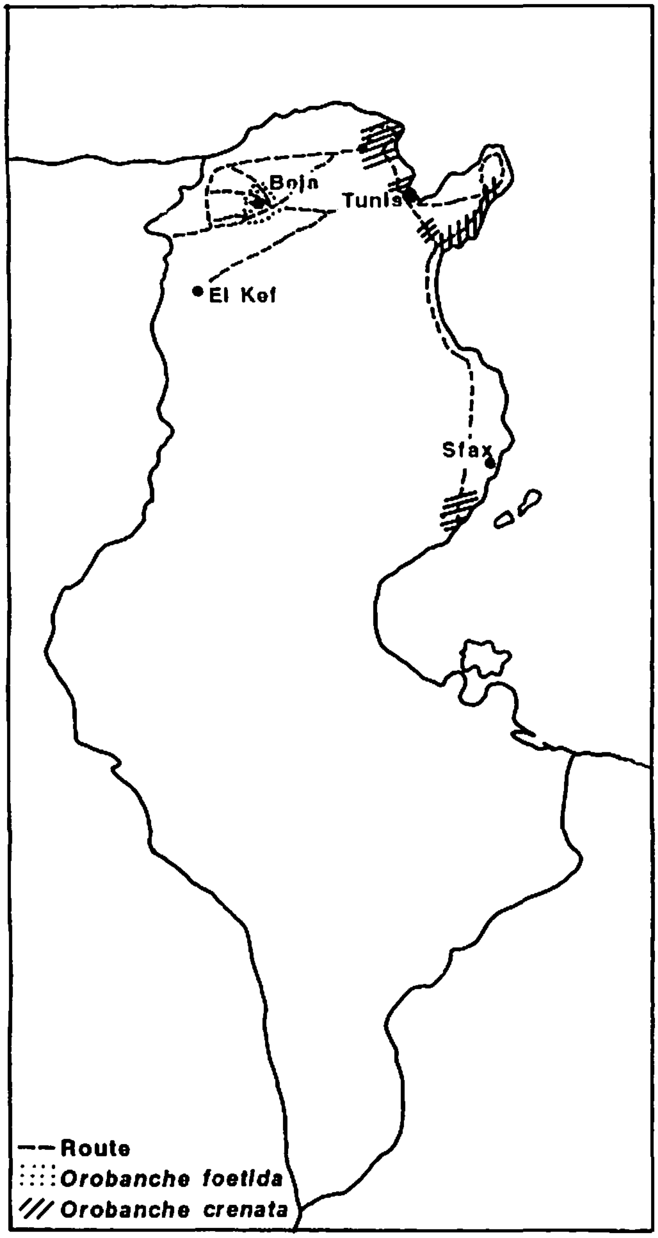

Fig. 1. Route followed during the survey, and *Orobanche*-infested zones in northern and central Tunisia.

Screening of BPLs from the ICARDA germplasm collection for resistance to *O. foetida* was initiated at Beja in a highly infested field. Preliminary data resulted in the identification of a few promising tolerant lines.

Acknowledgements

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A Classification System for Seeds of Faba Bean Infected by *Ascochyta fabae*

نظام تصنيفي لبذور الفول المصابة بالتبقع الأسكوكايتي

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الملخص

تم تصنيف بذور الفول المزروعة في حقل تجريبي إلى ست فئات من الإصابة بالتبقع الأسكوكايتي. واستند التصنيف على التقديرات المرئية للإختلافات في مساحة غلاف البذرة الكامد اللون التي يفترض أن تكون قد نجمت عن الإصابة بالمرض. وتم تحديد تأثيرات إصابة البذور على تكشف البادرات وعلى تطور النبات اللاحق. وانخفض نمو النباتات عندما تجاوزت مساحة غلاف البذرة التي يفترض أنها نجمت عن الإصابة بالفطر نسبة 25٪.

Abstract

Faba bean seeds produced in a field experiment were classified into six categories of infection by *Ascochyta fabae*. The classification was based on visual estimates of differences in the area of discolored seed coat assumed to be affected by the disease. The effects of seed infection on seedling emergence and on subsequent plant development were determined. The growth of plants was reduced when the area of seed coat assumed to be infected by the fungus exceeded 25%.

Introduction

Many fungi have a direct impact on seed primordia and maturing seeds, which results in reduced yields in terms of both quantity and quality. Yield reductions are related mainly to seed abortion and reduced seed size as, for example, in cereals infected by rust or powdery mildew fungi. Poor quality, in terms of seed discoloration and necroses produced by some seedborne fungi, may reduce the commercial value of the seeds for consumption and for industrial purposes (Neergaard 1977).

Several seed classification systems have been developed as an aid to evaluate seed quality and the degree of infection. For example, Brönnimann (1968) adopted a system with a 9-point scale to evaluate the grain quality in wheat affected by glume blotch [*Septoria nodorum* (Berk)], while Dodd (1971) divided the seeds of bean (*Vicia faba* L.) infected by *Ascochyta fabae* Speg. into three categories: uninfected, less than 50% infected and more than 50% of the seed coat covered with lesions. In some cases, necroses may be associated with reduced germination and emergence capacities of seeds and reductions in their longevity in storage. For example, Hewett (1973) found that from 4 to 8% of field bean seeds infected by *A. fabae* produced diseased seedlings.

This paper describes an improved disease classification for seeds of faba bean (*V. faba*) infected by *A. fabae*, a seedborne disease.

Materials and Methods

Classification of seed infection

The classification procedure was applied to seeds of the faba bean cv. Ticol, from a field experiment investigating the effects of disease on the growth and dry matter production of the crop. Disease treatments in the field were produced by inoculation with *A. fabae* at defined growth stages and compared with a fungicide treatment and an untreated control by Madeira (1988) and Madeira et al. (1988). The seeds were harvested from all treatments when their mean water content was approximately 14%. A subsample of about 5000 seeds was dried at room temperature and used for the assessment of seed infection. The discolored area of seed coat, which was assumed to be due to infection by *A. fabae*, was estimated visually and the seeds were classified into six categories according to the severity of infection. The seeds were weighed and the mean seed weight per category was determined.

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The incidence of seeds carrying infection, in terms of number of *A. fabae* colonies on a seed plate test, was assessed by assaying a subsample of 25 seeds from each category. These seeds were surface-sterilized in a 10% solution of sodium hypochlorite (1.5% available chlorine) for 5 minutes and then plated on V8 juice agar, five seeds per petri dish (9 cm diam.). The seeds were incubated under near-UV light (12-hour photoperiod) at room temperature for 7 days and the number of *A. fabae* colonies was counted.

Emergence and seedling development

Seedling emergence was assessed by using 25 seeds (dried at room temperature) per category of infection. The seeds were sown in pots (9 cm diam.), 1 seed/pot, containing John Innes No. 2 potting compost, watered and maintained at a temperature of about 16°C. Seedling emergence was determined from 8 to 16 days after sowing.

Seedlings were examined every day, after the first pair of leaflets unfolded. Five plants randomly selected from each category were harvested 50 days after sowing, and measurements were made of stem length, number of leaves, total leaf area and dry weight/plant.

Results

Classification of seed infection

Figure 1 shows a visual classification of the seed coat area assumed to be infected by *A. fabae* according to the six categories of seed infection (Table 1). Table 1 shows the incidence of *A. fabae*, in terms of the percentages of seeds showing infection in the agar plate test and the corresponding mean seed weights for the six categories of seed. The relatively low incidence of infection (73%)

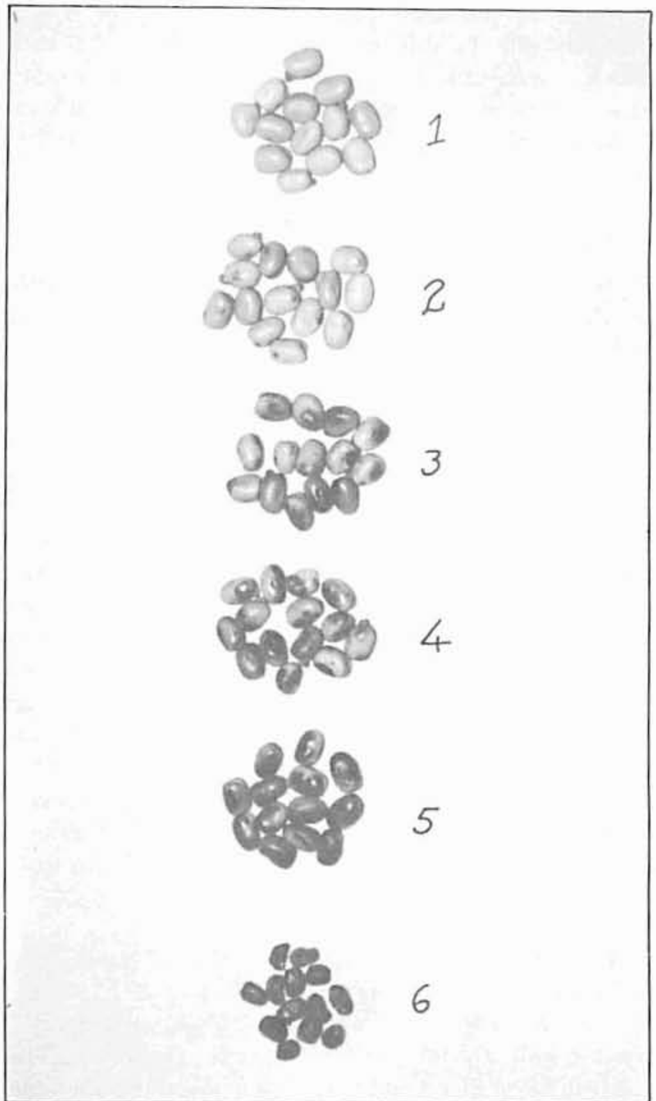

Fig. 1. Faba beans from six classification categories, indicating increasing infection by *Ascochyta fabae*.

Table 1. Assessment of *Ascochyta fabae* infection in six categories of seed.

Category	% seed coat affected	% seeds from which *A. fabae* colonies developed	Seed weight (mg)
1	Uninfected	0 (0.0)†	509 (9.5)†
2	Visible lesions on less than 5% of the seed coat	36 (4.0)	491 (8.3)
3	Lesion area 5–25%	48 (4.6)	490 (7.3)
4	Lesion area 25–50%	80 (6.3)	478 (13.7)
5	More than 50% of the seed coat with lesions	84 (4.0)	450 (10.5)
6	Badly discolored and undersized seeds, shrivelled and cracked	73 (4.9)	200 (15.1)

† The values in brackets are standard errors.

obtained in the seed plate test for category 6 was probably due to difficulty in distinguishing the seed damage caused by *A. fabae* infection from that by other causes. The mean seed weights represent significant decreases of 6, 12 and 61% for categories 4, 5 and 6, respectively, compared with that of uninfected seeds.

Emergence and seedling development

Figure 2 shows the time courses of seedling emergence for the six categories of seeds sown. For categories 1, 2 and 3, different numbers of seedlings had emerged by the 8th day after sowing, but 96% had emerged at day 16 in all three. Fewer seedlings emerged for categories 4 and 5 (72 and 76%, respectively), a marked reduction when compared with categories 1 to 3. The different percentages of coat area with lesions in categories 4 and 5 were not accompanied by reductions in emergence. Emergence of seedlings in category 6 was poor (4%). The subsequent development of seedlings also showed pronounced differences among seed categories. At day 25 after sowing, 42% of seedlings from category 5 manifested the typical symptoms of leaf and pod spot disease on stems and leaves, compared with 28 and 12% for categories 4 and 3, respectively. Leaf lesions were circular, dark brown with a lighter center; the lesions on stems were elongated, sunken and darker than the leaf lesions. At this stage, lesions were not visible on seedlings from seed categories 1 and 2.

Table 2 shows the stem length, number of leaves, total leaf area and dry weight/plant at 50 days after sowing. Measurements were not made on plants from category 6 because only a small number of seeds germinated. The plants in categories 4 and 5 were significantly smaller and weaker than the others, as assessed by dry weight and leaf area; in these categories the lower total leaf area/plant was due to fewer leaves and smaller areas per leaf. Figure 3 illustrates the visual differences in the development of plants grown from seed categories 1, 4 and 5 at 72 days after sowing.

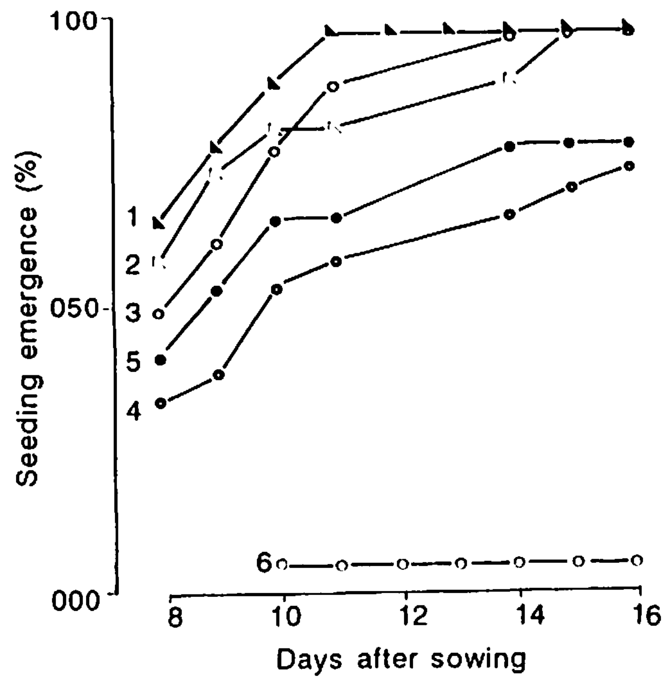

Fig. 2. Number of days after sowing for seedling emergence of faba bean plants infected with *Ascochyta fabae*.

Discussion

A subjective classification of seeds into six categories was established, based on visual assessment of the percentage of coat area assumed to be affected by *A. fabae*. This allowed both discrimination of differences in seed

Table 2. Growth analysis data at 50 days after sowing for seedlings grown from seeds given in Table 1.

Category	Stem length (cm ± S.E.)	Mean no. of leaves/plant (± S.E.)	Mean leaf area/plant (cm^2 ± S.E.)	Mean dry weight/plant (g ± S.E.)
1	51 (0.9)a†	10.2 (0.3)a	344 (4.8)a	1.92 (0.07)a
2	48 (0.9)a	10.0 (0.0)a	361 (22.6)a	1.96 (0.1)a
3	49 (2.3)a	9.5 (0.6)a	292 (30.5)a	1.68 (0.2)a
4	42 (0.9)b	8.6 (0.4)b	175 (17.4)b	1.07 (0.05)b
5	37 (1.6)b	7.8 (0.3)b	141 (18.2)b	0.82 (0.08)b
6	—‡	—	—	—

† Values with different superscripts are significantly different ($P < 0.05$) by Duncan's multiple range test.
‡ Insufficient viable seedlings for valid data.

Fig. 3. Development of *Ascochyta fabae*-infected faba bean plants from categories 1, 4 and 5 at 72 days after sowing.

infection between field treatments and measurement of the effect of different degrees of infection on emergence and subsequent seedling development. As *A. fabae* is a rain-splash disease, the most important factors in the dispersal of this fungus are the amount and intensity of rain falling during the crop lifetime and the number of consecutive rainy days. The fungus can adversely affect leaf area, crop growth and light-use efficiency, which ultimately reduces the final yield and the protein content of seeds (Madeira 1988).

Seed infection reduced both emergence and the subsequent growth of the seedlings, producing small plants from the infected seeds. Emergence was affected most in seeds with more than 25% of coat area with lesions, i.e., categories 4, 5 and 6. Dodd (1971) found that the germination of badly infected seeds was reduced to about 50% of that of uninfected seeds. In the present work, a similar value (45%) was obtained for categories 5 and 6 together. However, most of the unsuccessful seeds (which did not produce a seedling) were from category 6. This suggests that additional information is offered by the 6-category scale adopted here compared with the 3-category system used by Dodd (1971).

In the present work, although some seedlings from categories 3, 4 and 5 manifested abnormal development and symptoms of disease, not all infected seeds produced visibly infected seedlings and plants. However, in the long-term assessment of plant development, the growth of plants from the infected seeds was significantly affected by the degree of seed infection, showing associated decreases in stem length, number of leaves, total leaf area and total dry weight/plant. For example, 50 days after sowing the reductions in total dry weight represent decreases of 44 and 57% for categories 4 and 5, respectively, compared with the plants from category 1. In contrast, Dodd (1971) did not find significant differences between the dry weights of plants grown from his three categories of seeds. For Ticol, a classification based on six categories is justified for measurement of the effects of seed infection on succeeding seedling and plant development, and for classification of visible seed damage. A simplified approach would combine categories 1 to 3 in one, 4 and 5 in a second, and the badly infected seeds from category 6 in a third category. However, this approach would ignore visual evidence of infection in categories 2 and 3, which could affect the commercial value of the seed.

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News

Crop coverage in the FABIS newsletter will expand to include the tribe Viceae (*Vicia* and *Lathyrus* spp.), commencing in 1993. Authors are invited to submit papers dealing with these crops.

To allow for this expansion, the Editorial Committee recommends that all papers submitted for publication be restricted in length. Printed articles ideally should not exceed 4 pages in the newsletter (this is equivalent to approximately 8 pages (A4) typed double-spaced, including tables and figures.

Latest Faba Bean References

Commencing with this issue of the FABIS newsletter, faba bean references will be published annually in a supplement. The first supplement, containing 1990 references, will be published in 1992. Subsequent supplements will be published annually and distributed to recipients of the FABIS newsletter.

Proposal for a Global Grain Legume/Drought Research Network

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Summary

Grain legume crops are important sources of high-quality protein in human diets and important components of sustainable agriculture in rain-fed areas. Drought usually is the main constraint to crop production in such environments. A substantial body of information on responses of grain legume crops to drought has accumulated in recent years. We suggest this can be better mobilized and exploited through coordinated efforts to achieve significantly better adaptation of grain legumes to drought-prone environments. It is therefore proposed to organize a global grain legumes/drought research network. Expected outputs of such a network would include formulation of viable and cost-effective research projects and assistance to national agricultural research systems in focussing problem-solving research on drought-related constraints. We believe that this would contribute to enhancement of sustainable grain legume production, including legume benefits to the overall cropping system in drought-prone environments.

Background

- Drought is a major constraint to rain-fed production of grain legumes.
- Grain legume crops are important, particularly in developing countries as sources of proteins in human diets, and components of the sustainability equation in rain-fed, drought-prone agriculture.
- Increasing knowledge on the adaptation of grain legume crops to drought-prone environments has accumulated in recent years. This has been generated in separate studies with respect to crops, environments and researchers.
- Rapid progress in genetic adaptation of grain legumes to drought-prone environments could occur if research efforts are coordinated, and we propose a network to facilitate this.

Current Status

Little quantifiable progress has been made to date in minimizing the yield-reducing effects in grain legumes because of:

1) an unrealistic expectation of identifying crop varieties with high levels of resistance to drought,
2) an imperfect understanding of the complex nature of drought over time and its interactions with crop growth and yield,
3) an emphasis mainly on identifying simple physiological/biochemical criteria of drought resistance, which often do not relate to field performance,
4) lack of efforts to integrate studies across grain legume crops and environments to draw inferences and plan future strategies, and
5) reluctance to breed crops for drought resistance because of the unpredictability of drought environments.

Objectives

1. To establish a reference point for integrated global efforts on enhancing and stabilizing grain legume production in drought-affected environments by:

    a) providing information about active researchers and institutes working on drought and the areas of expertise,
    b) maintaining a list and passport information of traits of drought resistant grain legume crops and varieties,
    c) documenting and updating published literature on all aspects of drought relevant to grain legume crops and disseminating specific literature searches, and
    d) facilitating regular communication between network members by means such as an informal newsletter.
2. To characterize and map the types of drought affecting legume production globally, using Geographic Information Systems (GIS) and models.
3. To quantify yield losses due to drought by using existing knowledge and data, and through experimentation where such knowledge does not exist.
4. To relate area, production, productivity and yield losses to Item 2 and to:
    a) identify priority agro-ecological areas and legume crops for drought research,
    b) develop agronomic management/genetic enhancement strategies to alleviate drought effects in the target regions, and
    c) set parameters for increasing effectiveness and enhancing impact in the target region.
5. To extend available technologies of genetic enhancement for drought resistance in the target regions.
6. To stimulate basic research, including on cell biology, with well-defined impact on applied or problem-solving research.
7. To organize brainstorming sessions on drought research in workshops, group discussions, and conferences in crucial areas and disseminate the current understanding through publications.
8. To identify and facilitate linkages between organizations with expertise in specific areas of drought research.
9. To solicit funding to support the above activities.

Scope and Prospects

Prospects of mitigating drought effects on grain legume production appear more promising in the 1990s.

1. Good progress has been made toward a better understanding of the realities and complexity of types of drought and their effects on crop growth and yield.
2. Coordinated international efforts seem feasible because drought is an important theme of research at many international centers and institutes.
3. Precise and detailed characterization of atmospheric and soil moisture environments during crop growth is now feasible through computer modeling.
4. Various components of drought can now be mapped on field to global scale using programs such as GIS so that iso-drought environments can be delineated to enhance transfer of technology.
5. There are some examples of success in the development of grain legume crop varieties resistant to terminal drought.

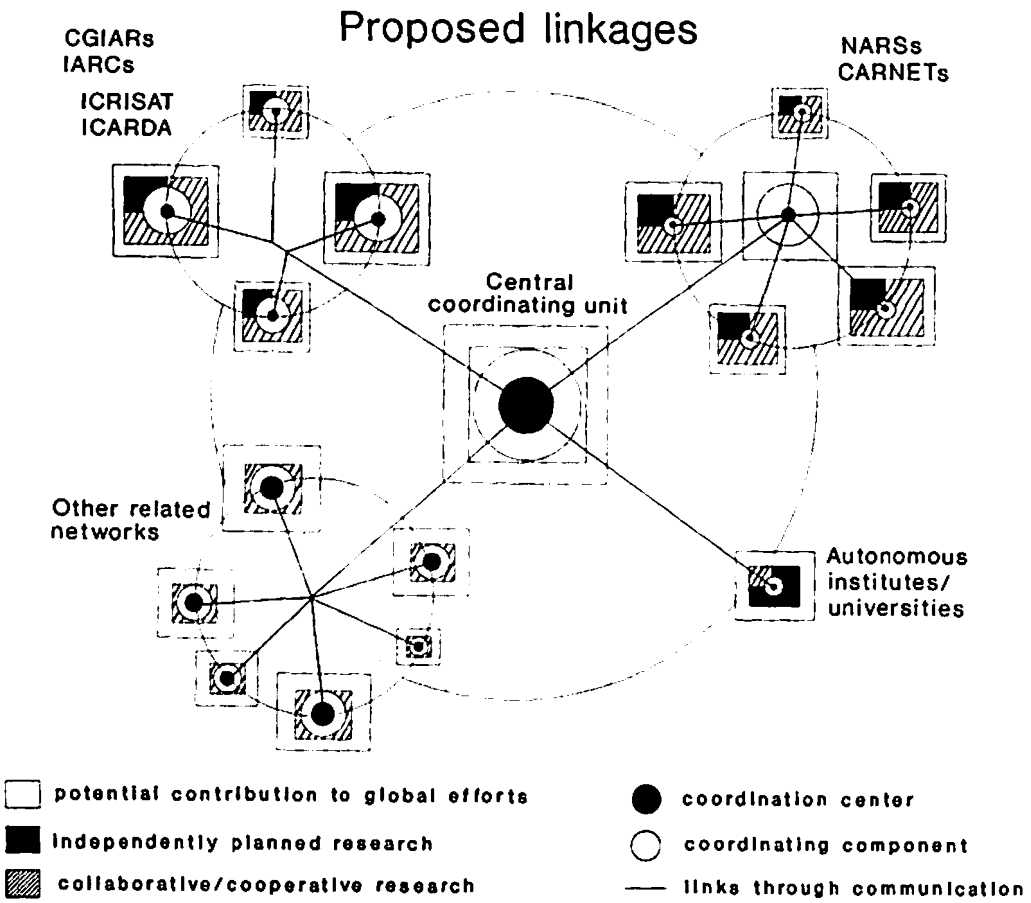
Expected Outputs and Impacts

1. Development of viable projects in drought research which set realistic goals for achieving success.
2. Creation of better awareness of the existing knowledge and experience amongst drought researchers.
3. Evaluation of research projects for most efficient use of resource inputs and possible benefits.
4. Generation of self-reliance and expertise in the conduct of drought research amongst the scientists of participating NARS.
5. Enhancement and stabilization of sustainable grain legume production under rain-fed conditions.

Proposed Linkages

The proposed linkages of the network are shown in Figure 1. We also intend to publish an informal newsletter as a means of communication between the network members. We are soliciting suggestions from other related networks, national and international organizations/ institutes, universities and individuals on various aspects of the network activities and wish to determine their interest in joining such efforts.

Please indicate to Dr M.C. Saxena, Leader, Legumes Program, ICARDA if you are interested in participating in such a network and if you have any comments and suggestions on this proposal. Our decision to proceed with establishing the network and the manner in which we proceed will depend on feedback from prospective members.



Publications

Harlan, Jack R. (ed.). 1992. *Crops & Man, Second Edition.* Crop Science Society of America, American Society of Agronomy, 677 South Segoe Road, Madison, WI 53711-1086, USA. 284 p.

This book explores the beginnings of man's interactions with plants and crops that provide food, feed and fiber, from the early human hunter/gatherer societies to present-day societies in industrial countries where only 2-3% of the population produces crops. The evolution of crop plants is described, from their wild progenitors to fully domesticated races, and the corresponding emergence of agricultural societies and economics. As human activities have shaped changes in crop plants, these in turn have shaped human history. Man the food gatherer, then the planter, has become the geneticist and plant breeder. The implications of this intricate coevolution are discussed: crops reshaped by selection and agricultural practice, societies adjusted to the successes and failures of the crops. Erosion of diverse gene sources from ancient landraces continues and more effective use of germplasm collections is needed. Dr Harlan suggests that we study more closely the natural ecosystems and use this knowledge in managing our new ecosystems.

Visuals

ICARDA has produced three slide/tape modules dealing with legume hybridization techniques. The three programs, *Hybridization Techniques in Faba Bean*, *Hybridization Techniques in Lentil*, and *Hybridization Techniques in Chickpea*, 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.

Conferences

The *Second International Food Legume Research Conference* was held in Cairo, Egypt, from 12—16 April 1992. It was attended by 250 participants from 38 countries. Following inauguration of the conference by Prof Dr Adel El-Beltagy, Director General of Agricultural Research Center and the National Agriculture Research Project of Egypt, progress in research on improvement of chickpea, faba bean, grasspea, pea and lentil was reviewed in plenary sessions, panel discussions and a workshop. Eight groups, formed of participants from different geographical regions, discussed regional goals, identified constraints and developed recommendations for future research. The proceedings of IFLRCII are in production, under the editorship of Drs W. J. Muehlbaur and W. J. Kaiser of Washington State University.

The next IFLRC is scheduled for 1997. Conference Chairman for that meeting will be Dr Fred Muehlbaur, assisted by Mr Habib Halila (Near East), Dr Geletu Bejiga (Africa) and Dr Bashir Malik (Asia), regional representatives of the International Steering Committee.

1992

***10th Latin American Weed Science Society Congress*, Chile, November 1992.** Contact: M. Kogan, Universidad Catolica del Chile, Vicuna Mackenna, 4860, Santiago, Chile.

1993

***Workshop on Engineering Plants against Pests and Pathogens*, Madrid, Spain, 11—13 January 1993.** Contact: Instituto Juan March, Castello 77, 28006 Madrid, Spain.

***10th Australian Plant Breeding Conference*, Gold Coast, Queensland, 19—23 April 1993.** Contact: Australian Convention and Travel Services Pty Ltd., GPO Box 2200, Canberra, ACT 2601, Australia.

***7th International Symposium on Iron Nutrition and Interactions in Plants*, Zaragoza, Spain, 27 June—2 July 1993.** 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.

***6th International Congress of Plant Pathology*, Montreal, Canada, 28 July—6 August 1993.** Contact: Managing Editor, Bureau of Crop Protection, CAB International, Wallingford, Oxon, OX10 8DE, UK.

***XII International Plant Nutrition Colloquium/Symposium —Zinc in Soils and Plants*, Perth, Western Australia, 21—6/27—8 September 1993.** Contact: Plant Nutrition Secretariat, The Conference Office, University of Western Australia, Nedlands, WA 6009, Australia.

***International Symposium on Pulses Research*, Kanpur, India, 4—8 December 1993.** Contact: Dr A.N. Asthana, Organizing Secretary, International Symposium ISPRD, Directorate of Pulses Research, Kanpur 208 024, India.

1994

***7th International Congress of Bacteriology, Applied Microbiology and Mycology*, Prague, Czechoslovakia, 3—8 July 1994.** 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.

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

Cosponsored by: Indian Council of Agricultural Research
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

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Benin	Iran	Somalia
Belgique	Italy	Spain
Bhutan	Kenya	Sri Lanka
Botswana	Korea (Republic)	Sudan
Brazil	Lesotho	Swaziland
Canada	Malawi	Syria
Chile	Malaysia	Taiwan
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ICARDA Publications
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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.

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.

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.

Library Services
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.

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

Opportunities for Field Research at ICARDA
This brochure is intended primarily to assist Master of Science candidates, who are enrolled at national universities within ICARDA region and selected for the Graduate Research Training Program. It explains to them the opportunity they have to conduct their thesis research work at ICARDA research sites under the supervision of international scientists. For your copy, write to: Training Coordination Unit.

Graduate Research Training Awards, Opportunities for Field Research at ICARDA
The Graduate Research Training Program (GRT) is intended primarily to assist Master of Science candidates who are enrolled at national universities within the ICARDA region. Men and women who are selected for the program will have an opportunity to conduct their thesis research work at ICARDA research sites under the cosupervision of university and center scientists. For further information on terms of award, nomination procedure, selection criteria, appointment conditions, the university's responsibilities, and the student's responsibilities, write to: GRT Program, Training Coordination Unit.

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.

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

Manuscript

Contributions should be sent to FABIS/CODIS, ICARDA, P.O. Box 5466, Aleppo, Syria. The name, address, and telex or fax number of the corresponding author should be included in the covering letter. One good-quality original of the text should be submitted, typed double-spaced on one side of the paper only. Figures should be original drawings, good-quality computer prints, or black and white photographs of good quality. Photographs and figures should be suitable for reduction to a printed size of 8.5 or 17.4 cm wide. Photocopies are not acceptable for publication in FABIS. Authors may submit color photographs to be considered for the cover.

All articles must have an abstract (maximum 250 words) and usually the following sections: Introduction, Materials and Methods, Results, Discussion, Conclusions and References. Articles will be edited to maintain uniform style, but substantial editing will be referred to author(s) for approval. Papers requiring extensive revision will be returned to the author(s) for correction. Authors can refer to a recent issue of FABIS for format. The following guidelines should be followed:

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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