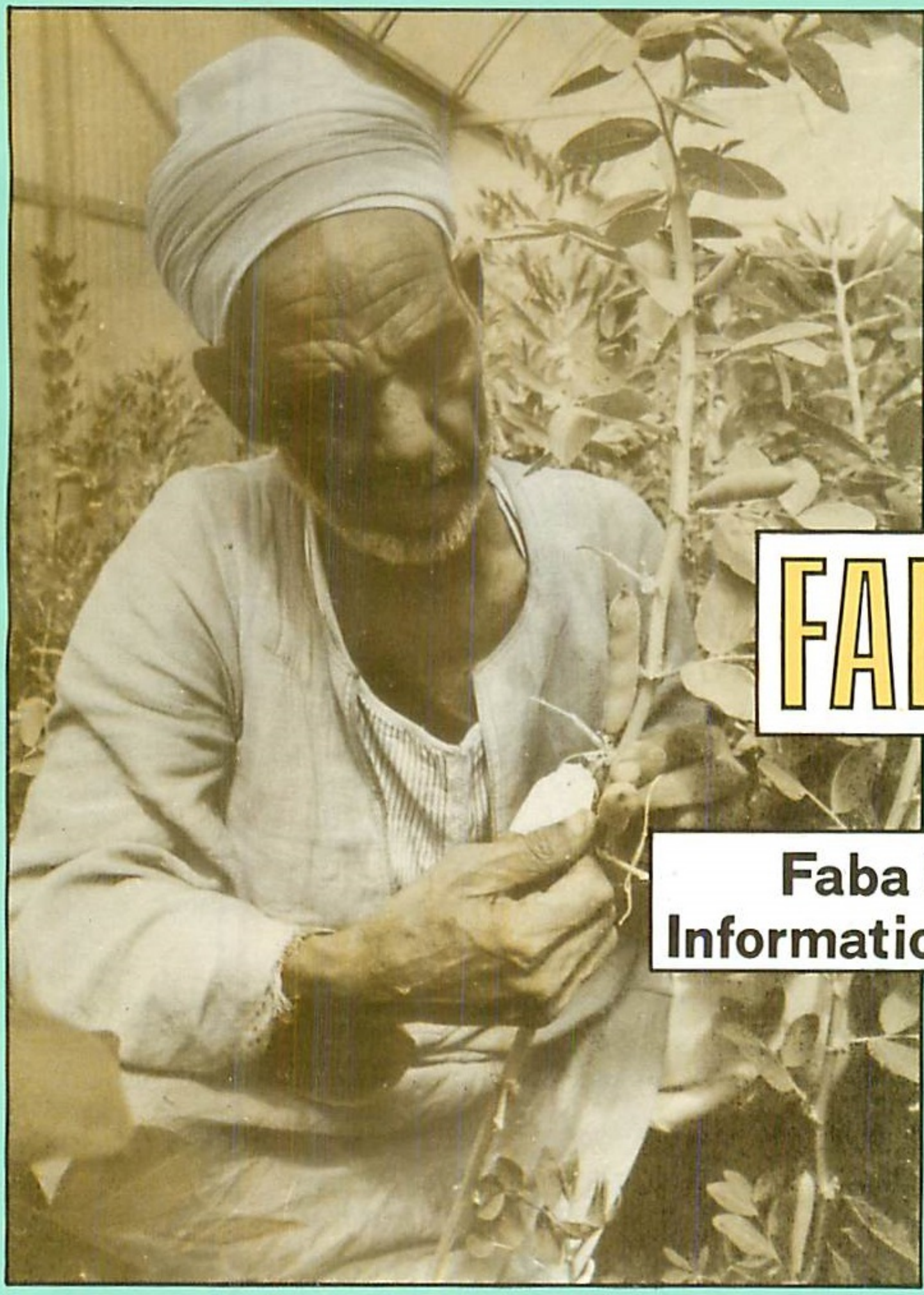

FABIS

Faba Bean Information Service

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No. 14
APRIL 1986

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(ICARDA)

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COVER PHOTO: A greenhouse attendant examines faba bean plants in a breeding trial, Nile Valley Project, Egypt.

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SHORT COMMUNICATIONS

Breeding and Genetics

Variation in Nitrogen Harvest Index in *Vicia faba* L.

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Abstract

This study assessed the variation in nitrogen harvest index (NHI) and its association with yield, harvest index (HI), and protein content of 40 genotypes of faba bean. NHI (47.07-77.76%) was positively correlated with HI (25.64-53.04%). There was a significant negative correlation between protein content (23.10-30.03%) and HI. Both HI and NHI were positively correlated with seed yield.

Introduction

Breeding for high harvest index (HI) has resulted in high grain yield, particularly in dwarf genotypes of cereals. However, it has not been very useful as a selection criterion in pulses, although a wide range of variation exists for this trait (Jain 1977; Singh and Shrivastava 1981). Singh and Shrivastava (1981), who observed poor association between HI and seed yield in pigeonpea genotypes with wide variation in HI (8.97-57.8%), suggested that selection of high HI genotypes under high population density can be effective for yield improvement. Since legumes are, unlike cereals, rich in protein, the efficiency of a genotype can be judged on the extent of translocation of assimilated nitrogen from vegetative parts to the seed.

Nitrogen harvest index (NHI) based on nitrogen distribution between seed and vegetative parts is important in several crops which face soil nitrogen deficiency and moisture stress during grain filling. Plants accumulate most of their nitrogen in vegetative parts prior to anthesis and this nitrogen is then redistributed to developing grains (Dalling *et al.* 1976). Also, genotypes with high grain protein contents require more nitrogen than those with low protein content. The additional nitrogen needs for seed can be met to some extent by redistribution of nitrogen from leaves and stem. Desai and Bhatia (1978) obtained values for NHI of 57-86% and a positive correlation between NHI and HI. Gameshaiah and Umashamker (1981) estimated NHI in cereals and pulses to be 66, 41, 74, 58, 57, 59, 46, and 56% for rice, ragi, maize, sorghum, groundnut, cowpea, pigeonpea, and soybean, respectively. McBlain and Hume (1981) reported that there was no difference in NHI between three early soybean cultivars (70-71%). Newton and Hill (1981) reported NHI values of 58 and 96% in autumn and spring sown *Vicia faba*.

Our study assessed the variation in NHI and its association with yield and yield components in 40 faba bean genotypes.

Materials and Methods

The experiment was carried out at the livestock farm of the Department of Plant Breeding and Genetics, Agricultural University, Jabalpur, India. The experiment was laid out in a randomized block design with three replicates. Ten plants were selected at random for nitrogen estimation and the seeds and plants were ground separately. Nitrogen was estimated by the micro-Kjeldhal method.

Results and Discussion

There was wide variation in NHI (47.07-77.76%). HI ranged from 25.64 to 53.04% (Table 1) and was positively correlated ($r = 0.706$) with NHI (Table 2). Protein content (23.10-30.03%) showed significant negative correlation with HI ($r = -0.402$). There was no correlation between protein content and NHI or

Table 1. NHI, HI, protein content, and seed yield/plant.

Characters	Range
NHI	47.07 - 77.76%
HI	25.60 - 53.04%
Protein content	23.10 - 30.03%
Seed yield/plant	5.07 - 14.12 g

Table 2. Correlation coefficients between HI, NHI, protein content, and seed yield.

	HI	Protein content (%)	Seed yield/ plant
NHI	0.7066**	0.0810	0.8207*
HI		0.4016*	0.4756**

** Significant at P=0.01
* Significant at P=0.05

seed yield (Table 2). Both HI and NHI were positively correlated with seed yield (r = 0.476 and 0.321, respectively).

These findings clearly suggest that selection for high NHI can result in high yield since yield/plant depends on NHI. NHI can also be used in selecting the parents for hybridization and evaluating promising selections.

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Combining Ability for Protein and Cellulose Content in a Five-Parent Diallel of Vicia faba L.

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Abstract

Studies were made on combining ability using diallel crosses among five cultivars of faba bean. Both general combining ability (GCA) and specific combining ability (SCA) were highly significant, showing the existence of both additive and dominance effects on protein and cellulose content. Individual values for GCA and SCA for the two traits were calculated and discussed.

Introduction

Faba bean (*Vicia faba* L.) forms an important part of the protein diet of the Egyptian people.

Eden (1968) and Clarke (1970) noted significant differences between the crude protein content of spring and winter types. Chapman and Peat (1978) and Griffiths and Lawes (1978) found genetic variation in the protein content of dry seeds of *V. faba*. Picard (1979) showed that seed protein content can be improved without affecting yield. Therefore, we studied the genetic system controlling protein and cellulose content using a number of faba bean cultivars in a diallel crossing system in an attempt to improve seed quality.

Materials and Methods

A half-diallel cross experiment was performed with five inbred faba bean parents, to study the protein and cellulose content of dry seed. The parents used were: Somali (P_1), Balady (P_2), Kobrosy (P_3), Long Equadore (P_4), and Bunyard's Exhibition (P_5). Protein contents were determined in the dry seeds using the method of Gornall *et al.* (1949). Cellulose content was determined in the seed coat using Poschenok's method (1976).

The genetic analysis was based on the method proposed by Griffing (1956).

Results and Discussion

The analyses of combining ability for protein and cellulose contents are shown in Table 1. The partitioning of genotype variance into general and specific combining ability components shows a highly significant SCA component and a large GCA effect for both traits. A comparison of the relative magnitudes of GCA vs SCA effects indicated that the latter was much more important than the former for both traits, emphasizing the importance of dominant gene action for protein and cellulose content.

The significant GCA and SCA effects for each trait indicated that estimates of individual effects for parents and parental combinations could be calculated.

The GCA effects for the two traits and the five parents are given in Table 2, and SCA effects in Table 3.

Protein content

Parents 2 and 5 had the highest GCA effect for protein content, while parents 1 and 4 had the lowest. In the estimate of the SCA effect, cross 1 x 2 had the greatest effect for protein content (Table 3). Parent 2 was used in two other crosses with large SCA effect. Five crosses, 2 x 3, 3 x 5, 4 x 5, 1 x 5, and 1 x 3 had a significant negative effect for protein content.

Table 1. Analysis of variance of data on protein and cellulose content in a 5 x 5 diallel cross of faba bean cultivars.

	Degrees of freedom	Mean square	F ratio
Protein			
Genotypes	14	6492.6	683.43**
GCA	4	805.43	508.80**
SCA	10	1392.93	879.93**
Cellulose			
Genotypes	14	2681.82	10120.07**
GCA	4	214.18	4856.80**
SCA	10	619.68	14051.70**

** Significant at P = 0.01.

Table 2. Estimates of GCA effects for protein and cellulose content.

Array	Protein content	Cellulose content
P_1	-6.72**	-0.891**
P_2	14.96**	-6.067**
P_3	-0.03	1.372*
P_4	-12.98**	8.594**
P_5	4.77*	-3.008**
S.E. $(g_i - g_j)$	$\pm$ 0.67	$\pm$0.275

*, ** Significance at P = 0.05 and P = 0.01, respectively.

Table 3. Estimates of SCA effects for protein and cellulose content.

Crosses	Protein content	Cellulose content
1 x 2	13.66**	6.92**
1 x 3	-13.12**	23.73**
1 x 4	1.72	-2.90*
1 x 5	-35.31**	-1.21*
2 x 3	-54.08**	28.24**
2 x 4	11.60**	29.69**
2 x 5	2.34*	6.71**
3 x 4	3.09**	20.17**
3 x 5	-39.83**	-19.33**
4 x 5	-37.16**	-30.68**
S.E. $(S_{ig} - S_{ik})$	$\pm$2.71	$\pm$0.67
$(S_{ij} - S_{kl})$	$\pm$2.26	$\pm$0.61

Cellulose content

Parents 4 and 3 showed a significant positive GCA effect for higher cellulose content while the other parents had a significant negative GCA effect for this trait.

For the SCA effect, the crosses 2 x 4, 2 x 3, 1 x 3, 3 x 4, and 2 x 5 had significant positive effects for cellulose content and the other five crosses had significant negative effects (Table 3).

From these results, parent 2 (Balady) was superior for GCA and produced high SCA effects in most crosses for protein content. For cellulose content parents 1 (Somali) and 5 (Bunyard's Exhibition) appeared to be the best parents to produce crosses with low cellulose content. This indicates that the genetic variation is present and available for the plant breeder to improve the seed quality of faba bean. Progress can be made in breeding for both protein and cellulose quality using this information.

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Physiology and Microbiology

Seasonal Pattern of Symbiotic Nitrogen Fixation in Faba Beans and its Association with some Physiological Traits

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Abstract

The seasonal pattern of symbiotic nitrogen fixation in three faba bean (*Vicia faba* L.) cultivars, as measured by acetylene reduction and nitrogen content, and its association with some growth parameters were investigated in a greenhouse experiment at ICARDA in 1983. Genotypic differences in nitrogenase activity were apparent early in the season but became small with the start of pod filling. There was significant, positive correlation between leaf area and nitrogenase activity until the onset of flowering. Most of the growth parameters correlated better with plant nitrogen content than with nitrogenase activity. Nitrogen content and nitrogenase activity were highly correlated only in the linear phase of plant growth.

There were no genotypic differences in relative growth rate or net assimilation rate and both were poorly correlated with nitrogenase activity and nitrogen content. However, early on, absolute growth rate was highly correlated with nitrogen content. Nitrogenase activity peaked shortly after pod initiation and up to this period most plant nitrogen was in the leaves. During seed filling a substantial amount of nitrogen was remobilized from the leaves and stems to pods. The implications of these results for faba bean crop improvement are discussed.

Introduction

Symbiotic nitrogen fixation is an energy-intensive process necessitating the translocation of large quantities of photosynthates from leaves to root nodules. Several workers have attempted to estimate the cost of symbiotic nitrogen fixation to the host plant. Schubert and Ryle (1980) stated that symbiotic nitrogen fixation in legume nodules may utilize 10-30% of the total photosynthate produced by the host plant. Atkins and Rainbird (1982) estimated theoretically that a total of 1.13-2.37 moles glucose/mole N_2 fixed may be required to meet the needs of all component processes (nitrogenase activity, ammonia assimilation, transport of fixed N, and nodule growth and maintenance) in actively fixing legume nodules. Minchin and Pate (1973) found that, in peas, about 32% of the total photosynthate is utilized by the nodules. Mahon (1977) estimated an energy equivalent of 17g of carbohydrate consumed/gram of N fixed in nodulated pea roots. Dixon *et al.* (1980) reported a requirement of 5.8-8.7 g of carbon /gram N fixed in peas, while in soybean 6.4-7.8g of carbon were required. Layzell *et al.* (1981) estimated that 27% of the net photosynthesis of nodulated white lupin was used in root and nodule respiration. Pate *et al.* (1979) found that respiration of roots plus nodules accounted for 34-45% of plant carbon consumption during the study period. In faba bean, Lawrie and Wheeler (1975) reported that ^{14}C translocated to the nodules was rapidly used in amino acid formation from ammonium produced by N fixation.

Therefore any limitation to photosynthesis could adversely affect N fixation (Lawn and Burn 1974; Hardy and Havelka 1975; Sprent and Bradford 1977; Osman 1982) and so improving photosynthesis is important in maximizing the nitrogen fixing capacity of legumes.

This investigation studies the relationship between some physiological traits related to photosynthesis--such as leaf area, specific leaf weight, relative growth rate, and net assimilation rate--and symbiotic nitrogen fixation in different faba bean genotypes.

Materials and Methods

A pot-culture experiment was conducted in the greenhouse during February-May 1983 at Tel Hadya, the principal research station of ICARDA in Syria. Three faba bean cultivars, ILB 1814 (Syrian Local Large), ILB 1278 (Giza 402, from Egypt), and ILB 460 (Hudeiba 72, from Sudan) were arranged in a randomized block design with four replicates. Each plot consisted of nine pots filled with a mixture of 66% silty clay loam soil from Tel Hadya farm and 33% river sand. A peat-based faba bean inoculum (1-ICAR-SYR-Fa-65) was mixed with the soil before sowing. Each cultivar was sown as a plot and two plants/pot were maintained.

Samples were taken at 2-week intervals, commencing 28 days after sowing and continuing to maturity. At each sampling date, one pot (two plants) was randomly selected from each plot and plants removed with their roots. The roots and shoots were separated and the latter divided into leaves, stems, and fruits. Leaf area was measured using a LICOR leaf area meter. All plant parts were then dried at 65-70°C for 48 hr and dry weight was determined. From these measurements, the absolute growth rate (AGR), relative growth rate (RGR), net assimilation rate (NAR), and specific leaf weight (SLW) were computed.

Nitrogenase activity of the root systems was estimated at 8 - 8.30 A.M. on each sampling date using an acetylene reduction technique (Hardy *et al.* 1968). The roots were placed in a plastic jar which was then sealed and 10ml acetylene injected into each jar. The jars were incubated in the greenhouse for 30 min., after which 1ml gas samples were removed from each jar for ethylene content measurement by gas chromatography (Packard Model 437). Activity was expressed as u moles C_2H_4/hr/plant.

Total nitrogen concentration was determined in each plant part at each sampling stage using the Kjeldahl method. The N-content/plant and its distribution among different plant parts was calculated by multiplying the dry weight of each part by its nitrogen concentration.

Results and Discussion

Leaf area and dry matter development

Although the three faba bean cultivars in this study had similar total leaf area and dry weight in their initial growth phase, genotypic differences in these two traits became evident 7 weeks after sowing and persisted up to final harvest (12 weeks after sowing). ILB 1814, which is a local cultivar, had the greatest leaf area and total dry weight at all sampling dates; a reflection of its adaptation to the environment in which the experiment was conducted.

The pattern of crop growth

The pattern of AGR, RGR, and NAR for the three cultivars is shown in Table 1. AGR exhibited a lag

Table 1. Variation in growth rate and assimilation efficiency of some faba bean genotypes.

Physiological trait	Genotype	Sampling intervals (days from sowing) 28-42	43-57	58-72	73-87
	ILB 1278	0.86	0.96	1.28	1.89
AGR (g/week)	ILB 1814	1.05	1.53	2.10	1.74
	ILB 460	0.84	0.56	1.42	2.22
	SE ±	0.13	0.26	0.34	0.53
	ILB 1278	0.61	0.29	0.29	0.24
RGR (g/g/week)	ILB 1814	0.49	0.31	0.26	0.15
	ILB 460	0.68	0.21	0.31	0.26
	SE ±	0.06	0.05	0.06	0.06
	ILB 1278	5.18	2.82	2.63	1.43
NAR ($mg/cm^2/week$)	ILB 1814	4.25	3.25	3.89	1.79
	ILB 460	5.99	2.15	3.37	1.53
	SE ±	0.56	0.62	0.66	0.51

phase but increased subsequently. RGR and NAR declined sharply 42 days after sowing, remained about the same up to 72 days, and then reduced again conspicuously. This later decline may partly be due to increased nitrogen remobilization from the leaves to the fruiting bodies (Fig. 1). Rapid senescence of mung bean leaves was reported to be triggered by nitrogen remobilization from the leaves to the developing fruits (Sinclair and de Wit 1976) and a decline in photosynthetic rates of the youngest mature cotton leaf coincided with an increase in the rate of boll development and seed filling (Ibrahim 1977). Studies on crop growth and partitioning of assimilates in faba beans by Thompson (1979) also indicated that net assimilation rate and relative growth rate declined with time.

Symbiotic nitrogen fixation

Although the rate of nitrogenase activity was different in the three faba bean cultivars, the seasonal pattern was nearly the same (Fig. 2). Activity increased during the vegetative and early reproductive phase, peaked at 72 days, shortly after pod initiation, but declined sharply thereafter. ILB 1814 maintained a significantly higher enzyme activity than the other two cultivars up to 56 days after sowing but thereafter differences in activity were reduced. The genotypic variation in nitrogen fixation observed in this study supported earlier work by Sherbeeny *et al.* (1977).

Nitrogenase activity decreased substantially with pod filling. Sprent and Bradford (1977) also observed that nitrogenase activity reached its maximum after flowering and then declined. A similar decline in nitrogenase activity was observed in soybean by Lawn and Brun (1974).

The reduction in nitrogenase activity with pod filling was perhaps due to competition between the pods and nodules for photosynthates. Reduced activity coincided with a fall in nitrogen content of leaves and stems, and reduced net assimilation rates, which were also observed by Igwilo (1982).

Nitrogen accumulation and distribution

Throughout the season, ILB 1814 accumulated more nitrogen than ILB 1278 and ILB 460, and nitrogen accumulation increased as growth progressed.

During the vegetative and early reproductive stages, the leaves were the major sink for fixed nitrogen. With the onset of pod filling, the nitrogen content of leaves, stems, and roots decreased substantially. At the same time, fruiting bodies showed increased dry weight and nitrogen content, despite reduced nitrogenase activity. Probably part of the nitrogen accumulated in the pods came from current fixation and soil uptake while the rest was translocated from leaves, stems, and roots. Igwilo (1982) found that, by harvest time, 30-45% of

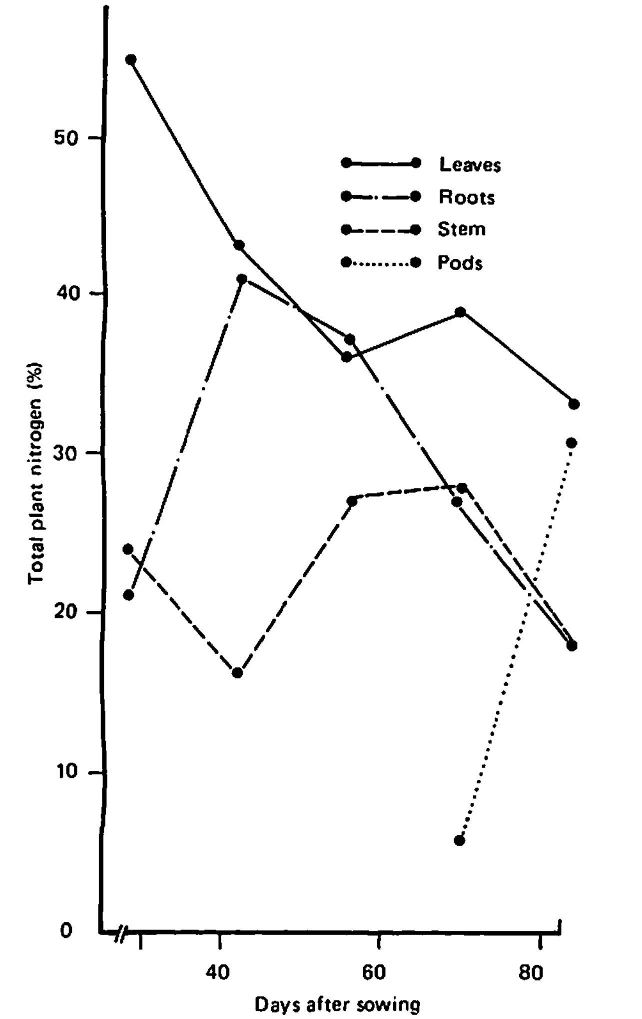

Fig. 1. Changes in distribution of nitrogen among various faba bean plant organs at different stages of growth.

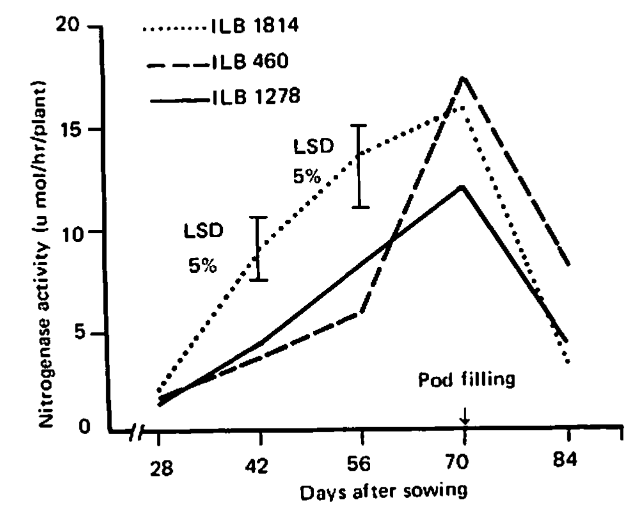

Fig. 2. Nitrogenase activity in three faba bean genotypes (ILB 1818, ILB 460, ILB 1278).

the total seed nitrogen in faba bean was mobilized from other plant parts. He concluded that improvement of the nitrogen supply to faba bean fruits during this period might improve both yield and quality. Dekhuijzen and Verkerke (1984) used ^{15}N to study nitrogen uptake and redistribution by *V. faba* L. They found that, at maturity, 83% of ^{15}N in seeds came from the vegetative parts present at flowering. The nitrogen accumulation and distribution observed in this study agreed with the self-destructive hypothesis of seed legumes described by Sinclair and de Wit (1976). Dantuma and Hulze (1979) concluded that high-yielding faba bean plant types should accumulate large quantities of dry matter and nitrogen before the onset of high seed growth rates.

Relationship between plant growth attributes and nitrogen fixation.

Correlations among various growth parameters, nitrogen content, and nitrogenase activity at different phases of plant development are shown in Table 2. Dejong and Phillips (1981) concluded that nitrogen fixation in peas interacted with photosynthetic efficiency and plant growth, and this interaction was dependent on the allocation of fixed nitrogen. In our study, there was a significant correlation between nitrogenase activity and leaf area during the early growth stages. This correlation was insignificant after the onset of seed filling when nitrogen remobilization started and probably resulted in reduced photosynthesis. However, nitrogenase activity correlated poorly with net assimilation rates (Table 3).

Igwilo (1982) found that the correlation between leaf area and nodule dry weight in faba beans was insignificant and, through the entire growth period, net assimilation rate was not closely correlated to nodule weight ($r=-0.17$). As shown in Table 2, nitrogenase activity (NA) was positively correlated with nitrogen content/plant throughout the season but was significant only during the linear growth phase, before the beginning of seed filling. These observations point to the complexity of the relationships between nitrogen fixation, assimilate synthesis, and nutrient remobilization.

To improve nitrogen fixation in any crop, the supply of photosynthate to the nodules must be improved, without affecting the development of the reproductive organs. At the same time, an efficient nitrogen fixing system is needed that remains operational during part of the seed filling period. This would avoid nitrogen remobilization from the leaves and consequent reduction in photosynthesis at an early stage of seed filling. Varieties with increased leaf area and extended leaf area duration

Table 2. Coefficients of correlation between nitrogen fixation traits and various growth parameters during plant development in some faba bean genotypes.

Growth parameter	Nitrogen fixation traits	Days after planting 28	42	56	70	84
Leaf area	NA+	0.81**	0.88**	0.71**	0.10	0.49
	NC++	0.93**	0.96**	0.90**	0.95**	0.28
Leaf weight	NA	0.14	0.56	0.68**	0.16	0.35
	NC	0.93**	0.95**	0.95**	0.97**	0.28
Stem weight	NA	0.06	0.50	0.65*	0.03	0.09
	NC	0.94**	0.94**	0.91**	0.90**	-0.12
Root weight	NA	0.36	0.31	0.78**	0.08	-0.55
	NC	0.90**	0.76**	0.87**	0.82**	-0.29
Fruit weight	NA				0.23	0.23
	NC				-0.17	0.14
Total dry weight	NA	0.02	0.39	0.78**	0.15	-0.34
	NC	0.99**	0.69*	0.94**	0.94**	-0.06
Specific leaf weight	NA	0.85**	-0.41	0.49	0.19	-0.25
	NC	0.84**	-0.33	0.82**	0.09	0.14
Nitrogenase activity	NC	0.08	0.79**	0.70*	0.25	0.52

* Significant at P = 0.05
** Significant at P = 0.01
+ Nitrogenase activity
++ Nitrogen content

Table 3. Coefficient of correlation between nitrogen fixation traits and growth rates in some faba bean genotypes.

Days from planting	AGR NA	AGR NC	RGR NA	RGR NC	NAR NA	NAR NC
28-42	0.59*	0.79**	-0.31	0.18	-0.33	-0.06
43-57	0.73**	0.94**	0.55	0.14	0.51	0.72**
58-72	-0.12	0.70*	-0.26	0.14	-0.08	0.19
73-87	-0.02	0.29	-0.45	0.13	0.23	0.20

* Significant at P = -0.05
** Significant at P = 0.01

may be of value in this regard. Sinclair and de Wit (1975; 1976) used simulation models to show that increasing the rate of N supply from the roots to the seeds lengthened the duration of seed growth and increased yield when there was sufficient photosynthate to support efficient nitrogen fixation. Further studies on these interactions should be done for faba beans.

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Interactions Between the Application of Growth Regulators, Yield Components, and Content of Phytohormones in the Fruits of Vicia faba L.

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Abstract

The effect of growth regulator application and bud removal on yield was studied over 2 years in faba bean variety Herz-Freya. Growth regulators were sprayed in the field and extractable phytohormone contents determined for various plant parts. Plants were also decapitated and whole inflorescences or only the oldest buds were removed to remove possible dominance effects. Yields from treated plants were generally similar to control plants, except for GA_3 treatment at the sixth leaf stage in the first trial year which significantly increased yield. Removal of the two proximal buds of every inflorescence reduced fruit drop and number of flowers. The course of hormone contents corresponded to fruit development but this cannot be related to yield components.

Introduction

The yield of *Vicia faba* L. is often reduced to an uneconomically low level by a high abscission rate of the reproductive organs. This is due to competition for assimilates between vegetative and reproductive organs and between the reproductive organs themselves (Jaquiery and Keller 1978; Gehriger and Keller 1979). Dominance effects from older fruits on younger fruits of the same inflorescence may also be important (Tamas *et al.* 1979; Huff and Dybing 1980; Gates *et al.* 1981). Competition for assimilates and dominance effects are probably influenced or mediated by phytohormones.

It is possible to reduce flower and pod drop by applying plant growth regulators e.g., GA_3, which probably change assimilate partitioning. However, flower and pod drop are very inconsistent from year to year and in different locations (Bellucci *et al.* 1982; Burkhard and Keller 1983).

Different plant growth regulators (ABA, NAA, GA_3, $GA_{4/7}$, BA, Alar, Atrinal, Paclobutrazol, Tetcyclacis) have been applied in various combinations, concentrations, and at different developmental stages but pod set was not significantly improved. Plant development e.g., plant height, was more easily influenced than the development of the reproductive organs (Kellerhals and Keller 1984a; 1984b; Kellerhals *et al.* 1986).

In this study we looked at the internal phytohormone levels in developing fruits and how applied plant growth regulators affect these levels. This should indicate whether there is a 'hormonal balance' which prevents abscission. With such information, it should be possible to apply plant growth regulators more precisely.

Since treatments were necessary which may result in significantly different pod sets, we also decapitated plants and removed whole inflorescences or only the oldest buds of the inflorescences. By removing these oldest buds, possible dominance effects within an inflorescence could be eliminated.

Materials and Methods

All the experiments were conducted as field trials with the indeterminate one-stem variety Herz-Freya during 1981-84. This variety produces about 20 inflorescences, each with 5-7 buds. Of these buds and flowers, only the proximal (older) 1-3 usually develop into mature pods while the distal (younger) buds abscise as flowers or as young pods. The definitive pod number is more or less set by mid-July and harvest is about the end of August.

Growth regulators were sprayed in run-off treatments with a back sprayer, as aqueous solutions containing 0.2% Tween 20 as wetting agent (Table 1).

Buds, flowers, and pods of different reproductive nodes and different positions within the inflorescences were removed at approximately weekly intervals. For analyses, the inflorescences were separated into two proximal fruits and the remaining distal fruits. The sampled fruits were rapidly frozen in liquid nitrogen, freeze-dried, and homogenized. Extractable phytohormone content was determined by the methods shown in Table 2.

Table 1. Details of treatments in the field trials, 1983 and 1984.

Treatment	Stage of treatment
Field trial 1983 (IAA- and ABA-analyses)	
Control	
GA_3 (10^{-4}M	6-leaf stage
NAA (5×10^{-5}M)	Twice per week during flowering (total 7 times)
Buds removed	Two proximal (oldest) buds of every inflorescence removed as soon as they appeared
Field trial 1984 (GA_3-analyses)	
Control	
GA_3 (10^{-4}M)	6-leaf stage

Table 2. Methods for phytohormone determination.

Phytohormone	Method
IAA	Spectrofluorometry (Stoessl and Venis 1970; Knegt and Bruinsma 1973)
ABA	Gas chromatography (with ECD)
GA_3	Barley endosperm bioassay (Coombe *et al.* 1967)

In the spectrofluorometric method we used for auxin determination, IAA (indole-3-acetic acid) and 4-Cl-IAA (chlorinated IAA) contents cannot be separately determined (Bottger *et al.* 1978). Therefore, the term IAA as used in this paper includes 4-Cl-IAA.

Results and Discussion

The results for 1983 and 1984 are presented here.

Yield components

Applying growth regulators to improve yield resulted in little success and the results were not easily duplicated (Kellerhals and Keller 1984a; 1984b; Kellerhals *et al.* 1986). All treatments generally resulted in yields similar to those of control plants. Nevertheless, many years' trials show that, by applying GA_3, shoot growth and therefore assimilate partitioning during flowering can be influenced (Bellucci *et al.* 1982; Burkhard and Keller 1983). In 1983, it was possible to influence vegetative growth and significantly increase yield by applying GA_3 at the sixth leaf stage (Table 3). Applications at the fourth, fifth, or seventh leaf stages did not have any effect on yield. In 1984, vegetative growth was influenced but not yield. The changed growth rhythm of the shoot and the flowering period is obviously important in the influence of GA_3 on pod set.

Frequent applications of NAA during flowering should increase the sink activity of flowers and prevent a shortage of auxin during flower and pod development, which accelerates the processes in the abscission zone of the pedicels. The treatment described in this paper resulted in an insignificant yield increase (Table 3). Weekly applications of higher concentrations of NAA did not change the yield components compared to untreated plants.

The number of flowers/plant was generally reduced by growth regulator application but the percent abscission of flowers and young pods could also be reduced resulting in a greater number of pods/plant (Table 4).

Removing the two proximal buds of every inflorescence reduced the number of flowers early in development. This caused a significant change in the competition for assimilates between the reproductive organs and possibly influenced the dominance relations between fruits. Fruit drop was also reduced (Tables 3 and 4). These results show the adaptability of the faba bean which allows the plant to produce a grain yield comparable to the yield of

Table 3. Influence of treatments on different yield components. Mean of 36 (control) or 12 plants (other treatments) in 1983 and of 48 plants in 1984.

Treatment	Pods/ plant	Grains/ plant	Total grain weight (g)	Grain dry weight/ plant (g)
1983				
Control	24	77	324	25
GA_3	33***	101**	349	35**
NAA	26	88	356	31
Buds removed	22	70	358	25
1984				
Control	19	65	308	20
GA_3	21	65	310	20

** $P \leq 0.01$; *** $P \leq 0.001$

Table 4. Number of flowers and percent pod set, 1983. Mean of 36 plants.

Treatment	Flowers/ plant	Pods/plant at harvest	Pod set (%)
Control	63.3	23.8	37.6
GA_3	61.8	33.1	53.6
NAA	50.8	25.9	51.0
Buds removed	34.5	22.4	64.9

untreated plants even under unfavorable conditions. These results also show that the distal fruits of inflorescences of variety Herz-Freya do not abscise due to lack of fertilization (Rowland *et al.* 1983) or as a result of limitations caused by vascular architecture (Gates *et al.* 1983). More results are necessary to determine whether the improved pod set at these distal positions is a consequence of the elimination of dominance effects of the proximal buds or flowers. The mature pods showed the same distribution along the fruit-bearing zone as the pods of untreated plants.

Course of hormone contents in the developing fruits

A characteristic course of the hormones under investigation - extractable IAA, ABA, and GA_3 - was found in developing fruits (Figs. 1-4). Hormone contents in the buds were slightly higher than in the fully-opened and withered but fertilized flowers. A hormone increase paralleled dry matter increase in young pods, then decreased up to maturity. Of the three hormones investigated, IAA increased in young pods prior to the increase in dry matter. ABA and GA_3 increased along with the dry matter. The course of the hormones corresponded well with fruit development (Wheeler 1972; Eeuwens and Schwabe 1975; Goldbach and Michael 1976; Mounla *et al.* 1980). Greatest fruit drop begins when the hormone content is at its lowest. However, this is not an explanation for fruit drop since this low point also occurs in the proximal flowers which mature to pods.

The slight decrease in hormone content from buds to fully-opened flowers agrees with the results of Jaquiery and Keller (1980). They showed that young 4-5 day old flowers have decreased growth compared to younger or older fruits. It is during this period of decreased growth that it is determined whether or not the fruit will go on growing.

On 70-80% of the investigated inflorescences of control plants (Fig. 1), flowers and young pods which did not ripen to mature pods had a lower IAA content compared to fruits which developed into mature pods. These differences in IAA content did not occur in decapitated plants or in plants of the GA_3 6-leaf treatment in 1983 in which more pods/inflorescence reached maturity. As auxins probably promote assimilate transport (Wareing 1978; Patrick 1979), this lower extractable IAA content may be one reason for the abscission of distal flowers and young pods. The content of extractable ABA and GA_3 does not vary with the position of fruits in the inflorescence i.e., according to their chances of reaching maturity.

Effect of treatments on hormone content

All growth regulator applications had a similar effect on the course of hormone content. In general, the treatments had a greater influence on the course

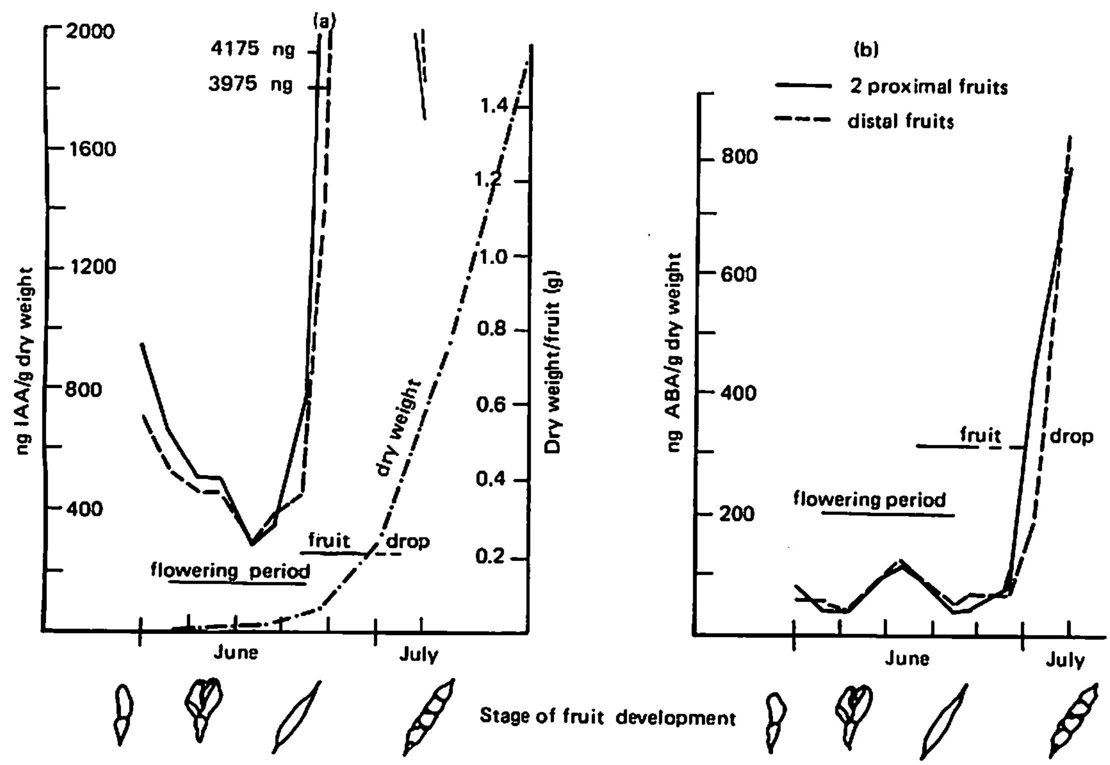

Fig. 1. Content of extractable IAA (a) and ABA (b) in developing fruits of the two basal inflorescences of control plants. (Inflorescences were divided; two proximal fruits and the remaining distal fruits, mean of two replications, 1983.)

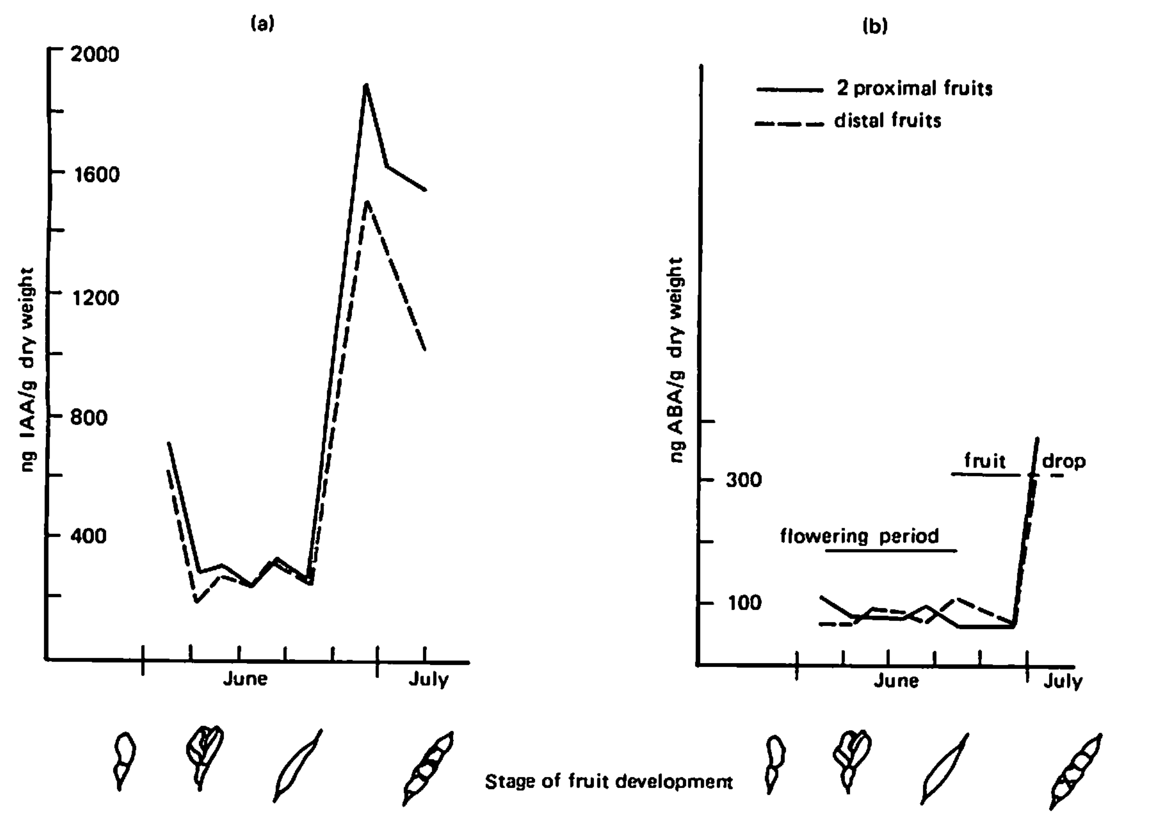

Fig. 2. Content of extractable IAA (a) and ABA (b) in the developing fruits of the two basal inflorescences. Plants repeatedly treated with NAA. (Inflorescences were divided; two proximal fruits and the remaining distal fruits, one replication, 1983.)

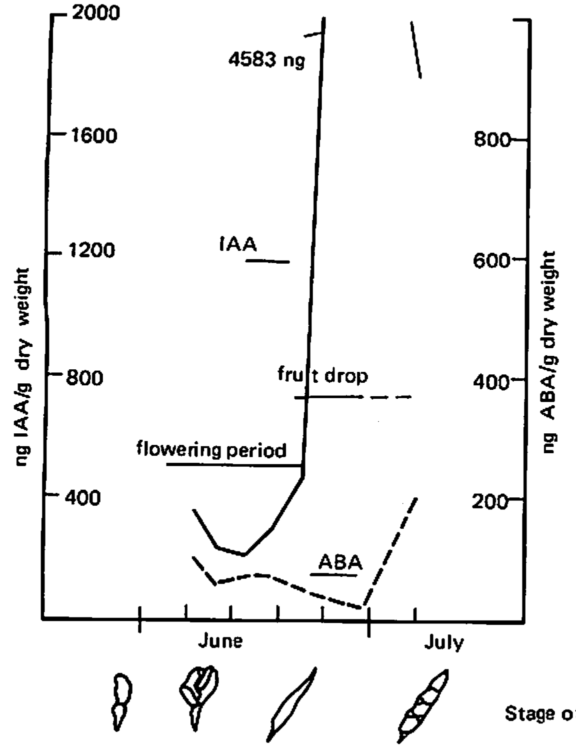

Fig. 3. Content of extractable IAA and ABA in the developing fruits of the two basal inflorescences. (Two proximal buds removed, one replication, 1983.)

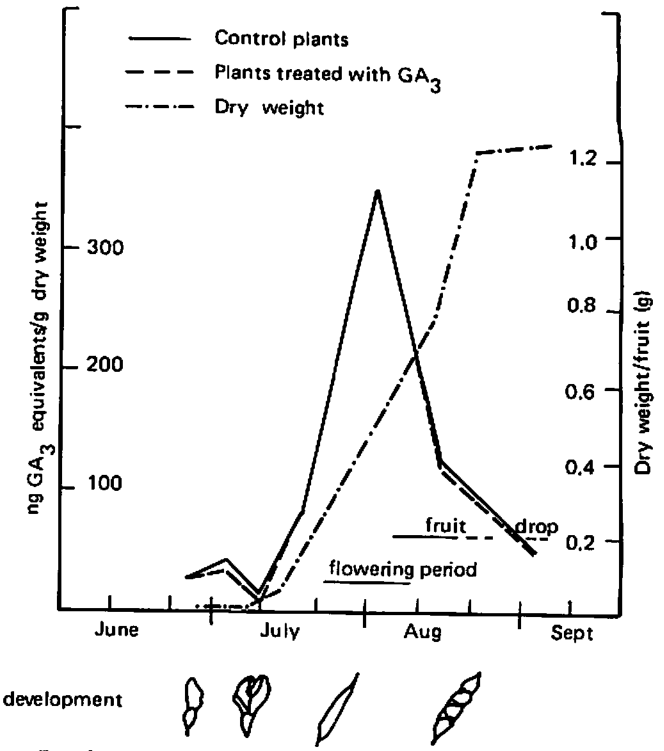

Fig. 4. Content of extractable gibberellins in developing fruits of the 5th and 6th inflorescences. (Whole inflorescences of control plants and plants treated with GA_3, mean of two replications, 1984.)

of IAA than on ABA or GA_3. All treatments in a single year showed the same changes in hormone course in the fruits, and yield components were only seldom significantly influenced. It is therefore not possible to relate the course of hormones in fruits to yield components.

GA_3 applied at the sixth leaf stage had a positive effect on yield components in 1983 only. The distal buds and flowers in only 55% of the investigated inflorescences contained less IAA than the proximal fruits (control plants = 70%). The content of gibberellins was determined in 1984 (Fig. 4) and the application of GA_3 influenced neither the course of gibberellins in the fruits nor the yield.

Plants treated repeatedly with NAA showed no change in growth but had a lower IAA content in vegetative and reproductive organs (Fig. 2) compared to untreated plants. Treated plants were apparently able to use the exogenously available auxin instead of using that which they produced internally. As a result, they synthesized less auxin themselves.

Removal of the two proximal buds from every inflorescence had a strong effect on competition for assimilates and possibly on dominance effects within and between inflorescences. There was, however, no considerable change in the course of IAA and ABA in the distal fruits (Fig. 3). Two to three distal pods matured on the nodes of plants of this treatment, whereas only 0.5 distal pods reached maturity on the same nodes of control plants. The absolute content of extractable IAA and ABA in the fruits is not important in determining whether or not the flowers will mature to ripe pods.

The sensitivity of plant tissues also seems to be important in the effect of hormones or applied plant growth regulators (Trewavas 1982). The possible role of hormones on plant and fruit development is discussed more fully in the thesis of Diethelm (1985).

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Induced Genetic Variability in Rhizobium leguminosarum of Vicia faba L. to Improve Nitrogen Fixation

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Abstract

Ten isolates of *Rhizobium leguminosarum* from different genotypes of *Vicia faba* L. were tested on two genotypes of *V. faba.* Three strains were gamma irradiated to produce mutants which were highly variable genetically. These mutants were studied for several traits. The number of nodules per plant was shown to be the best selection criterion for rhizobial isolates with better nitrogen fixation.

Materials and Methods

Ten genotypes of *Vicia faba* L. were grown in the field and from them 30 isolates of natural rhizobial strains were obtained. Of these, 24 were authentic rhizobia and may be one or more strains of *Rhizobium leguminosarum.* Ten isolates were randomly selected and tested on two genotypes of *V. faba,* selected on the basis of 1000-seed weight and protein content. The three best rhizobial isolates were subjected to gamma irradiation at 10, 20, and 30 kR to produce mutant strains. Survival, colonial morphology, Congo red absorption capacity (cra^+), growth, gelatinase activity, and nutritional totipotence of 24 mutants were studied.

Results and Discussion

Eighteen mutants varied in colony size while five mutants varied in cra^+. Several mutants grew better than their parents, the non-irradiated isolates. The majority of mutants lost gelatinase activity; only five retained this activity.

The genotypic coefficient of variation indicated a high magnitude of genetic variability for morphological traits; grain yield, number of nodules, biological yield, and deficiencies in adenine, biotin, thiamine, adenine-biotin, adenine-thiamine biotin-thiamine, and biotin-thiamine-adenine. Three parents were a distinct strain of *R. leguminosarum.* There was much variation among parents and some strains proved more effective with respect to number of nodules and biological yield per plant.

Heritability estimates were high for the number of nodules per plant, dry weight of nodules, and dry weight of shoot per plant. High heritability was also estimated for deficiencies in adenine and adenine-biotin-thiamine. High heritability with high genetic advance for two *V. faba* genotypes and 24 mutants of rhizobia showed that the host x strain interaction can be exploited for improved symbiosis.

The number of nodules per plant was positively correlated with dry weight of nodule per plant, dry weight of shoot per plant, dry weight of root per plant, biological yield, and grain yield. Adenine deficiency was positively correlated with deficiencies in biotin, adenine-biotin, and thiamine-biotin. The number of nodules per plant produced by a particular rhizobial strain was the best selection criterion for rhizobial isolates with better nitrogen fixation.

Agronomy and Mechanization

Responses of Faba Beans To Sowing Date at El Rahad, Sudan

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Abstract

These trials aimed to identify optimum sowing dates for faba beans at El Rahad, Sudan. There were six sowing dates with 7-day intervals in the period 15 October to 19 November in each of three successive years. Sowing date had a significant effect on yield each year and the optimum sowing date for El Rahad was 15 October to 12 November. The factors important for high yield are number of pods/plant, seed weight, stem length, and number of branches/ plant.

Introduction

In recent years there has been a steady increase in faba bean consumption in Sudan but a gradual decline in acreage and yield (Hassan 1984). Faba bean prices are therefore rising, and will continue to do so until supplies improve. Supplies may be augmented by importing, or by increasing local production through yield improvement in existing producing areas and expansion of the area under the crop.

The Rahad Agricultural Scheme in the El Rahad area (around 14°N and 34°E) is ideally situated, in terms of facilities and transport, for the horizontal expansion of the faba bean crop. The crop, which may be easily incorporated into the existing vegetable crop rotation, is also well suited to local farmers' needs as it does not require special handling, storage, or marketing facilities. However, the El Rahad area has short winters and relatively high temperatures compared to the traditional faba bean-growing areas in the Northern Province of Sudan, which may limit the potential of the crop in this area.

Our approach to this problem is twofold. Firstly, optimum sowing dates can be selected which enable the crop to have full benefit of the short winter, and secondly, differences in temperature requirements between existing cultivars may be identified and promising cultivars selected to produce early maturing cultivars tolerant to warm conditions.

This paper reports on investigations to identify optimum sowing dates for faba beans at El Rahad.

Materials and Methods

The trial was conducted at the Vegetable Research Farm, Rahad Research Station, El Fau, in the seasons 1982/83, 1983/84, and 1984/85. The trial compared six sowing dates with 7-day intervals between 15 October and 19 November. The cultivars Beladi and Silaim were used in 1982/83 in a factorial combination in a randomized complete block design. As the first season's results showed that the two cultivars were similar in their responses, one cultivar, BF 2/2, was used in the latter two seasons in a randomized complete block design. In all three seasons, four replicates were employed.

Medium-sized seeds were sown (2/hole) in holes 20cm apart along two sides of ridges 60cm apart. The plots were 3.0m x 7.0m and were irrigated every 7-10 days. The fertilizers superphosphate, at 42.5kg P_2O_5/ha and urea, at 85kg N/ha, were applied. The fungicide Sofrel and the insecticides Lannate, Roger, and Sevin were used and weeding and other cultural operations were done as necessary.

Crop phenology, growth, yield, and yield attributes were studied.

Results

1982/83

Sowing date had a highly significant effect (P = 0.01) on seed yield. Maximum yield (3365 kg/ha) was produced from crop sown on 29 October (Table 1) and yields of crops sown prior to 29 October were higher than those recorded after that date.

The sowing date also exerted significant effects on number of pods/plant (P = 0.05), plant height (P =

0.01), and number of days to 50% flowering (P = 0.01), podding (P = 0.01), and 90% pod drying (P = 0.01). The two cultivars Silaim and Beladi were similar in the various parameters (Table 1).

1983/84

The effect of sowing date on seed yield was significant (P = 0.05). Maximum yield was attained by crop sown on 5 November, followed by that sown on 29 October (Table 2).

The sowing date effect was significant for 1000-seed weight (P = 0.01), plant height (P = 0.01), branches/plant (P = 0.01), and number of days to 50% flowering (P = 0.01), podding (P = 0.01), and 90% pod drying (P = 0.01). However, the effect of sowing date was not significant for number of pods/plant, number of first podding node, or plant stand early and late in the season (Table 2).

1984/85

The effect of sowing date on seed yield was highly significant (P = 0.01). Maximum yield was attained by crop sown on 15 October with 22 October closely following. Yield data for 29 October were statistically similar to data for 22 October, and data for 5 November were similar to 29 October. The lowest yielders were plants sown on 12 and 19 November (Table 3).

Sowing date had a significant effect on 1000-seed weight (P = 0.01), pods/plant (P = 0.01), and plant height (P = 0.01), but was not significant for the number of first podding node, plant stand early and late in the season, or seeds/pod (Table 3).

Discussion

The data indicate the importance of sowing date for yield and growth of faba beans in El Rahad as seed yield responded significantly to sowing date in each of the three seasons 1982/83, 1983/84, and 1984/85. The 29 October sowing date produced the highest yield in the first and second seasons, with the 22 October sowing date producing highest yields in the third season. These results are supported by other research in Sennar and Medani (Hassan 1984), and Hudeiba (Abu Salih 1979; Ageeb 1981; Baghdadi and Khalifa 1968; Heipko and Kaufmann 1965; Heipko 1966), where sowing date was reported to have highly significant effects on faba bean seed yield. The optimum sowing date was reported by Hassan (1984) to be 1 November and around the middle of October at Hudeiba.

The data suggest that number of pods/plant, 1000-seed weight, plant height, and branches/plant were the factors through which the sowing date effect is exerted. The sowing dates resulting in high yields produced plants with higher numbers of pods, heavier seeds, taller stems, and more branches than low-yielding sowing dates.

Table 1. Response of faba beans to sowing date at El Rahad, Sudan, 1982/83.

Treatment	Seed yield (kg/ha)	Pods/ plant	Plant height (cm)	Number of days to 50% flowering	50% podding	90% pod drying
Sowing date						
15 Oct	3001	17	101	44	64	107
22 Oct	2875	16	93	42	66	105
29 Oct	3365	18	101	44	66	105
5 Nov	2775	18	98	41	69	101
12 Nov	2240	13	92	41	67	101
19 Nov	2002	14	92	41	68	97
SE ±	140	1.4	3.0	1.0	1.0	1.0
Cultivars						
Silaim	2770	14	98	42	65	102
Beladi	2649	17	94	43	68	103
SE ±	NS	NS	NS	NS	NS	NS

NS: Not significant.

Osman (1966; 1968) showed that the number of pods is a major factor in yield differences between varieties, although the number of seeds/pod did not affect yield of different varieties. Ishag (1979) showed the number of pods to be important in differences among sowing dates. Also, among the yield components tested by Abu Salih (1979) and Ageeb (1979), yield was significantly correlated with the number of pods/plant. Hassan (1984) showed that pods/plant, seed weight, and stem length were positively correlated with yield.

Though there were significant differences among sowing dates in number of days to reach the 50% flowering and 50% podding stages, the magnitude of such differences was too small to significantly affect yield. It is more likely that days to 90% pod drying were more effective since their ranges were wider. The pods of the later sown crop dried quicker than the earlier sown one which finished the crop prematurely resulting in yield loss.

The plant stand/unit area was not significantly affected by date of sowing because there was a low prevalence of early seedling diseases. If the disease incidence had been higher, it would have resulted in high seedling mortality in early sowing dates because of warmer soil temperatures. Unlike the traditional faba bean growing areas in North Sudan, the serious faba bean diseases which occur early in the season--phyllody (Hussein 1979), root rot, and wilt (Abu Salih 1979)--were negligible in the experimental plots possibly due to the wet irrigation regime adopted. Such a regime discourages disease spread (Ageeb 1981; Khalifa 1978). The late season disease, powdery mildew (Heipko 1966), and the insect leafminer, both appearing late in December, occurred especially in the late sown crops. Leafminer caused more damage because it was resistant to the insecticides used. The earlier sowings were less affected because, by late December, vegetative growth and pod formation were nearly complete.

The yields in 1983/84 were lower than either 1982/83 or 1984/85 which could be related to weather conditions. Unlike the other two seasons, the winter of 1983/84 started late, was short, and mean temperatures were higher than normal. This resulted in shorter plants, lighter seed weight, and lower yields in 1983/84.

Table 2. Response of faba beans to sowing date at El Rahad, Sudan, 1983/84.

Sowing date	Seed yield (kg/ha)	1000-seed weight (g)	Pods/ plant	No. of 1st podding node	Plants/m row length: 2 weeks after sowing	Plants/m row length: at harvest	Plant height (cm)	Branches/ plant	Number of days to: 50% flowering	Number of days to: 50% podding	Number of days to: 90% pod drying
15 Oct	1162	352	8	11	26	26	85	3	40	68	110
22 Oct	1532	354	8	10	27	26	77	3	37	66	109
29 Oct	1824	351	6	10	25	24	84	2	36	64	108
5 Nov	1908	352	8	11	26	28	82	2	37	63	108
12 Nov	1711	340	6	11	28	28	82	3	40	62	104
19 Nov	1256	321	6	12	22	29	92	2	39	63	99
SE ±	170	5.2	0.8	0.9	0.4	1.3	2.2	0.03	0.1	0.5	0.4

Table 3. Response of faba beans to sowing date at El Rahad, Sudan, 1984/85.

Sowing date	Seed yield (kg/ha)	1000-seed weight (g)	Pods/ plant	No. of 1st podding node	Plants/m row length: 2 weeks after sowing	Plants/m row length: at harvest	Plant height (cm)
15 Oct	3162	391	1	4	0	6	1
22 Oct	2885	358	9	4	0	6	6
29 Oct	2520	356	7	1	8	7	6
5 Nov	2132	351	7	6	0	6	0
12 Nov	1577	335	6	4	0	6	5
19 Nov	1466	352	6	4	8	6	6
SE ±	254	6.5	1.0	0.8	0.6	1.2	4.0

Conclusions

1. It is feasible to produce faba beans in the Rahad area due to low production costs, availability of fertile land, good organization of the Rahad Agricultural Scheme, and high prices available to farmers.
2. Sowing date is important in optimizing yield. The optimum sowing time for El Rahad is from 15 October to 12 November, which results in taller plants, more branches/plant, more pods/plant, heavier seeds, and thus higher yields than later sowing dates.
3. For high yields the disease powdery mildew and the insect leafminer must be controlled.

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Effect of Irrigation at Different Stages of Plant Growth on the Yield and Water Use by Faba Beans

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Abstract

Faba bean plants were subjected to different irrigation regimes, after a common post-sowing irrigation, at four sites in Egypt. In Sakha, in Northern Delta, faba beans could be grown successfully without supplemental irrigation while in Matana, in southern Egypt, at least three irrigations were required for optimum yields. In the combined analysis for the different locations, highest seed yield was obtained with three irrigations post-planting. Potential evapotranspiration, consumptive use of water, and crop coefficient values for different stages of crop growth were also calculated. The most important period for water demand was shown to be from flowering to pod filling.

Introduction

In Egypt's agricultural economy, the main problem is poor water management and lack of water resources. Therefore, knowledge of the critical stages for irrigation is very important.

This study examined the effect of different irrigation regimes on faba bean yield and water relations at four sites in Egypt.

Materials and Methods

Faba bean plants were grown under nine different irrigation regimes at Sids, Mallawi (Middle Egypt), Matana (Upper Egypt), and Sakha (Northern Delta). For each regime, plants were irrigated at planting and differed thereafter depending on whether or not plants were irrigated at preflowering, flowering and/or pod filling stages (Table 1).

Soil moisture was determined gravimetrically on an oven dry basis in soil samples taken in increments of 15 cm to a depth of 60 cm and meteorological data were recorded (Table 2). Consumptive use of water (ET_c) was calculated based on soil moisture change, amount of irrigation water applied, and rainfall received. No rainfall was received at any of the sites except at Sakha where a total of 54.6 mm of rainfall was recorded during the crop season. Potential evapotranspiration (ET_p) was calculated using the Penman Combination formula (Doorenbas and Pruitt 1977). Crop coefficient values were calculated using the formula:

$$K_c = ET_c/ET_p$$

where
K_c = crop coefficient
ET_c = crop evapotranspiration (mm/day)
ET_p = potential evapotranspiration (mm/day)

Results and Discussion

Seed yields

Irrigation at different stages of plant growth had a highly significant effect on seed yield at Sids, Mallawi, and Matana (Table 2). Differences in yield were insignificant at Sakha (Northern Delta) where the water table was shallow and rainfall occurred during the crop season. At Sakha, the highest yield was obtained from treatment I_1 which was not irrigated after irrigation at planting. At Sids, the highest yield was obtained from the I_2 treatment, followed by the I_7, I_9, and I_6 treatments, but there were no significant differences between the four treatments. These results indicate the importance of irrigation at preflowering plus one irrigation at

Table 1. Seed yield of faba beans (t/ha) under different irrigation regimes at various locations.

Treatments	Irrigations[1] Planting	Preflowering	Flowering	Pod filling	Locations Sakha	Sids	Mallawi	Matana	Mean[4]
I_1	+	0	0	0	2.875	1.390	0.780	1.542	1.647
I_2	+	Irrigated when plants wilt during the day[2]			2.389	3.389	1.559	2.128	2.366
I_3	+	+	0	0	2.666	1.380	1.571	1.861	1.870
I_4	+	0	+	0	2.713	1.894	2.053	2.242	2.226
I_5	+	0	0	+	2.409	1.357	1.428	2.132	1.832
I_6	+	+	+	0	1.923	3.037	2.285	2.351	2.399
I_7	+	+	0	+	2.470	3.341	1.904	2.437	2.538
I_8	+	0	+	+	2.185	2.323	2.392	2.613	2.378
I_9	+	+	+	+	1.666	3.332	2.600	2.918	2.629
Significance level[3]					ns	@@	@@	@@	@@
LSD 5%						0.758	0.528	0.308	0.308

1 + = one irrigation; 0 = no irrigation.

2 One irrigation at Sakha and two at the other locations.

3 ns = non significant, @@ = highly significant.

4 Combined analysis for the four locations.

Table 2. The mean temperature, relative humidity, wind velocity, cloud cover, and solar radiation for different locations.

Location (latitude)		Oct	1984 Nov	Dec	Jan	1985 Feb	March	April
	Temperature [1]	ND	18.40	14.60	14.80	14.80	17.50	19.20
Sakha	Relative humidity[2]	ND	74	78	73	73	74	65
	Wind[3]	ND	1.10	1.30	1.40	1.70	1.50	1.50
(31°07'N)	Cloud cover[4]	ND	2.70	3.00	3.10	2.90	2.50	1.50
	Solar radiation[5]	ND	9.30	8.00	8.50	10.50	13.00	15.10
	Temperature	ND	19.10	14.80	12.90	14.10	17.20	22.10
Sids	Relative humidity	ND	70	71	67	64	58	55
	Wind	ND	1.15	1.30	1.01	1.15	1.22	1.77
(29°05'N)	Cloud cover	ND	1.60	2.40	2.10	2.00	1.60	1.50
	Solar radiation	ND	9.70	8.60	9.10	10.90	13.30	15.30
	Temperature	ND	18.60	14.50	12.20	14.30	17.00	23.00
Mallawi	Relative humidity	ND	72	74	70	65	54	47
	Wind	ND	1.18	1.26	1.48	1.48	1.78	2.00
(27°42'N)	Cloud cover	ND	1.10	2.10	1.40	1.70	1.40	1.70
	Solar radiation	ND	9.80	8.80	9.30	11.30	13.40	15.30
	Temperature	27.80	20.00	16.00	15.00	15.30	22.00	26.40
Matana	Relative humidity	35	49	54	48	42	37	50
	Wind	1.31	1.44	1.22	1.22	1.35	1.65	1.53
(25°40'N)	Cloud cover	0.70	1.00	1.30	1.30	1.10	1.10	1.00
	Solar radiation	12.50	10.50	9.50	10.00	11.70	13.80	15.40

1 = °C; 2 = %; 3 = m/sec; 4 = Octs; 5 = inequivalent evaporation (mm/day)
ND = No data.

flowering or at pod filling. At Mallawi, where ET_p was higher than at Sids (Table 3), the highest yield was from treatment I_9, followed by the I_8 and I_6 treatments. At Matana, where the ET_p was the highest, treatment I_9 produced the highest yield, with significant differences over the other treatments. Clearly, as the ET_p increased the response to increased frequency of irrigation also increased.

In the combined analysis for the different locations (Table 1), the highest yield was scored from the I_9 treatment which was irrigated at preflowering, flowering, and pod filling. There was no significant difference between it and I_2, or those treatments receiving more than one irrigation post-planting (I_6, I_7, and I_8). Day and Legg (1983), while reviewing the water relations and irrigation response of faba bean, stated that there is little evidence that any stage of faba bean development is particularly sensitive to drought, and most experiments have shown a similar response to irrigation when water is short at any stage in the season.

Water relations

Potential evapotranspiration

ET_p values at Matana were higher than at the other locations (Table 3) which is mainly due to the difference in meteorological parameters which control evapotranspiration. Mean ET_p values indicate moderate evapotranspiration during the vegetative period, decreasing at flowering due to decreased air temperature and solar radiation at this time. Thereafter, daily ET_p increased till the end of the growing season along with air temperature and solar radiation.

In the combined analysis for the different locations, potential evapotranspiration values were 3.39, 2.88, 3.93, and 6.03 mm/day for preflowering, flowering, pod filling, and ripening, respectively.

Table 3. Daily evapotranspiration (mm) and crop coefficient at different stages of plant growth.

	Preflowering	Flowering	Pod filling	Ripening
		Sakha		
ET_p[1]	1.89	2.59	3.74	5.05
ET_c[2]	1.09	1.99	2.50	2.88
K_c[3]	0.58	0.77	0.69	0.57
		Sids		
ET_p	2.98	2.41	3.33	4.48
ET_c	2.09	2.14	3.12	2.80
K_c	0.70	0.89	0.94	0.63
		Mallawi		
ET_p	2.49	2.57	4.01	5.65
ET_c	1.78	2.15	3.83	3.91
K_c	0.71	0.84	0.96	0.69
		Matana		
ET_p	6.19	3.92	4.66	8.95
ET_c	3.00	2.42	2.50	3.25
K_c	0.49	0.62	0.54	0.36
		Means		
ET_p	3.39	2.88	3.93	6.03
ET_c	1.99	2.18	2.99	3.21
K_c	0.62	0.78	0.79	0.56

1 = Potential evapotranspiration, 2 = actual evapotranspiration, 3 = crop coefficient

Consumptive use of water

The lowest actual evapotranspiration (ET_c) values were recorded at Sakha, the highest figures were obtained at Matana and at Sids and Mallawi. This is mainly due to differences in the weather conditions which control the diffusion of water vapor from the evaporating surface to the air. Mean values of daily water use over all locations were 1.99, 2.18, 2.99, and 3.21 mm for preflowering, flowering, pod filling, and ripening stages, respectively. Values were low when plants were small and intercepted little of the net radiation, and then increased gradually as the plants grew (Table 3).

Crop coefficient

Crop coefficient (K_c) reflects the physiology of the crop, the degree of crop cover, and potential evapotranspiration. The crop coefficient values obtained in this experiment are presented in Table 3.

Mean values of crop coefficient (K_c) over all locations were 0.62, 0.78, 0.79, and 0.56 for preflowering, flowering, pod filling, and ripening stages, respectively. The lower value of K_c at preflowering may be due to the relatively large diffusive resistance of bare soil after planting and limited plant cover as the seedlings emerge and develop. The increase in K_c values throughout flowering and pod filling can be attributed to the decrease in diffusive resistance as the canopy completely shades the ground. Those two stages can be considered as the peak for water demand. At ripening, K_c values were much lower than at any period of growth, which can be attributed to the increase in diffusive resistance to transpiration as plants begin to mature. It can be concluded that the most important period of water demand in faba beans is from flowering to pod filling.

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Effect of Dilutions of Sea Water on Primary Growth of Faba Bean Seeds Planted on Washed Sea Sand

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Abstract

Seeds of faba bean line ILB 1814 were planted in washed sea sand and irrigated with six different concentrations of sea water. At concentrations of 500 ml sea water/l of distilled water, germination did not occur. At 250 ml/l, germination occurred but growth was weak. The best germination rate and growth were observed in the weakest dilution of sea water (50 ml/l).

Introduction

The concept of using sea water for irrigating desert sands is the result of frequent droughts and the salinization of large areas of cultivated land. Although sea water does not alter the structure of soils, it does damage crops.

To develop lines with high salt tolerance, the behavior of a given line must be tested against salinity in its primary growth stages. Thus the optimum limits of response can be identified in individual plants in a given line. This study continues earlier work on the imbibition of water by faba bean seeds (Kamel 1985) and focuses on the germination, and primary growth, of faba bean line ILB 1814.

Materials and Methods

Seeds of faba bean line ILB 1814 were planted in washed sea sand with an electrical conductivity of 174 mmho/cm at the rate of 10 seeds per tray, each tray containing 10 cork pots. Different concentrations of sea water were prepared using 50, 100, 250, 500, 750, and 1000 ml sea water/l of distilled water. The pots were irrigated at a rate of 5 ml/48 hr/pot with these solutions; the pH and electrical conductivity values of these are shown in Table 1.

Sand and air temperatures were measured during the 21 days of the experiment.

Germination rate (%) was recorded daily. The water content of the imbibed seeds and seedlings and the mean root and vegetative growth were also recorded.

The electrical conductivity and pH of each of the solutions were measured.

Results and Discussion

The seeds did not germinate in sea water concentrations of 500 ml/l or more (Table 1).

Table 1. Effect of different concentrations of sea water on the electrical conductivity and pH of irrigation water, and the progress of germination of faba bean seeds when watered with these solutions.

	Sea water concentration (ml/l)					
	50	**100**	**250**	**500**	**750**	**1000**
Electrical conductivity						
(mmhos/cm)	3.63	7.2	16.9	31.5	43.5	57.7
pH	6.27	6.46	6.90	7.70	8.0	8.1
Germination (%)						
1 DAS[1]	0	0	0	0	0	0
7 DAS	30	30	10	0	0	0
14 DAS	100	100	80	0	0	0
21 DAS	100	100	90	0	0	0

1 DAS = Days after sowing.

Germination rate increased gradually in the 250 ml/l concentration, reaching 100% 21 days after planting. In the 50 and 100 ml/l concentrations, germination was rapid and 100% germination occurred 14 days after planting. It is worth noting that germination did not occur all at one time in a given concentration i.e., individual plants of a line vary in their ability to germinate early, and also differ in vegetative and root growth rates.

Seed moisture content did not change throughout the experiment in those seeds watered with sea water concentrations of 500 ml/l or more (Table 2). For concentrations below 500 ml/l, seed moisture content increased with decreasing sea water concentration, parallel to germination rate and vegetative and root growth responses. Kamel (1985) found that imbibition of water by faba bean seeds in salty solutions exceeded 100% but did not exceed 73.12% in sand irrigated with different concentrations of sea water.

Mean root length was greater than mean plumule length and decreased with increasing sea water concentrations. The difference between these values also decreased with greater sea water concentration (Table 2). At concentrations of 500 ml/l or more, mean root and shoot growth were zero.

Therefore, concentrations of 500 ml/l or more prevented germination of faba bean seeds. At 250 ml/l, germination occurred but growth was weak. The best germination rate and growth were observed in the weakest sea water solution. These observations may be related to the balance of osmotic pressure between the seed and the medium.

Table 2. Effect of different sea water concentrations on seed moisture content (%) and mean vegetative and root growth (cm) 21 days after sowing.

	Sea water concentration (ml/l)					
	50	100	250	500	750	1000
Moisture content (%)	189.9	148.19	114.5	70.0	73.12	73.12
Mean root length (cm)	8.75	4.99	1.33	0	0	0
Mean stem length (cm)	6.10	3.47	0.80	0	0	0
Difference (stem-root)	2.65	1.52	0.53	0	0	0

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Effect of Potassium and Nitrogen on Germination and Primary Growth of Faba Beans Irrigated with Diluted Sea Water

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Abstract

Seeds of faba bean line ILB 1814 were grown in washed sea sand mixed with different quantities of potassium nitrate and ammonium nitrate. Plants were irrigated with diluted sea water (50 ml/l). Germination rate, shoot and root lengths, increase in seed weight, and change in seed size were recorded. Potassium nitrate at 0.4% increased germination and primary and secondary root growth, while high doses of potassium and ammonium nitrates (>2%) reduced germination and damaged roots.

Introduction

Sea water is a nutritious growth medium for many organisms but its high sodium content - almost 28 times as high as potassium - limits its use for irrigating crops.

Faba bean line ILB 1814 has been shown to germinate and grow well in sand culture irrigated with diluted sea water. To test the potential for improving the tolerance of this line to sea water it was grown in sand culture irrigated with diluted sea water. The ionic balance of the sand was altered with different concentrations of potassium and ammonium nitrates.

Materials and Methods

The experiment was conducted in the laboratory over a period of 5 weeks. Twenty-five gram quantities of washed sea sand were mixed with different amounts of potassium nitrate (100,250,1000, and 1500 mg) and ammonium nitrate (500 and 1500 mg). Controls had neither potassium nor ammonium nitrates. Each mixture was then put in a petri dish (103.87 cm^2) and a piece of sterilized cotton placed on top of the sand. Ten faba bean seeds were placed on the cotton in each dish, at a rate of one seed/10.4 cm^2. The seeds were covered with filter paper moistened with diluted sea water (50ml/l), which was removed when the seeds began to germinate.

During the experiment, the mean daily air temperature changed from 8°C to 13°C.

Germination rate was recorded daily in each treatment, and at the end of the experiment (5 weeks) shoot and root lengths were measured. The rate of increase in seed weight and of change in seed size after germination and primary growth were calculated.

Results and Discussion

For all plants and all treatments, the period of imbibition was long (Table 1). In some treatments, imbibition took 2 weeks due to the low air temperature (8°C), while in others imbibition continued without germination due to the high concentration of potassium or ammonium nitrate.

At the end of the second week, the air temperature was raised to 13°C and this resulted in germination.

Germination rates varied with different treatments. For example, the best germination occurred with 100 mg potassium nitrate. However, in the test with ammonium nitrate the best germination rates occurred with a higher concentration of ammonium nitrate (500 mg). Therefore, to improve germination a low potassium ion concentration and a high ammonium ion concentration is required to adjust sodium/potassium and sodium/nitrogen ratios in the diluted sea water used for irrigation.

Shoot and root length measurements are shown in Table 2. The difference between the mean shoot and root measurements was +4.47, +6.0, -0.35, and -3.55 cm for the control, 100 mg KNO_3, 500 mg KNO_3, and 500 mg NH_4NO_3 treatments, respectively. Ammonium nitrate was harmful to root growth and improved shoot growth, while potassium nitrate was harmful to root growth but did not improve shoot growth. The harmful effects of the fertilizers on root growth included burning, deformity, and emaciation of primary roots and few, thin secondary roots. The harmful effect on root growth was not observed in the control or the 100 mg KNO_3 treatment. In fact, the latter had a positive difference between mean shoot and root length. Therefore, a low concentration of potassium ions favors germination and early root growth.

Percent increase in seed weight at various stages of germination was calculated using the formula:

$$E = \frac{\text{weight after a certain stage - weight of dry seeds}}{\text{weight of dry seeds}} \times 100$$

The weight was recorded after imbibition, after imbibition and germination, or after imbibition, germination, and growth.

Weight increase in the control (168.6%) was greater than in all other treatments, and was greater in the ammonium nitrate treatment than the potassium nitrate treatment. Kamel (1985) found that maximum imbibition of faba bean seeds was 160% in distilled water and 136% in a buffering solution of NaCl.

In conclusion:

- Planting this line when the mean air temperature is 13°C shortens the period of imbibition, and germination and primary growth occur earlier.

Table 1. Change in germination (%) of faba bean seeds within five weeks of planting as affected by different treatments.

Time (week)	Treatments*			
	Control	Potassium nitrate 100 mg	Potassium nitrate 500 mg	Ammonium nitrate 500 mg
1	0	0	0	0
2	40	80	40	70
3	80	80	50	80
4	80	100	60	90
5	80	100	60	90

* See text for details.

Table 2. Change in root and shoot length (cm) with treatments in faba bean plants five weeks after planting.

Treatment		No. of individual plants 1	2	3	4	5	6	7	8	9	10	Mean (cm)
Control	root	22	22	22	13	11	5.5	4	0.2	0	0	9.97
	shoot	19	7	6	8	13	1.0	1	0	0	0	5.50
Potassium nitrate 100 mg	root	16	14	13	13	12	4.5	4	2.5	2.5	0.5	8.20
	shoot	4	3	10	2	3	0	0	0	0	0	2.20
Potassium nitrate 500 mg	root	2	2	1	1	0.5	0	0	0	0	0	0.65
	shoot	3	1.5	3	0.5	1.0	1	0	0	0	0	1.00
Ammonium nitrate 500 mg	root	1	2	2	1.5	1	1	1	0.5	0.5	0	1.05
	shoot	29	5	3	3.5	2	11	0.5	1.5	0.5	0	4.60

- Adding 0.4% potassium nitrate increases the efficiency of germination and primary and secondary root growth in plants grown in sand and irrigated with diluted sea water.
- High doses of potassium or ammonium nitrates (>2%) reduce germination and damage roots.

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Pests and Diseases

Control of Damage by Sitona lineatus in Autumn-Sown Faba Beans

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Abstract

Different insecticides were applied in spring to autumn-sown faba beans to control the bean weevil *Sitona lineatus*. The trials were conducted during the period 1982-85. Treatments included sprays and granules at different doses. Of the granules, carbosulfan was least effective. Carbofuran and phorate decreased numbers of larvae while pyrethroid sprays, especially as divided applications, decreased adult feeding damage. The best granule treatment was carbofuran and the best spray was permethrin.

Introduction

Incorporating insecticide granules in seed furrows at sowing is an effective method of protecting spring-sown beans from attack by the pea and bean weevil, *Sitona lineatus* (Bardner *et al.* 1979; 1983). For autumn-sown beans, however, insecticides applied at sowing do not persist long enough to protect the crop from invasion by *S. lineatus* the following spring. This paper describes experiments with spring applications of insecticide to the autumn-sown crop as a means of defence against *S. lineatus*.

Materials and Methods

The experiments were conducted between 1982 and 1985 at Rothamsted farm, on a clay-with-flints soil overlying chalk. Faba beans were sown in rows 53 cm apart at approximately 200-250kg seed/ha. Plot size was 10 rows x 14m long. The cultivars were Throws MS (1982/83) and Banner (1984/85).

Insecticides were supplied by the manufacturers; phorate granules as Campbell's Phorate, carbosulfan granules as Marshal (FMC), carbofuran granules as Yaltox (Bayer), permethrin e.c. as Ambush (ICI) or Permit (Pan Britannica Industries), triazophos as Hostathion (Hoechst), and cyfluthrin as an experimental e.c. formulation (Bayer). Granules were applied manually to plant rows by shaking weighed quantities from containers with perforated tops. Sprays were applied using a hand-held boom with hydraulic nozzles delivering 200 l spray/ha. Feeding activity of adult weevils was estimated by counting the notches on the last pair of fully-expanded leaves of 10 plants/plot. Soil cores (5cm diameter, 15cm deep, centered on the row) were taken in July-August, larvae and pupae being extracted by the method of Bardner and Fletcher (1979). The center six rows of each plot were harvested to measure yields.

Results

In the 1982 trial, carbosulfan applied to the seedbed in autumn was less effective in controlling adults and larvae than the same dose applied to the foliage in spring (Table 1). Carbofuran was the most effective granular treatment, decreasing adult feeding and giving the lowest number of larvae in the soil cores. Phorate was not as active as carbofuran although it decreased larval numbers significantly. Permethrin spray almost completely prevented adult feeding. The heaviest yields were obtained with the carbofuran granules and the permethrin spray.

In 1983, the insecticide treatments were all applied in spring. All treatments decreased adult feeding and larval numbers significantly and increased yields (Table 2). As in 1982, the treatment that gave the greatest reduction in larval numbers was carbofuran granules, while permethrin applied as a spray decreased feeding by adults most effectively. The notch count was made before the second of the divided permethrin sprays had been applied and so it underestimates the effect of this treatment on adult feeding. The divided spray gave fewer larvae/core than the single spray, and the best yield of any treatment.

In 1984 (Table 3), there were few larvae/core even in untreated plots and no significant yield

Table 1. Control of *Sitona lineatus* on autumn-sown faba beans, 1982.

Treatment	Granules (G) or spray (S)	Rate (kg a.i./ ha)	Feeding notches/ leaf	Larvae/ core	Yield t/ha (85% DM)
Carbosulfan to seedbed in autumn	G	2.2	9.0	11.2	3.30
Carbosulfan to foliage in spring (2/4/82)	G	2.2	4.3	2.3	3.47
Carbofuran to foliage in spring (2/4/82)	G	2.2	1.0	0.2	3.58
Phorate to foliage	G	2.2	10.1	9.8	3.22
in spring (2/4/82)	"	1.1	10.9	12.1	3.53
Permethrin (5/5/82)	S	0.15	0.3	11.5	3.56
Control (untreated)			10.0	28.0	3.28
SED (18 degrees of freedom)			1.64	3.87	0.154

Table 2. Control of *Sitona lineatus* on autumn-sown faba beans, 1983.

Treatment	Granules (G) or spray (S)	Rate (kg a.i./ ha)	Feeding notches/ leaf	Larvae/ core	Yield t/ha (85% DM)
Carbosulfan to foliage in spring (14/4/83)	G	2.2	1.5	7.3	3.44
Carbofuran to foliage in spring (14/4/83)	G	2.2	0.3	0.5	3.67
Phorate to foliage	G	2.2	2.1.	4.8	3.70
in spring (14/4/83)	"	1.7	2.2	6.3	3.69
Permethrin once (4/5/83)	S	0.15	0.2	12.0	3.72
Permethrin twice (4/5 and 25/5/83)	S	2(0.075)	0.4	4.5	3.82
Control (untreated)			6.2	26.8	3.23
SED (18 degrees of freedom)			0.52	4.70	0.142

increases with any treatment, although the two high doses of carbofuran eradicated larvae. The greatest yield was obtained by two sprays of permethrin, which also gave least feeding notches, even though only the first spray had been applied at the time of the notch count.

In 1985 (Table 4), the divided pyrethroid sprays were again very effective in decreasing notch counts. Resources were inadequate to do soil cores. Yields were increased, though not significantly, by all granule treatments and by the divided spray of permethrin.

Table 3. Control of *Sitona lineatus* on autumn-sown faba beans, 1984.

Treatment	Granules (G) or spray (S)	Rate (kg a.i./ ha)	Feeding notches/ leaf	Larvae/ core	Yield t/ha (85% DM)
Carbofuran to	G	1.7	8.6	0.0	5.07
foliage	"	0.85	8.0	0.0	4.81
in spring	"	0.425	9.9	1.3	4.69
Phorate to foliage in spring (13/4/84)	G	1.7	5.9	0.3	4.82
Triazophos once (30/4/84)	S	0.353	1.9	2.8	4.67
Cyfluthrin twice (30/4/84 and 23/5/84)	S	2(0.025)	2.3	0.5	4.63
Permethrin twice (30/4/84 and 23/5/84)	S	2(0.025)	0.8	2.0	5.17
Control (untreated)			9.9	1.9	4.88
SED (21 degrees of freedom)			2.39	1.21	0.197

Table 4. Control of *Sitona lineatus* on autumn-sown faba beans, 1985.

Treatment	Granules (G) or spray (S)	Rate (kg a.i./ ha)	Feeding notches/leaf		Yield t/ha
			16/5	3/6	(85% DM)
Carbofuran to	G	0.850	7.5		4.82
foliage in spring (19/4/85)	"	0.425	8.1		4.61
Phorate to foliage	G	1.7	3.3		4.58
in spring (19/4/85)	"	0.850	6.6		4.73
Cyfluthrin twice (10/5/85 + 22/5/85)	S	2(0.025)		0.1	4.40
Permethrin once (10/5/85)	S	0.05		3.6	4.45
Permethrin twice (10/5/85 + 22/5/85)	S	2(0.025)		0.9	4.74
Control (untreated)			9.7	5.9	4.45
SED			1.29 (12df)	0.38 (9df)	0.192 (21df)

Discussion

The trials in 1982-85 concentrated on spring applications of pesticide to autumn-sown crops. The only autumn application was of carbosulfan in 1982, which resulted in poor insect control and had no effect on yield.

Spring treatments included both granules and sprays, gradually decreasing doses being tested over the 4-year period. Of the granules, carbosulfan was the least effective and was discontinued in 1984. Carbofuran and phorate decreased larval numbers in soil cores and the pyrethroid sprays decreased feeding damage by adults, the divided applications being extremely effective.

There was not always a good correlation between feeding notches, larval counts, and yields. Yield is probably the best criterion of effectiveness, as it is based on a large sample of the plot. Compared with the controls, the best granule treatment, carbofuran, gave yield increases of 9, 14, 4, and 8% in the 4 years of the trials. Permethrin sprays gave increases of 8.5, 15, 6, and 6.5%.

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Orobanche in Faba Bean Fields in Ethiopia

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Abstract

***Orobanche* is not commonly found in faba bean fields in Ethiopia. However, in a recent survey in the central and south-eastern highlands of Ethiopia, two flowering stalks of *Orobanche* were found in one field (0.1 ha). The morphological features of the *Orobanche* stalks matched those described for *Orobanche minor*. More areas should be surveyed to assess the magnitude of infestation and develop plans to eradicate the parasite if necessary.**

In the Nile Valley of Egypt, faba bean fields are often infested with *Orobanche* spp. In Middle and Upper Egypt, the level of infestation is so high that there have been crop failures. In the Nile Valley of Sudan, however, the parasite has rarely been found and there are no reports of *Orobanche* in faba beans in Ethiopia.

In a field visit (8-9 October 1985) to the central and south-eastern highlands, several faba bean fields were examined for general crop growth and disease and pest infestation. The levels of chocolate spot (*Botrytis fabae*), rust (*Uromyces fabae*), and ascochyta blight (*Ascochyta fabae*) were variable, and were not high in any of the infested fields surveyed. However, there were two stalks of *Orobanche* sp. in a 0.1 ha field in Wangi Gora village near Assilla town in the Chilalo sub-province. The farmer did not know the weed and he had not noticed it in the field. The crop was at the pod filling stage and showed good vigor (Fig. 1). The farmer bought the faba bean seed from the local market and, unlike the common landraces which are of *minor* type, this population was of *equina* type. The *Orobanche* shoots were flowering and about 30 cm long (Fig. 1). They were purplish at the base and morphologically matched the description for *Orobanche minor* (J. Sauerborn, personal communication).

Fig. 1. *Orobanche* shoot uprooted from the field in Wongi Gora village being examined by an Ethiopian and a Sudanese scientist.

Although a systematic survey was not done, several other fields were examined by the roadside over a stretch of 150 km from Wongi Gora village and none of the fields had any *Orobanche*. The presence of two stalks of *Orobanche* in an isolated field suggests that the parasite might have been only recently introduced, possibly through faba bean seed. A systematic survey of the production area should be done to assess the magnitude of infestation and to plan for its eradication if necessary.

Pathological Studies on Root Rot Disease of Faba Bean (Vicia faba L.)

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Abstract

On the basis of differences in pathogenesis of a number of fungi, *Rhizoctonia solani* was the most virulent in causing root rot disease of faba bean. Other associated fungi were less pathogenic or had a negligible effect. Susceptibility of faba beans to *R. solani* increased with increasing inoculum level and decreased with increasing plant age. The fungus showed a degree of pathogenicity to some legume crops, while its saprophytic ability was low in soil previously cultivated with maize and soybean.

Introduction

In several countries, root diseases of *Vicia faba* L. limit yields (Yu and Fang 1984; Ibrahim and Hussein 1974). The severity of these diseases depends on several factors such as soil moisture status, nutrient supply, soil physical conditions, other diseases and pests, and competition from weeds. Several soil-borne fungi (*Rhizoctonia solani, Fusarium solani, F. oxysporum,* and *Pythium* sp.) have been reported to cause root rot (Salt 1983). *R. solani,* and to some extent the other fungi mentioned above, occur naturally and can infect other leguminous crops (Salt 1983).

The objective of this work was to identify the fungi associated with root rot and evaluate their pathogenicity and the factors affecting disease development.

Materials and Methods

Diseased roots from faba bean seedlings and mature plants were collected from five locations in lower and central Egypt (Nubaria, Kafr El-Shaik, Kalubia, Giza, and Sids). Roots were cut into small pieces, washed thoroughly with water, surface sterilized with sodium hypochlorite (3%) for 3 min., then rinsed in sterile distilled water and dried between two layers of filter paper. Samples were placed on potato dextrose agar (PDA) in petri dishes and incubated at 20 $\pm$ 2°C for 3 days. Pure colonies were obtained from growing hyphal tips and single spores, and cultures were identified by Dr R.A. Sampson (Centro-albureau Voor Schimmelcultures, Baarn, The Netherlands). The glasshouse experiments were carried out at Giza Research Station. Unless otherwise stated, clay soil, previously sterilized with formalin solution (5%) and left for 2 weeks, was mixed with the isolated fungi (grown on barley medium for 10 days) at 5% of the soil weight. The soil was then saturated with tap water to evenly distribute the fungi and enhance fungal growth. The control treatment was soil mixed with the same amount of autoclaved, fungus-free barley medium. Two weeks later, four healthy seeds of faba bean cultivar Giza 2 were sown per pot (20 cm diameter) in five replicates. Four weeks after sowing, all plants were carefully removed from the soil and washed gently and thoroughly with water. Severity of root rot was estimated according to the disease index of Salt (1981).

The length and dry weight of roots and/or shoots were also recorded.

Influence of inoculum potential on disease severity

The experiment was designed to determine the effect of different levels of *R. solani* inoculum on root rot severity. Sterilized soil was infested with the fungus at 0, 2.5, 5, 7.5, 10, and 15% of soil weight. Seeds were sown 1 week later and severity of infection was recorded 4 weeks after planting.

Effect of plant age on susceptibility to R. solani

Five sets of plants, each with 20 replicates, were sown at 7-day intervals. When plants were 0, 7, 14, 21, and 28 days old, *R. solani* at the standard dose (5%) was mixed with the soil in the pots, which were then watered. Four weeks after addition of the inoculum, all plants were pulled out and the severity of root infection was recorded.

Pathogenicity of R. solani to some legume crops

The susceptibility of seven hosts (lentil cv Giza 9, Egyptian clover cv Giza 1, lupin cv Giza 2, chickpea cv NEC 2022, fenugreek cv Giza 30, soybean cv Clark, and peanut cv Giza 4) to *R. solani* was tested. Plants were sown in soil previously infested with *R. solani*, as described above, and host reactions to the fungus were evaluated 4 weeks after planting.

Tolerance of R. solani to antibiotics

The degree of tolerance of *R. solani* to compounds produced by soil microorganisms was examined using Wastie's technique (Wastie 1961). PDA plates were inoculated in the center with approximately 5 mg of unsterile soil previously cultivated with maize and/or soybean. The soil particles were then covered with sterile cellophane paper (2 x 2 cm) and discs of *R. solani* (5 mm diameter) were placed on the cellophane above the soil inoculum. As a control, discs of *R. solani* were placed on soil-free cellophane paper. The fungal discs were applied when the soil inoculum was placed and/or 24 hr later. Incubation was at room temperature and there were four replicates for each treatment. Results were expressed as the reduction in diameter of colonies grown on cellophane paper in plates inoculated with unsterilized soil compared with the control.

Results

Eleven fungi were isolated with different isolation frequencies from diseased faba bean roots (Table 1). *R. solani* followed by *F. solani* were the most frequently isolated fungi, while *Gliocladium roseum* was least frequently isolated. Fungal distribution and type differed according to location. The highest number of fungi was isolated from Giza governorate, followed by Kafr El-Sheikh. *Macrophomina phaseoli* was found only in Nubaria.

Pathogenicity test

In artificial inoculation experiments, *R. solani* was the most virulent of the fungi tested (Table 2). It caused root discoloration and dark brown cankers in the area between the stem base and the main root. Roots were slightly affected but not seriously when plants were inoculated with *F. solani*, *F. heterosporum*, and *Pythium* spp. The remaining fungi tested were nonpathogenic. Vegetative growth was also affected in the presence of fungi. There was a positive correlation between the degree of pathogenicity and growth. However, some nonpathogenic fungi, such as *Talaromyces trachyspermus* and *Ulocladium chartarum*, partially enhanced plant growth compared to the control.

Effect of inoculum level

The severity of disease caused by *R. solani* was enhanced with increasing levels of inoculum at a given time (Fig. 1). Maximum disease severity was obtained when the inoculum dose was three times as much as the standard dose (5%). However, fungal concentrations of 5 and 7.5% caused almost equal damage to plant roots.

Relation between plant age and disease severity

In the early stages of plant growth, the susceptibility of root tissues to root rot fungus was high (Fig. 2). The severity of infection decreased when the plants were infected at 7 days old. When *R. solani* was inoculated onto plant roots which were 2 weeks old or more, infection was negligible.

Host range

The susceptibility of seven legume crops to faba bean root rot fungus was different for each crop. Hosts such as lupin, Egyptian clover, and peanut were least susceptible (disease index 1.1, 1.1, and 1.0,

Table 1. Percentage of fungi isolated from root rot infested faba beans at different locations.

Fungi	Locations				
	Giza	Kafr-El Sheikh	Nubaria	Kalubia	Sids
Rhizoctonia solani	50.3	23.0	4.9	7.1	18.0
Fusarium solani	22.0	6.0	6.2	7.5	2.1
F. proliferatum	2.7	18.8	2.4	8.0	1.3
F. verticillioiles	3.4		1.9	2.6	3.0
F. heterosporum	2.0	2.6		2.0	2.9
Talaromyces trachyspermus		1.3		2.7	
Macrophomina phaseoli			2.0		
Gliocladium roseum	0.9		1.1		
Penicillium verrucusom	4.0	3.8			5.1
Pythium spp.		1.5	4.0		
Ulocladium chartarum	3.2			7.0	

Table 2. Effect of the tested fungi on root rot severity and faba bean growth.

Treatments	Root rot disease index[1]	Shoot length (cm)	Root length (cm)	Shoot dry weight/ plant (g)	Root dry weight/ plant (g)
Control	0	73.8	36.8	3.8	2.9
Rhizoctonia solani	4	56.3	21.1	1.5	0.9
Fusarium solani	2.4	69.3	29.2	2.7	1.8
F. proliferatum	1.1	68.0	33.4	3.6	3.0
F. verticillioiles	1	65.0	33.0	2.7	1.2
F. heterosporum	2.2	58.7	26.1	2.1	1.0
Talaromyces trachyspermus	0	82.8	39.9	4.3	3.2
Gliocladium roseum	0.9	62.5	25.4	2.7	1.8
Penicillium verrucusom	0	65.3	28.9	3.8	2.7
Pythium spp.	1.2	60.8	32.0	2.5	2.0
Ulocladium chartarum	0	79.0	38.6	4.7	3.3
LSD (5%)	0.1	ns	ns	0.3	0.2

ns = not significant.

[1] Root rot disease index: 0, healthy; 5, severe infestation, plants moribund or dead.

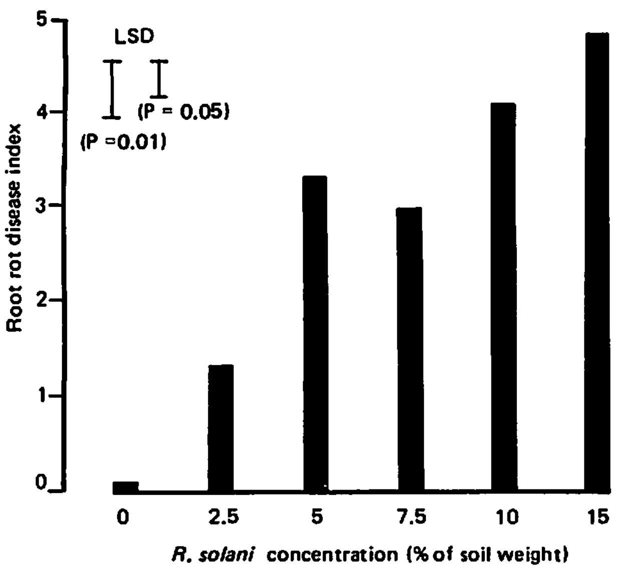

Fig. 1. Effect of *R. solani* inoculum level on root-rot disease severity.

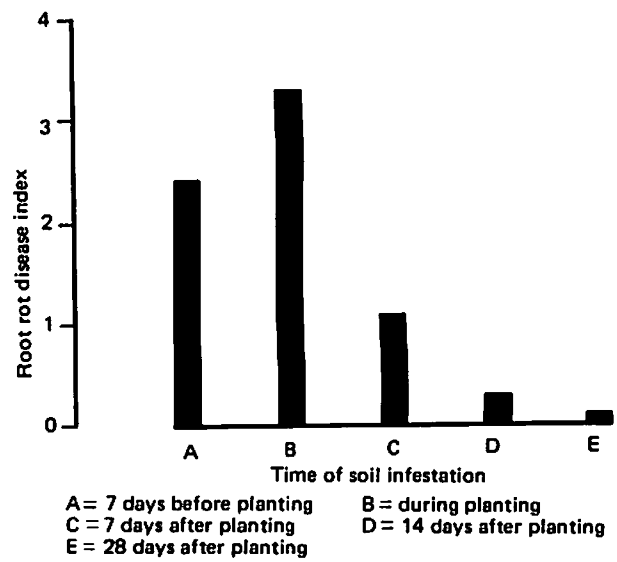

Fig. 2. Root rot disease severity in relation to the plant age at which soil was infested.

respectively) followed by soybean (2.0), while fenugreek, lentil, and chickpea were most susceptible (disease index 3.3, 3.2, and 2.9, respectively).

Tolerance to antibiotics

Compared with the control, there was a considerable reduction in *R. solani* growth in plates containing soil (Table 3). The antagonism between the tested fungus and the soil microorganisms was greater when the soil inoculum was incubated for 24 hrs before placing the fungus. Growth reduction was greater in maize soil than in soybean soil.

Discussion

Root rot in faba bean can rarely be ascribed to a single distinctive pathogen. It is usually a complex pathological condition which frequently involves more than one pathogen and is affected by adverse environmental factors (Salt 1983). In our work, *R. solani* was the principle organism of root rot and had a high pathological ability to cause the disease in faba beans, while *F. solani* ranked second. A number of associated soil-borne fungi were isolated and five of these fungi (*Fusarium verticillioilės, F. proliferatum, F. heterosporum, Talaromyces*

Table 3. Percentage growth reduction of *R. solani* due to antibiotics produced by soil microorganisms.

Soil type tested	*R. solani* discs placed immediately	*R. solani* discs placed 24 hrs after soil inoculum
Soybean	4.1	6.5
Maize	6.0	14.2
Control (no soil)	0.0	0.0

trachyspermus, and *Ulocladium chartarum*) had not previously been recorded in faba beans in Egypt. Interestingly, some of the associated nonpathogenic fungi partially enhanced plant growth. The reason for this is unknown, but it might be due to growth regulator-like substances, produced by these fungi, acting through the host's roots. Carmi and Heuer (1981) stated that, in bean plants, roots are the main source of growth regulators thought to affect basic physiological processes, mainly plant growth.

It is well established that successful infection requires a sufficient inoculum of the pathogen. Using insufficient inoculum, infection might not take place. However, applying a heavy inoculum may break down host resistance and more damage may occur. Our studies indicate that the optimum inoculum concentration for *R. solani* to induce infection was 5% of soil weight. Faba bean roots were greatly affected when the concentration was increased to 10 and/or 15%. Similarly, French (1965) and Omar (1977) found that disease severity increased linearly with inoculum potential. However, host genotypes, pathogen aggressiveness, soil type, and soil environment must be considered in studying soil-borne pathogens. The age of faba bean plants at inoculation influenced infection and our data show that plants were infected early only when the fungus was present in the soil at sowing and 1 week before or after sowing. Susceptibility of plants to infection in the early stages and not in the adult stage may be related to metabolic changes in the host tissues with age. Fulton and Hanson (1960) reported that *Fusarium* spp. and *Rhizoctonia* sp. were more pathogenic to seedlings than to older red clover plants. The pathogenicity of faba bean root rot fungus to some legume crops differed, suggesting that, within the same plant family, host roots may secrete certain substances affecting disease development.

Inhibition of *R. solani* growth due to soil microorganisms is of great interest. Results confirm that *R. solani* is weakly saprophytic in maize and soybean soils. The saprophytic microflora in soil associated with decomposition of soil amendments was assumed to play an important role in controlling *R. solani*; a crop rotation system including maize could partly reduce disease incidence in faba bean roots.

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Muscle and Liver Cellular Growth as Affected by the Stage of Development and Faba Bean Intake in Rats

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Abstract

Young and adult male wistar rats were fed *ad libitum* on diets containing casein or faba beans as protein source. After 10 days liver and gastrocnemius muscles were removed and analyzed for protein, DNA, and RNA contents. There was a significant weight difference between animals fed the different protein sources, while differences in liver protein between treatments were not significant. There were marked decreases in DNA contents of both tissues. Legume-fed rats had higher liver RNA: protein ratios, which were significantly different in older rats. The impairment of growth observed in rats fed the legume diet was attributed to reduced muscle protein synthesis.

Introduction

Legumes are widely used as sources of protein in human and animal nutrition (Hebblethwaite 1984). However, the ingestion of these seeds in raw form can produce serious physiological alterations, usually accompanied by impairment of growth (Larralde 1982).

Normal growth involves an increase in protein mass, achieved by various changes in the rate of protein synthesis and breakdown (Waterlow *et al.* 1978). These two processes are very sensitive to dietary conditions, stage of development, and hormonal status, (Buttery 1983). Furthermore, the changes in protein turnover accompanying growth are not the same in all tissues (Reeds and James 1983). The effects of dietary intake and age on protein turnover were estimated by Omstedt and van der Decken (1972) by measuring the nucleic acid content of liver and muscle. They showed the influence of diets containing proteins of different biological value (BV), viz. faba bean vs casein, on hyperplasia (DNA), hypertrophy (protein:DNA), protein synthesis capacity (RNA:protein), and protein content in liver and muscle at two stages of development.

Materials and Methods

Animals and Diets

Male wistar rats, weighing initially about 80 g (young group) and 180 g (adult group), were randomly assigned to dietary groups (n=6). The animals were housed in metabolic cages in a temperature-regulated room at 22 ± 1°C. Over a period of 10 days, rats were fed *ad libitum* on diets containing casein (BV=80) or the legume *Vicia faba* (BV=63). The composition of each diet was previously described by Martinez and Larralde (1983). After killing, liver and gastrocnemius muscles of test animals were removed and stored at -20°C before analysis.

Analytical Assays

Muscle and liver protein contents were determined according to the method of Lowry *et al.* (1951), and the analyses of DNA and RNA by the technique of Munro and Fleck (1966).

Statistical Procedure

The Duncan's multiple range test was used to statistically evaluate the results.

Results and Discussion

A significant weight difference ($p < 0.05$) occurred when young and adult rats were fed different protein sources. The muscle gastrocnemius - choosen because it seems to be a good indicator of the average response of the musculature (Munro 1978) - increased its contribution to body weight and its protein concentration during development in both dietary groups.

In contrast, liver mass, as a percentage of body weight, fell slightly during development. No significant changes in liver protein were found between dietary treatments.

The growth of tissues and organs in terms of increases in total DNA (hyperplasia) and in protein: DNA ratio (hypertrophy) is well documented (Leblond 1972). Since the DNA content of the diploid nucleus is constant, chemical determination of DNA concentration provides a measure of the number of nuclei and hence the number of cells in a tissue. Cell size can then be estimated as either whole weight per unit DNA or protein weight per unit DNA. This approach, when applied to growth and nutrition, yields average values for any particular tissue and where there is considerable polyploidy, as in the liver, cell number will be overestimated. Nevertheless, several clear patterns of post-natal growth become apparent (Leblond 1972).

Marked decreases in mg DNA/g tissue ($p < 0.05$), on a relative basis, were found for both tissues during development which were accompanied by increases in the protein: DNA ratio. The rise in liver ·ll number appeared to be more important than the ncrease in cell size which was previously reported (Waterlow *et al.* 1978). As pointed out by other authors (von der Decken and Omstedt 1972; Smith *et al.* 1982), indications of cellularity, supplied by DNA content and DNA: protein ratio, are not markedly influenced by the different biological value of the dietary protein.

The measurement of total RNA is probably the most reliable indirect indicator of total ribosome content. From the evidence available, it seems reasonable to assume that in most tissues, ribosomal RNA accounts for at least 80% of total RNA and it may be more than 90% (Young 1970). Since the amount of synthesis each nucleus controls is a function of the

Table 1. Mean body weight changes, muscle and liver weight, protein, and DNA and RNA contents in six rats fed two different sources of protein sources at two stages of development.

	Young Rats							
	Control				*V. faba*			
Initial body weight (g)	78.4	(2.5)			77.2	(3.7)		
Final body weight (g)	119.1	(9.2)			99.5	(4.6)		
	Muscle		Liver		Muscle		Liver	
Weight (g)	1.10	(0.07)	4.50	(0.13)	0.84	(0.03)	4.20	(0.26)
Protein (mg/g tissue)	190.4	(7.0)	178.8	(6.1)	175.4	(7.1)	161.2	(8.7)
DNA (mg/g tissue)	1.22	(0.06)	5.21	(0.41)	1.32	(0.05)	4.86	(0.13)
Protein:DNA (mg/mg)	152.9	(6.3)	34.6	(3.5)	131.9	(9.8)	33.1	(4.8)
RNA:protein (mg/g)	8.96	(0.58)	57.7	(3.55)	8.26	(0.38)	62.3	(1.34)

	Adult Rats							
	Control				*V. faba*			
Initial body weight (g)	178.2	(10.2)			177.8	(6.6)		
Final body weight (g)	242.2	(12.0)			208.6	(10.1)		
	Muscle		Liver		Muscle		Liver	
Weight (g)	2.60	(0.15)	8.73	(0.87)	2.14	(0.07)	8.52	(0.43)
Protein (mg/g tissue)	203.8	(12.7)	168.4	(9.0)	188.6	(5.2)	154.2	(4.6)
DNA (mg/g tissue)	1.07	(0.05)	4.10	(0.24)	1.11	(0.09)	3.68	(0.22)
Protein:DNA (mg/mg)	187.2	(6.8)	40.8	(5.1)	171.2	(7.6)	41.9	(3.7)
RNA:protein (mg/g)	7.66	(0.21)	35.1	(3.41)	7.62	(0.50)	45.04	(2.20)

•Figures in parentheses are ± SE values. The statistical significance is given in the text.

amount of its associated RNA, the conclusion that the RNA content of a tissue, or the RNA:protein ratio, is a good indicator of the rate of protein synthesis in it, seems obvious (von der Decken and Omstedt 1972). Therefore, it follows that in both tissues growth is accompanied by a fall in the fractional synthetic rate, merely confirming previous reports (Waterlow *et al.* 1978).

Early isotopic studies suggested that the fractional rate of liver protein synthesis increased in malnourished rats (Young 1970). In our study, the legume-fed animals showed higher values for RNA: protein ratios in liver, which were significantly ($P < 0.05$) different in the older rats. The capacity for muscle protein synthesis, indicated by the RNA: protein ratio, remained unaltered in both dietary groups. However, marked differences arose in absolute values as a consequence of the increased gastrocnemius weight ($P < 0.05$) in the control-fed rats. Therefore, changes in RNA activity or the extent to which the capacity is utilized should be involved (Waterlow *et al.* 1978). It is suggested that the impairment in growth observed in rats fed the legume diet could be attributed to reduced muscle protein synthesis, presumably accompanied by a small effect on amino acid supply to the liver. This would be responsible for the differences found in liver protein synthesis. Such a hypothesis agrees with previously reported evidence (Martinez and Larralde 1983; Goena *et al.* 1984) and allows a better understanding of the mechanism involved in the utilization of this legume as a source of protein.

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Comparative Performance of Faba Bean and Conventional Food Legumes in the Haryana State of India

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Abstract

The yields of seven faba bean genotypes were compared with those of commercial varieties of chickpea, field pea, and lentil. All the faba bean genotypes matured earlier and had higher yields than the other legumes. Faba beans could, therefore, prove an economic alternative to the traditionally-grown legumes and become an important part of the daily diet.

Introduction

Chickpea, field pea, and lentil are the conventional winter food legumes of India. These are generally grown under dryland conditions so their area and production are decreasing with increasing irrigation. Therefore, with a view to introducing non-conventional food legumes, a number of faba bean genotypes were evaluated for seed yield. Promising genotypes were tested in the field in replicated yield trials along with one popular commercial variety of each traditional food legume. The comparative performance of these four food legumes is reported.

Materials and Methods

Seven faba bean genotypes and one popular commercial variety each of chickpea, field pea, and lentil were grown for two seasons in a randomized block design with three replications. The inter-and intra-row spacings were 30 and 10 cm, respectively. Normal cultural practices were followed and weather conditions during both cropping seasons were normal.

Results

The yield data are shown in Table 1. Varieties of faba bean matured almost at the same time, with about 160 days between sowing and maturity, while the other food legumes took about 10 days longer. Faba bean seed yields ranged from 2754 kg/ha for LM-1 to 3741 kg/ha for VH-131. The recently developed variety of field pea, HFP-4, yielded least (2089 kg/ha) of the legumes tested. Although the faba bean varieties yielded significantly higher than the traditional winter food legumes, this newly introduced crop will take time to become popular due to consumers' tastes. Preliminary investigations on faba bean acceptability suggest that they could become part of the daily diet and some of the crop could be used as animal feed.

Further investigations on faba bean agronomy and utilization are being done.

Table 1. Mean yield (kg/ha) of faba beans and conventional food legumes in Haryana 1983-85.

Varieties	1983/84	1984/85	Mean	Days to maturity
VH-131	3698	3784	3741	159
VH-130	3218	3798	3508	158
VH-134	3246	3298	3272	164
VH82-1	3090	3044	3068	159
VH-132	2898	2998	2948	162
VH-133	2535	3275	2905	162
LM-1	2465	3044	2754	159
Chickpea (Gaurav)	2274	2558	2416	171
Lentil (L9-12)	2031	2372	2201	174
Field pea (HFP-4)	1979	2199	2089	169
C.D. (P = 5%)	139	240		

ANNOUNCEMENTS

The Fourth Symposium on Parasitic Weeds.
The International Parasitic Seed Plant Research Group (IPSPRG) is holding its next meeting in the summer of 1987 at Philips University, Marburg, Germany. The date of the meeting will be announced later.

International Meeting

Food Safety and Health Protection.
This meeting, organized by the Consiglio Nazionale delle Ricerche (CNR), will be held in Rome, 27-29 October 1986. Topics covered by the meeting will include: natural toxicants in foods, problems in food processing, xenobiotics in foods, experimental models in food toxicology, and the problem of population groups "at risk". There will be a series of invited lectures, short communications, and discussions.

Further information from:

Ms. G. Silvetti
c/o Istitutq Nazionale della Nutrizione
Via Ardeatina, 546
00179 - Rome
Italy

Discussion Meeting on A Century of Nitrogen Fixation Research: Present Status and Future Prospects.
This meeting will be held at the Royal Society, London, 22-23 October 1986. Further information may be obtained from:

Miss C.A. Johnson
Discussion Meetings Organizer
The Royal Society,
6 Carlton House Terrace,
London SWIY 9 AG,
England

The Bulletin des Varietes, Plantes Four ageres Annuelles (Bulletin of Varieties, Annual Forage Plants) 1984 is produced by the Institut National de la Recherche Agronomique. It contains lists of the characteristics of faba bean varieties registered in the bulletin. Information about the bulletin may be obtained from:

Institut National de la Recherche Agronomique
G.E.V.E.S. - La Miniere,
F - 78280 Guyancourt
France

Fourth *Vicia Faba* International Cytogenetics Review Meeting.
This meeting will be held 5-11 April 1987 at the Agricultural Research Institute, Nicosia, Cyprus. Offers of papers, posters and request for further details should be sent to:

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

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

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

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ICARDA has been designated as the world center for information on faba beans, and as such we are trying to assemble a complete collection of papers relevant to this subject.

We would be most grateful if readers who have published papers relating to faba beans would send reprints to:

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We request that those who currently receive FABIS should inform us of any change in their address or position in good time to allow us to maintain an efficient service.

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

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

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

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

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

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

Submission of articles
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