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Faba Bean Information Service

NEWSLETTER
No. 13
DECEMBER 1985

INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS
(ICARDA)

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COVER PHOTO: Severe infestation of *Vicia faba* by pod borer (*Heliothis armigera*).

ISSN 0255 6448

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Breeding and Genetics

Component Analysis of the Factors Determining Grain Yield in Faba Bean (Vicia faba L.)

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Abstract

Twenty-four strains of faba bean were grown to determine the extent of the direct and indirect effects of component characters on grain yield. Number of primary branches, flowers, seeds, and pods/plant had significant positive correlations with grain yield. Path analysis showed that flowers and seeds/plant had direct positive effects on yield while primary branches and pods/plant had direct negative effects.

Introduction

Grain yield is a complex character which is determined by a number of component characters. To understand the contribution of each of these characters to the build up of grain yield it is necessary to identify them and study their correlation and causation. Such a study gives information on the importance of each of these attributes which is necessary in deciding upon suitable selection criteria for genetic improvement of yield.

This investigation deals with the extent of the direct and indirect effects of component characters on the expression of grain yield in faba bean.

Materials and Methods

The study was conducted at the University Farm in Kanpur, N. India. Twenty-four strains of faba bean from different geographic regions in Europe, Africa, and Asia were selected. Plots were planted in randomized blocks in triplicate, with four 5m long rows. The rows and plants were spaced 50 and 15 cm apart, respectively. Observations were recorded on 10 randomly selected plants for 10 attributes: days to flower; primary branches; plant height; days to maturity; flowers, pods, seeds, and grain yield/plant; 100-seed weight; and seed protein content.

The association between grain yield and its components, and among the components themselves, were computed in terms of genotypic and phenotypic correlation coefficients using genotypic and phenotypic variance and covariance components. These correlations were analyzed by path-coefficient analysis as suggested by Dewey and Lu (1959).

Results and Discussion

Genotypic and phenotypic correlation coefficients between grain yield and the characters contributing to it, and among the characters themselves, are presented in Table 1. Number of primary branches, flowers, seeds, and pods/plant had significantly positive correlations with grain yield. Positive and significant associations were also observed among these attributes. Thus selection for one trait may cause a corresponding increase in other attributes which singly or collectively affect grain yield. Almost similar results were reported by Redondo and Salmeron (1969) and Hebetinek *et al.* (1982).

Flowers and seeds/plant had direct positive effects on grain yield (Table 2), while primary branches and pods/plant had direct negative effects. Significantly positive correlations of primary branches and pods/plant with grain yield may be due to their indirect effects via seeds/plant and flowers/plant. It is likely that the indirect effects of these two traits nullify the direct positive effect.

The residual value of path (Pxi=0.149) suggested that some other important agronomic attributes

Table 1. Genotypic and phenotypic correlations among grain yield and its contributing characters in faba bean.

Characters	Days to flower 1	No. of primary branches 2	Plant height 3	No. of flowers/ plant 4	Days to maturity 5	No. of pods/ plant 6	No. of seeds/ plant 7	Grain yield/ plant 8	100-seed weight 9	Protein content
1.		-0.545** (-0.522)**	0.227 (0.223)	-0.655** (-0.644)**	0.739** (0.719)**	-0.816** (-0.805)**	-0.818** (-0.808)**	-0.330 (-0.325)	0.292** (0.780)**	-0.300 (-0.289)
2.			-0.060 (-0.057)	0.905** (0.887)**	-0.398** (-0.377)*	0.672** (0.655)**	0.679** (0.660)**	0.773** (0.768)**	-0.316 (-0.301)	0.091 (0.089)
3.				0.005 (0.005)	0.412** (0.402)**	-0.182 (-0.182)	-0.220 (-0.219)	-0.008 (-0.008)	0.027 (0.026)	-0.027 (-0.025)
4.					-0.571** (-0.560)**	0.871** (0.876)**	0.858** (0.853)**	0.805** (0.802)**	0.563** (-0.556)**	0.388* (0.389)
5.						-0.816** (-0.805)**	-0.839** (-0.822)**	0.419** (-0.410)**	0.601** (0.589)**	-0.334 (-0.316)
6.							0.991** (0.990)**	0.651** (0.650)**	0.755** (-0.752)**	-0.477** (-0.456)**
7.								0.662** (0.660)**	-0.739** (-0.736)**	0.449** (0.437)**
8.									-0.155 (-0.152)	0.267 (0.259)
9.										-0.396** (-0.386)*

* Significant at P = 0.05
**Significant at P = 0.01
Figures in parentheses denote phenotypic correlation

Table 2. Path coefficient analysis for 10 characters in faba bean.

Characters	Days to flower 1	No. of primary branches 2	Plant height 3	No. of flowers/ plant 4	Days to maturity 5	No. of pods/ plant 6	No. of seeds/ plant 7	100-seed weight 8	Protein content 9	Genotypic correlation with yield
1.	*0.167*	0.060	0.013	-0.562	0.058	0.666	-1.144	0.451	-0.038	-0.330
2.	-0.091	*-0.110*	-0.004	0.777	-0.031	-0.547	0.951	-0.180	0.009	0.774**
3.	0.038	0.007	*0.058*	0.004	0.032	0.149	-0.308	0.015	-0.003	-0.008
4.	-0.109	-0.099	0.003	*0.858*	-0.045	-0.710	1.201	-0.321	0.029	0.805**
5.	0.123	0.044	0.024	-0.490	*0.078*	0.667	-1.174	0.343	-0.033	-0.419**
6.	-0.136	-0.074	-0.011	0.748	-0.064	*-0.815*	1.386	-0.430	0.047	0.651**
7.	-0.136	-0.075	-0.013	0.737	-0.066	-0.808	*1.399*	-0.421	0.044	0.662**
8.	0.132	0.055	0.002	-0.483	0.047	0.616	-1.034	*0.570*	-0.039	-0.155
9.	-0.065	-0.010	-0.002	0.258	-0.026	-0.389	0.628	-0.226	*0.097*	0.267

Italic figures denote direct effects; residual effect is 0.148
** Significant at P = 0.01

contributed to yield, which were not included in this study. Therefore, further studies are needed to identify these attributes. Also, an understanding of the genetic reasons for correlations among the component characters of yield would be useful in genetically altering the morphological characters associated directly or indirectly with grain yield.

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Inheritance of Testa Color and Seed Size in Vicia faba L.

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Abstract

Seven genotypes of *Vicia faba* with different testa color were crossed. Three genotypes of different seed size were included in the crosses. There were differences in dominance between the testa colors; color was found to be an easily altered character. Black testa color was dominant to green-yellow and dull yellow. Small seed size was dominant to large and medium size seeds, and medium seeds were dominant to large seeds.

Introduction

Consumers attach much importance to the seed coat color of grain legumes. In general, green or yellow faba beans are used as split dal in India and are preferred to faba beans with black or brown seed coats. This is important in breeding programs evolving varieties to suit the consumer. Therefore an understanding of the inheritance of seed coat color is necessary.

Buff-colored testae are dominant over red (Fruwirth 1906), green (Picard 1963; Singh 1975), and yellow testae (Nilan 1966), while light yellow testae are dominant over normal green (Hua 1944). The difference between brown and black testae is due to variation in the intensity of expression of one gene (Picard 1963).

Like seed coat color, seed size is also important to consumers. In general, bold seeded varieties fetch a better price than medium or small seeded ones.

In pulses, small seed size is generally dominant over medium and large seed size (Reddy and Chopde 1977). Small seeded character is dominant or partially dominant in chickpea (Rastogi 1979). Seed size is a polygenic character and crosses between large and small seed size in *Phaseolus vulgaris* resulted in some medium or intermediate size seed (Motto *et al.* 1978). Marekar (1979) reported that seed size in *Cajanus cajan* is controlled by one or a few genes with one inhibitor and one anti-inhibitor. In this study the inheritance of testa color and seed size in faba bean was studied.

Materials and Methods

Crosses were made between seven genotypes of *Vicia faba* differing in testa color: JV-2, JV-6 (black); JV-3, JV-8 (yellow); JV-4 (brown); JV-5 (green); JV-7 (dull yellow). Three genotypes differing in seed size were included in the crosses: JV-2 (small), JV-5 (medium), and JV-8 (large). Observations were recorded on testa color and seed size in the F_2 population of these crosses, and data were analyzed using the chisquare (x^2) test.

Results and Discussion

Testa color

It is evident from Table 1 that all the crosses involving genotypes with black testae (JV-1 and JV-6), segregated with typical monohybrid ratios, indicating dominance of black testa color over green-yellow and dull yellow. Brown testa color (JV-4) was dominant over green, yellow, and dull

Table 1. Inheritance of seed color in F_2 populations.

Crosses JV-	Total plants	Traits	Observed value	Expected value	x^2
2x3	178	black-yellow	143:35	133.50:44.5	2.69
2x4	97	black-brown	58:39	72.75:24.25	11.96*
2x5	64	black-green	52:12	48:16	1.33
2x6	67	black-black	All black		
2x7	53	black-dull yellow	43:10	39.75:13.25	1.06
2x8	72	black-yellow	49:23	54:18	1.85
3x4	93	yellow-brown	11:76	23.25:69.75	2.24
3x5	82	yellow-green	66:16	61.50:20.5	1.31
3x6	62	yellow-black	10:52	15.50:46.5	2.60
3x7	64	yellow-dull yellow	11:53	16:48	2.88
3x8	58	yellow-green	40:18	43.50:14.5	1.12
4x5	67	brown-green	46:21	50.25:16.75	1.43
4x6	91	brown-black	35:56	22.75:68.25	8.70*
4x7	73	brown-yellow	58:15	54.75:18.25	6.77
4x8	62	brown-yellow	40:20	46.50:15.5	1.67
5x6	53	green-black	10:43	13.25:39.75	1.06
5x7	102	green-dull yellow	19:83	25.50:76.5	2.20
5x8	65	green-yellow	11:54	16.25:48.75	2.26
6x7	51	black-dull yellow	41:10	38.25:12.75	0.79
6x8	71	black-yellow	58:13	53.25:17.75	1.69
7x8	68	dull yellow-yellow	57:11	52:17	2.82

* Significant at 1% P.

yellow. Yellow and dull yellow testae were dominant over green (JV-5) while dull yellow testa color was dominant over yellow. In the crosses between brown and black genotypes (JV-2 x JV-4) there was no clear *segregation in the* F_2 generation. This may be due to variation in the intensity of expression of one gene. Therefore black testa color seems to be the original color of *V. faba* and testa color can be very easily incorporated into the desired genetic background.

Seed size

The segregation of crosses between different seed size (Table 2) revealed monogenic inheritance in F_2 for small vs medium seed size, and medium vs large. Small seed size was dominant over medium and large, and medium seed size was dominant over large seed size. Crosses between small seeded and large seeded genotypes resulted in some medium sized seeds. Therefore seed size seems not to be under simple genetic control and it cannot be easily incorporated into the desired genetic background.

Table 2. Inheritance of seed size.

Crosses JV-	Total plants	Traits	Observed value	Expected value	X^2
2x5	64	small:medium	42:21	48:16	2.08
2x8	72	small:medium large	26:35:11	18:36:18	6.30*
5x8	65	medium:large	51:14	48.75:16.25	0.40

* Significant at 1% P.

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White-Flowered Faba Beans (Vicia faba L.): Advantages and Disadvantages

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Abstract

Colored and white-flowered spring faba beans were sown in February to study differences in emergence between the two types. Lines with colored flowers had 84% emergence while the white flowered lines had 39% emergence. This difference was thought to be due to the lower tannin content of the white-flowered lines.

Introduction

The breeding of white-flowered faba beans has received much attention, because of the improved digestibility due to the low tannin content of the testa. However, white-flowered beans may also have the disadvantage of poor emergence under Dutch conditions, as this trial in 1985 showed.

Spring faba beans are usually sown in March in the Netherlands. In 1985 the structure of the trial field, a light clay soil, was optimal for tillage at the end of February. Therefore a very good seedbed could be prepared of 10 cm depth, with the subsoil still frozen.

Materials and Methods

The trial was sown with a Vicon precision drill on 27 February, at a depth of 7 cm and with a seed density of 27 seeds/m^2. The seed was treated with the fungicides benomyl and thyram. A cold period followed sowing during which the daily mean temperature for March, measured 1.5 m above the ground, was 3.7°C. Precipitation during the period from seeding to emergence was 3.6 mm. The beans emerged in the first week of April and plants were counted in each plot on 9 May.

Results and Discussion

Obvious differences in emergence were observed within and between the groups of beans with white and colored flowers respectively (Fig. 1 and Fig. 2). In

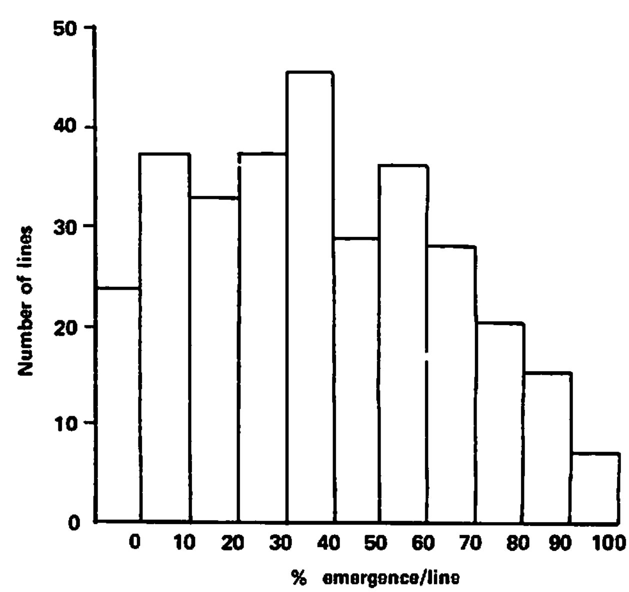

Fig. 1. Frequency distribution of emergence percentages of 300 white-flowered F_3 lines.

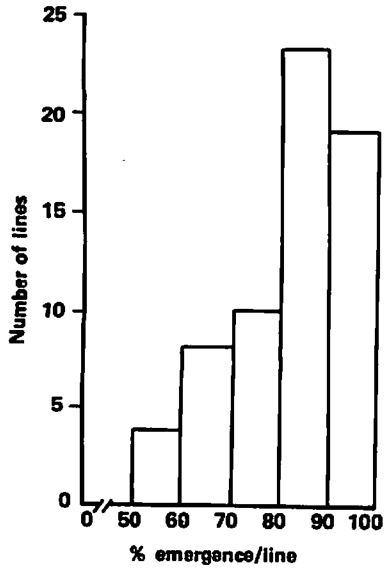

Fig. 2. Frequency distribution of emergence percentages of 60 colored-flowered F_{3-7} lines.

the 60 F_{3-7} lines with colored flowers, average emergence was 84% and in the 300 white-flowered F_3 lines, 39%. However, there was a large variation in emergence in the latter group of lines, indicating that there is a need for further selection and improvement for emergence in the white-flowered faba bean.

The comparatively low percentage emergence of the white-flowered beans may be due to differential susceptibility to soil fungi caused by low tannin content. Tannins also protect beans against the adverse effects of a long and cold pre-emergence time as occured in this study. Harris (1969) found that varieties with a low tannin content were also more susceptible to bird damage than those with a high tannin content.

Reference

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The Application of Electrophoresis to the Characterization of Cultivars of Vicia faba L.

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Abstract

The use of polyacrylamide gel electrophoresis in the presence of sodium dodecyl sulphate (SDS-PAGE) to analyze the seed proteins of faba bean cultivars is described. Considerable variation in seed protein composition within most cultivars complicates the use of SDS-PAGE for characterizing cultivars using individual seeds, even though there are differences in protein patterns between cultivars. By applying a bulk extraction method it is possible to minimise intra-cultivar variation and distinguish between the composite protein banding patterns of cultivars.

Introduction

For a breeder to be granted Plant Breeders Rights in the UK, his cultivar must satisfy the requirements of distinctness, uniformity, and stability (DUS). Thus any new cultivar submitted either for Plant Breeders Rights or for addition to the National List must be proven to be distinct from all existing cultivars in terms of morphological, physiological, or other characters. Therefore it is important to be able to classify cultivars into small discrete groups. In the case of faba beans this has proved difficult and existing schemes of classification suffice only to produce a very limited resolution of cultivars (Higgins and Evans, 1983). This is due mainly to a lack of adequate discriminatory characters and the outbreeding nature of most current faba bean cultivars, which results in substantial variation within populations. Thus there is a pressing need to investigate the use of other distinguishing characters for faba beans. One approach is to use chemotaxonomic methods, the most promising being electrophoretic analysis of seed proteins. This method has been used to distinguish cultivars of cereals and other crops (Cooke 1984) but limited work has been done on faba beans.

This study investigated the use of electrophoretic analysis of seed storage proteins of *Vicia faba* as an aid to cultivar identification. As a necessary preliminary, the extent of the electrophoretic variation within and between individuals in a population was compared to that found between populations.

Materials and Methods

The cultivars used were Banner, Blaze, Nabor, Red Epicure, Reina Mora, Threefold White, Throws MS, Troy, Vesuvio, Webo, and Polo, all from the UK reference collection held at the National Institute of Agricultural Botany. Seeds were grown in a glasshouse from which pollinating insects were excluded, since cross-pollination between cultivars would have complicated the results. Pod setting was enhanced by hand 'tripping' of flowers. Seeds were harvested at maturity and a record kept of the cultivar, plant, and pod from which they were derived.

For protein extraction of individual seeds, the testa was removed and 0.05 g of cotyledon material used. When preparing bulk sample extracts, cotyledons from each of 10 seeds were pulverized and a 0.6 g sample of the meal used.

Protein extraction, sample preparation, and SDS-PAGE were done as described by Cooke (1983) using gels of 17.5% acrylamide concentration. Electrophoresis was performed overnight with a constant current of 10 mA/gel. Gels were fixed and stained according to Cooke's method.

Results and Discussion

Variation within cultivars

To examine variation in protein composition within cultivars, a number of seeds of each cultivar were analyzed. Usually seeds were taken from within a single pod, from different pods on the same plant, and from different plants. Typical results for one cultivar (Throws MS) are illustrated in Fig. 1. It shows that the storage proteins exist in many different forms, i.e. they are highly polymorphic, which has been previously reported by Barratt (1980). In all cultivars, most polymorphism was detected amongst the polypeptides with molecular weights greater than 25 kilodaltons.

The results given in Fig. 1, and those for most other cultivars (Goodrich 1984), demonstrate clear differences in protein composition within cultivars. For example, in cultivar Throws MS, there were differences within pods (tracks 1 and 2 of Fig. 1), between pods (tracks 1 and 4), and between plants (tracks 1 and 11). In general less variation was found within the progeny of an individual than between progenies of different individuals. With the exception of Troy, all cultivars had similar variability. Troy appeared to be very uniform in its protein composition, probably because it is more inbred than the other cultivars.

These results are not surprising in view of the outbred, heterogenous population of most faba bean cultivars grown in the UK. However, they conflict with those of Barratt (1980), who reported that the storage protein patterns produced by SDS-PAGE were uniform within certain cultivars, and could be used to check the purity of batches of seed.

Variation between cultivars

Different cultivars were analyzed to see if it was possible to discriminate between cultivars using protein composition. The results in Fig. 2 indicate

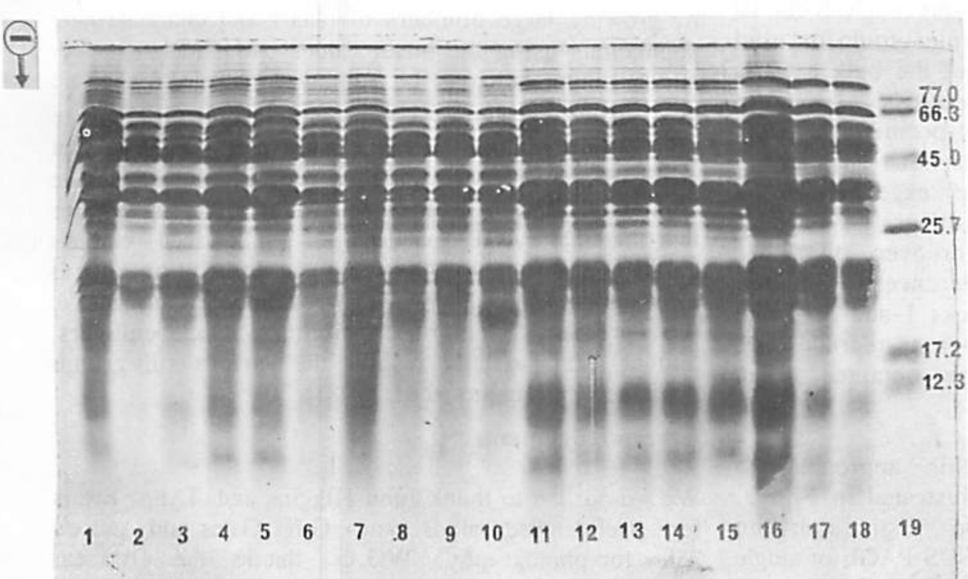

Fig. 1. Protein composition of single seeds of *V. faba* cultivar Throws MS using SDS-PAGE. Tracks 1,2,3 - seeds from one pod; 4,5 - seeds from another pod, same plant as 1,2,3; 6,7,8 - seeds from one pod, different plant from 1-5; 9,10-seeds from another pod, same plant as 6,7,8; 11,12,13 - seeds from one pod, different plant from 2-10; 14,15,16,17, 18 - seeds from the reference collection; 19-molecular weight markers (BDH). The numbers (*) refer to the stated molecular weights (in kdaltons).

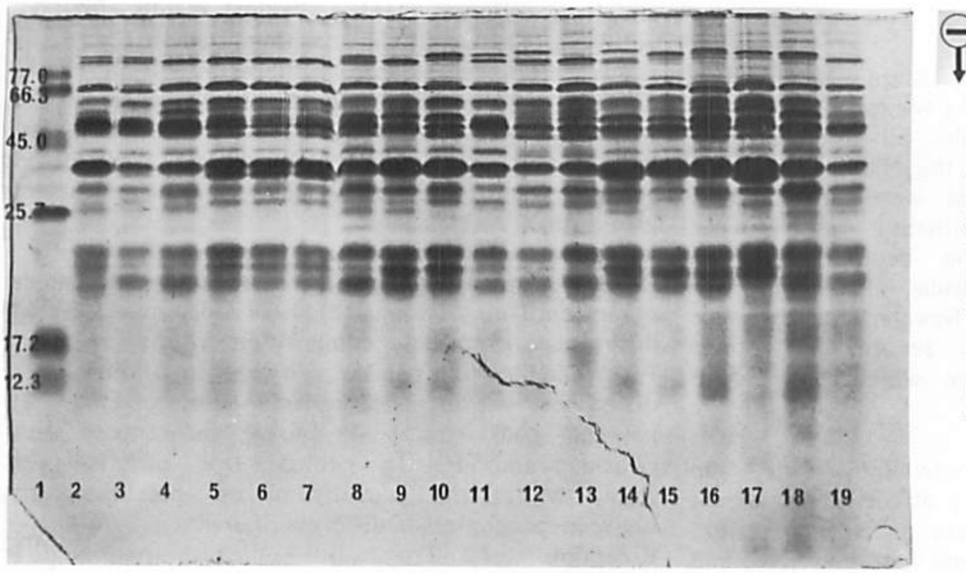

Fig. 2. Protein composition of single seeds of different cultivars of *V. faba* using SDS-PAGE. Track 1 - BDH molecular weight markers; 2,3,4 - Throws MS; 5,6,7 Troy; 8,9 - Red Epicure; 10,11 - Banner; 12, 13 - Reina Mora; 14,15 - Blaze; 16,17 - Vesuvio; 18,19 - Threefold White. Tracks 2-17, seeds were taken from different pods on the same plant; tracks 18,19, seed from the reference collection.

some of the difficulties with this approach. Although there are clear differences between cultivars (tracks 2 and 5, 6 and 8, 13 and 14), variation within cultivars complicates the situation. Thus with the exception of Troy (tracks 5, 6, and 7), the protein patterns of individual seeds within each of the cultivars differ (tracks 2 and 4, 8 and 9, 12 and 13). In a few cases, individual seeds from different cultivars had the same banding pattern. Clearly, another approach is required if electrophoresis is to be used effectively for characterizing faba bean cultivars.

Bulk extracts

To minimise the variation in protein composition within cultivars, protein extracts were made from 10 seeds/cultivar, although larger samples could be used if necessary. SDS-PAGE analysis of the bulk extracts was then carried out. A typical result is shown in Fig. 3. These results are very promising, as the intra-cultivar variation found earlier has been virtually eliminated. With the exception of the cultivar Nabor (tracks 7 and 8), cultivars now appear electrophoretically uniform. Moreover, there are qualitative and quantitative differences between cultivars, for example compare tracks 1 and 3, 4 and 5, 15 and 17. These differences appear reproducible, as similar protein profiles were obtained when further samples were analyzed.

A possible application of this approach to cultivars Webo and Polo is illustrated in Fig. 3. These two cultivars are difficult to distinguish on morphological grounds and with SDS-PAGE of single seeds (Goodrich 1984). However, the bulk approach showed small but reproducible differences between the cultivars (tracks 11, 12 and 13, 14, arrowed in Fig. 3).

In conclusion this study demonstrated the substantial variation in seed protein composition within most cultivars of *V. faba*, such that it is impossible to use SDS-PAGE to unambiguously identify individual seeds. This is in contrast to cereal crops where electrophoresis of single seeds is used routinely to monitor varietal identity and purity (Cooke *et al.* 1984).

In *V. faba*, as in other outbreeding species, the distinctness of a cultivar is a statistical feature of the cultivar as a whole and not the property of single individuals. When morphological or agronomic characters are considered distinctness is estimated by growing large numbers of plants and characterizing populations using the mean values of characters. A similar approach can be employed for electrophoretic analysis by extracting a bulk sample of seeds rather than individuals. These results suggest that cultivars may be distinguished reproducibly using the composite protein profiles so produced. This implies that the SDS-PAGE patterns of bulk seed extracts could be used in the cultivar description. Thus electrophoresis could form a much needed adjunct to the present system of classifying *V. faba* cultivars, and at least partially resolve the various sub-groups described by Higgins *et al.* (1981).

Acknowledgements

We would like to thank John Higgins and Lynn Evans for useful discussions and Giff Gates and Andrew Tiley for photography. W.J.G. thanks the Overseas Development Administration for financial support.

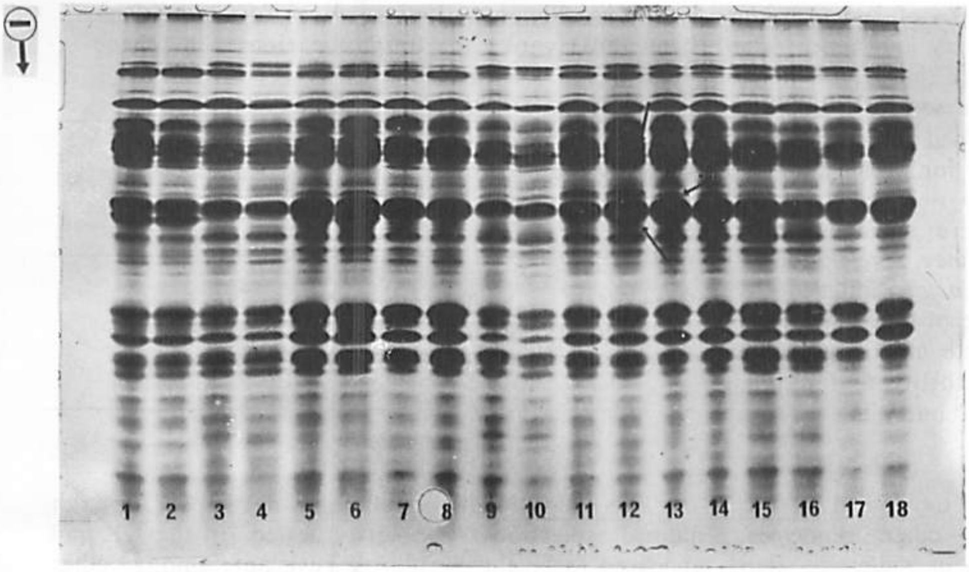

Fig. 3. Protein composition of seeds of different cultivars of *V. faba*, using SDS-PAGE of aliquots from bulk extracts of 10 seeds. Tracks 1,2 - Troy; 3,4 Banner; 5,6 - Blaze; 7,8 - Nabor; 9,10 - Threefold White; 11,12 - Webo; 13,14 - Polo; 15,16 - Throws MS; 17,18 -Vesuvio. Seed from the reference collection used in all cases.

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"Cote d'Or", A Highly Frost Resistant Population of Vicia faba

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Abstract

One of the winter faba bean populations from the Cote d'Or region of France, preserved by INRA, France under the name "Cote d'Or", was found to possess a very high level of winter hardiness as expressed by the 60% survival of plants during the winter of 1984/85 when temperatures fell below -25°C with no snow protection. In contrast cv Bourdon showed 14% plant survival and cv Talo 0% in this season, averaged over four different locations.

Introduction

Cote d'Or is a regional political division of 876,000 ha located in central eastern France. The altitude ranges from 180 to 600 meters. The climate is continental with mean winter temperatures around 2°C. The minimum temperatures are usually higher than -15°C but may sometimes reach -25°C, as occurred last winter (1984/85). Precipitation is usually 780 mm/year, mainly in spring and autumn.

In this area, winter varieties of *Vicia faba minor* have been grown for a very long time. The statistics of 1812 and 1882 indicate that 5,000 ha of faba beans were grown (in comparison to 110,000 ha under wheat) and used for animal food (horses, sheep, pigeons) or incorporated into flour for bread making.

Populations of faba bean were maintained by farmers up to about 1960-65 when they were no longer grown. The breeding work on *Vicia faba* initiated by INRA in 1950 has preserved one of the very typical populations. This population is late maturing, with high tillering capacity, susceptibility to lodging, and small seeds (450 g/1000 seeds), but with a very high level of winter hardiness.

The relative winter hardiness of cv Cote d'Or was assessed in comparison to two other genotypes, Bourdon and Talo, by growing them in winter at four different locations in France in the past three seasons. Percentage plant survival in winter was the highest in Cote d'Or in 1984/85 when the winter was most severe and there was no snow protection (Table 1).

Table 1. Percent plant survival of three faba bean cultivars at four locations in three years.

Cultivars	Year		
	1982/83	1983/84	1984/85
Cote d'Or	84.1	58.5	60.5
Bourdon	81.1	64.3	14.1
Talo	25.3	14.3	0

This old local population, developed through natural selection, was also tested in the UK and appeared to be the most frost resistant among other entries (personal communication D.A. Bond).

In France this variety was used in a winter bean breeding program as a progenitor for frost resistance in crosses with highly productive spring types.

Inheritance of Asynapsis in Three Oligochiasmatic Lines of Vicia faba

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Abstract

One standard and three oligochiasmatic lines of *Vicia faba* Primus were used in a diallel cross to determine whether reduced chiasma frequency is coded by different genes or by different alleles of one locus. Chiasma frequency was scored on 20 pollen mother cells/plant. Results show that the partial asynaptic character of each of the lines is coded by one recessive gene. These genes are not alleles and must be located at different loci.

Introduction

Synapsis of homologous chromosomes during meiotic prophase and chiasmata formation are known to be under genetic control. Meiotic mutants may be classified into two groups; mutants with complete or partial failure of chromosome pairing are termed asynaptic, while in the desynaptic ones, the synaptic alignment and formation of the synaptonemal complex is normal, but the molecular process of meiotic recombination is affected. Both cases result in reduced chiasma frequency, and often a high percentage of univalents at diakinesis/metaphase I.

In *V. faba*, Sjodin (1970) was able to select several induced oligochiasmatic mutants, characterized by a gradual reduction in chiasma frequency/cell. The early stages of meiotic prophase could hardly be analyzed in *V. faba*, but at least some of these lines showed reduced pairing at zygo-pachytene, indicating the partial asynaptic character of these mutants (Linnert *et al.* 1981). Also, reduced chiasma formation in some of these lines was determined by the action of a single gene (Sjodin 1970).

Table 1. F_1 and F_2 segregation of mean chiasma frequency/pmc in diallel crosses between three partial asynaptic (A8, A16, A52) and one standard line (N) of *V. faba*.

Cross	F_1 progeny	Mean chiasma frequency/pmc	F_2 progeny	Mean chiasma frequency/pmc	Estimated ratios	X^2
N x A8	16 N	17.52 (16.23-18.77)*	65 N	18.42 (16.70-19.85)	(3:1)	1.72
A8 x N			29 A8	3.02 (1.50-5.45)		
N x A16	4 N	17.44 (17.07-18.13)	15 N	17.93 (16.00-19.15)	(3:1)	0.67
A16 x N			3 A16	8.49 (6.15-9.70)		
N x A52	5 N	18.35 (17.63-18.93)	9 N	17.62 (17.33-19.67)	(3:1)	0.27
A52 x N			2 A52	4.33 (3.70-4.95)		
A8 x A16	17 N	17.84 (17.20-18.57)	32 N	17.81 (16.95-19.20)		
A16 x A8			7 A8	3.36 (1.05-4.92)		
			3 A16	9.97 (8.95-9.98)	(9:3:3:1)	5.87
			2 A8/A16	0.03 (0.00-0.05)		
A16 x A52	8 N	18.32 (17.33-19.13)	9 N	18.44 (17.65-19.86)		
A52 x A16			1 A16	9.50	(9:3:3:1)	3.06
			1 A52	3.92		
A8 x A52	9 N	17.67 (17.03-18.40)	20 N	18.51 (16.70-19.90)		
A52 x A8			11 A8 or A52	3.47 (1.55-5.40)	(9:6:1)	0.16
			2 A8/A52	0.30 (0.20-0.40)		

* Figures in parentheses are highest and lowest values.

To determine whether reduced chiasma frequency is coded by different genes or by different alleles of one locus, a diallel cross was carried out between three partial asynaptic and one standard line.

Materials and Methods

The standard and oligochiasmatic lines of *V. faba* Primus were obtained from Sjodin. Chiasma freqency was scored in 20 pollen mother cells (pmc) of each plant, using the karmine technique. The standard line of *V. faba* has a mean chiasma frequency/pmc of about 17.60 while line A8 is characterized by 3.81, line A16 by 9.48, and line A52 by 3.78 chiasmata/pmc, respectively (Linnert *et al.* 1981). The three oligochiasmatic lines are partially asynaptic according to the definition given above, as they show reduced pairing of homologues at pachytene. Diallel crosses between these lines were carried out and the segregation of the asynaptic characters in F_1 and F_2 progenies was analyzed using the X^2-test.

Results and Discussion

The segregation pattern of the F_1 and F_2 progenies is given in Table 1. All F_1 plants had a chiasma frequency similar to that of the standard line (N), even in combinations between two asynaptic lines, indicating that the genes involved are not allelic. The F_2 segregation of crosses between the standard and different asynaptic lines do not differ significantly from the expected 3:1 segregation using the X^2-test, showing that asynapsis in these lines is determined by one gene.

In F_2 progenies of crosses between two asynaptic lines, plants were obtained whose reduced chiasma frequency was even lower than both parents. These plants (A8/A16 and A8/A52) are probably homozygous for both asynaptic genes, which results in nearly complete failure of chiasma formation. The F_2 segregation in these crosses did not indicate any deviations from a bifactorial 9:3:3:1 or 9:6:1 segregation, which could be expected if two recessive and non-linked genes are involved.

These data, although limited, clearly demonstrate that:

1. the partial asynaptic character of each of the lines analyzed is coded by one recessive gene.
2. these genes are not alleles of one locus, but must be located at different loci.

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Physiology and Microbiology

Isoenzymes of Glutamine Synthetase in Leaves From Two Cultivars of Vicia faba L.

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Abstract

The presence of glutamine synthetase isoenzymes was investigated using polyacrylamide gel electrophoresis of leaf extracts of two faba bean cultivars, Reina Blanca and Reina Mora. Two isoenzymes were detected in both cultivars; one had similar mobilities in both cultivars while the other had different mobilities in the two cultivars.

Introduction

It is generally accepted that glutamine synthetase (GS), together with glutamate synthase (GOGAT), is the main route for the assimilation of ammonium ions in higher plants. The presence of GS has been shown in different tissues of many species such as leaves, hypocotyls, roots, and nodules.

Many forms of the enzyme, separable by ion exchange chromatography and starch or polyacrylamide gel electrophoresis, have been found in leaves. These isoenzymes have similar molecular weights but different stabilities, optimum pH values, and kinetic behavior (Stewart *et al.* 1980). Subcellular location studies indicate that one form (GS_I) can be found in the cytosol, and its function is reassimilation of ammonium released in the photorespiratory nitrogen cycle. Another isoenzyme (GS_{II}) has been found in the chloroplast, which assimilates ammonium from N_2-fixation or nitrate reduction (Wallsgrove *et al.* 1980).

This communication describes the results obtained from a study of GS in leaves from two cultivars of *Vicia faba* L.

Materials and Methods

Leaf extracts from two cultivars of *Vicia faba* L., Reina Blanca and Reina Mora, were obtained by the method described by Cullimore *et al.* (1983) and analyzed using polyacrylamide gel electrophoresis (PAGE) for five hours at 60 mA. Each gel was divided into two parts; one was stained with Coomassie Brilliant Blue G-250 for protein determination, and GS activity was detected in the other using the transferase test (Barratt 1980).

Plants, sown in December in an experimental field, were treated at flowering with sodium nitrate as nitrogen supplement (180 kg N/ha) and extracts were made from at least five 18-20 week old plants.

Results and Discussion

We detected two forms of GS in leaves ($GS_{1\text{-}h}$ and $GS_{2\text{-}h}$) from the two cultivars under study (Fig. 1). These results agree with those obtained previously in *Phaseolus vulgaris*, *Pisum sativum*, and *Hordeum vulgare* (McNally *et al.* 1983), while Barratt (1981) found more than two forms in faba beans. Differences in the number of isoenzymes detected may be due to different extraction and purification methods and/or to mechanisms of enzyme regulation by covalent inactivation.

One of the GS isoenzymes ($GS_{2\text{-}h}$) had similar mobility (Rf 0.196) in both cultivars which was similar to the mobility of the forms we found in nodules and roots of *V. faba*. These results suggest that this isoenzyme is present in several tissues and therefore it is not localized in the chloroplast. However it could be the form of GS_I described by other authors, who localized it in the cell cytoplasm.

We have found the other isoenzyme ($GS_{1\text{-}h}$) only in leaves, and it probably corresponds to the isoenzyme GS_{II} described in the introduction. We have detected a difference in mobility of this isoenzyme between both cultivars (Reina Blanca, Rf 0.167 and Reina Mora, Rf 0.175). This difference could be due to the different origins of the enzyme, and to differences in the stage of plant development. These two cultivars showed unequal growth: while the cultivar Reina Mora had finished its growth at sampling, the cultivar Reina Blanca was still in the linear growth phase. Further research is required to clarify this problem and to confirm or discard these suggestions.

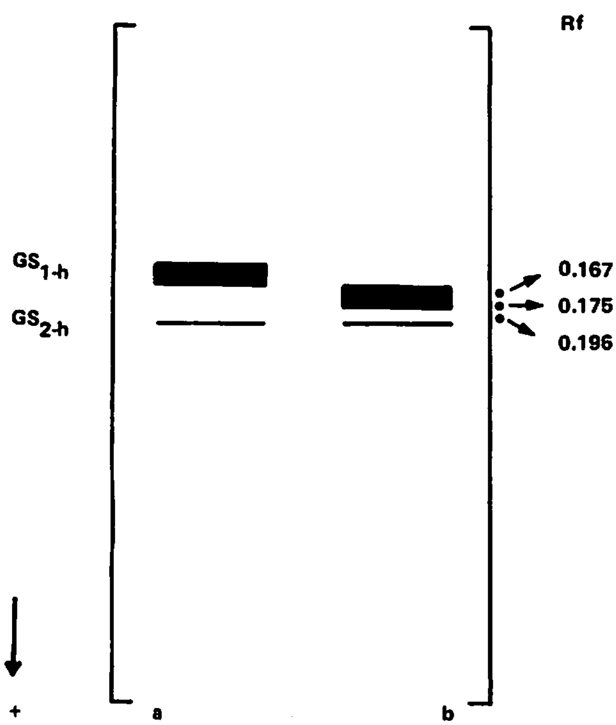

Fig. 1. Diagrammatic representation of GS banding patterns using PAGE and glutamyl transferase reaction. Leaf extracts: (a) cv Reina Blanca and (b) cv Reina Mora.

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Varietal Performance of Faba Bean Under Two Different Watering Intervals

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Abstract

Among the 11 genotypes of faba bean tested under two watering regimes, four varieties (00656, 00634, 00535, and 00636) recorded the least reduction in seed yield under the dry regime (obtained by an irrigation interval of 14 days) as compared to the wet regime (irrigation every seventh day).

Introduction

Drought stress has been identified as a yield-limiting factor for faba bean cultivation in the Sudan. From previous research done at Hudeiba, Wad Medani, and Shambat Research Stations during 1979-81 it was concluded that for good faba bean yields the crop must be irrigated every 7-10 days, and that water stress during flowering and pod formation was detrimental to seed yield. Water could be saved during the early vegetative stage with minimum yield losses by applying irrigation at intervals longer than seven days (Mohamed *et al.* 1983).

The purpose of this experiment was to see if there is any genetic variability in faba bean for tolerance to soil moisture stress under normal production conditions.

Materials and Methods

A split plot design with four replicates was used in which the main plot was assigned to watering intervals (irrigated every 7th or 14th day) and the subplots to 11 diverse faba bean types. The experiment was sown on 20 October 1984. Planting was done on both sides (east and west) of a 60 cm ridge, at 20 cm plant spacing with two seeds/hole, giving a theoretical plant population of 333,200 plants/ha. To establish the crop, it was irrigated twice before the start of the differential moisture regime. The number of waterings given for the 7 and 14 day watering intervals were 12 and 6 respectively.

Results and Discussion

The overall effect of the two watering regimes on seed yield and yield attributes of faba bean are presented in Table 1. Watering every 7 days increased seed yield by 114% compared to the 14 day watering regime. This increase was due to significant increases in seed yield/plant, number of pods/plant, and number of seeds/pod.

The interaction of variety and watering interval was significant for seed yield (Table 2). Variety 00656 gave larger seed yields than all other varieties for both watering intervals. The reductions in seed yield/ha due to watering at 14 day intervals compared to 7 day intervals were 75%, 71%, 65%, 62%, 60%, 51%, 44%, 40%, 40%, 37%, and 28% for BF 2/2, 00452, 00633, 00517, 00482, 00532, 00637, 00636, 00656, 00634, and 00535 respectively. The least reduction in seed yield was recorded for the varieties 00656, 00634, 00535, and 00636 under the

Table 1. Effect of watering intervals on seed yield of faba bean and its yield components.

Watering intervals (days)	Seed yield (kg/ha)	Seed yield/ plant (g)	Number of pods/ plant	Number of of seeds/ pod	1000-Seed weight (g)	Number of plants/m^2
7	3299	15 54	15.6	2.42	401	27.6
14	1539	8.87	10.8	2.25	375	26.4
SE	±67	±0.07	±0.11	±0.01	±5.5	±1.43

Table 2. Response of faba bean cultivars to two watering intervals.

Cultivar	Watering intervals (days)	Seed yield (kg/ha)	Seed yield/ plants (g)	Number of pods/ plant	Number of seeds/ pod	1000-seed weight (g)	Number of plants/m^2
00656	7	4013	21.51	20.5	2.64	395	30.5
	14	2408	12.24	13.4	2.31	355	26.7
BF 2/2	7	3965	14.08	15.1	2.37	398	26.9
	14	968	7.62	10.2	2.36	378	24.7
00637	7	3170	13.57	14.1	2.38	406	28.9
	14	1735	9.69	9.5	2.36	336	26.6
00633	7	3587	16.15	17.2	2.57	368	29.5
	14	1254	10.64	11.4	2.16	411	28.2
00634	7	2968	13.35	15.3	2.27	344	26.6
	14	1875	9.39	8.6	2.22	359	25.5
00636	7	3092	14.28	14.2	2.53	404	26.8
	14	1721	8.34	10.1	2.23	417	27.2
00535	7	2754	17.29	16.8	2.24	415	27.8
	14	1985	8.55	10.7	2.08	381	27.6
00517	7	3322	14.45	12.9	2.47	434	28.4
	14	1245	8.93	10.5	2.43	416	26.8
00482	7	3144	19.63	17.2	2.63	428	25.7
	14	1259	7.87	9.5	2.40	363	26.4
00452	7	3396	12.29	11.9	2.36	423	28.4
	14	995	8.40	12.1	2.19	340	26.6
00532	7	2880	14.29	15.1	2.19	401	24.3
	14	1409	6.94	12.7	2.08	365	24.5
SE (±)		156	0.84	0.51	0.05	11.32	1.18

dry regime compared to the wet regime because the least reduction occurred in the yield contributing factors; number of seeds/pod, and number of plants/square meter (Table 2).

The data suggest that these four varieties are better adapted to drought stress than the other varieties. This approach could be used in breeding programs to improve faba bean tolerance to moisture stress.

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Effect of Irrigation Frequency and Wetting Depth on the Yield of Faba Beans

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Abstract

This paper examines the effect of irrigation frequency, wetting depth, and their interaction on faba bean yield at three sites in Egypt. Plants were irrigated at three frequencies; 80%, 65%, and 50% field capacity. Depth of soil wetting, seed yields, irrigation frequency, and water use efficiency were recorded. Optimum yields resulted from frequent irrigations of moderate application while maximum water use efficiency was obtained from frequent irrigations of light application.

Introduction

The objective of irrigation in arid regions is to prevent water becoming a limiting factor in crop production. However, where the water supply is inadequate in relation to land use, limited irrigation is often practiced to optimize crop production/unit of applied water, rather than maximize yield/unit of land (Stewart and Musich 1982).

Three field trials were carried out at Sids and Mallawi (Middle Egypt), and Matana (Upper Egypt), in 1983/84 to study the effect of irrigation frequency and wetting depth and their interactions on faba bean yield.

Materials and Methods

Plants were irrigated at three frequencies: 80% field capacity (frequent irrigation); 65% field capacity (intermediate irrigation); 50% field capacity (infrequent irrigation). Depth of soil wetting was recorded at four levels for each irrigation frequency: 30 cm (very light applications); 45 cm (light applications); 60 cm (moderate applications); 75 cm (heavy applications). Seed yields (t/ha) were recorded for each wetting depth and irrigation frequency, and the water use efficiency calculated using the weight of seeds produced (kg/ha/cm of water applied.).

Results and Discussion

Means for the combined effect of irrigation frequency and wetting depth on seed yields are shown in Table 1.

Table 1. Mean seed yields (t/ha) for different irrigation frequencies and wetting depths.

Irrigation* frequency (F)	Wetting depth** D_1	D_2	D_3	D_4	Mean
F_1	2.650	2.812	3.230	3.273	2.991
F_2	1.930	2.230	2.535	2.542	2.309
F_3	1.831	2.331	2.229	2.285	2.169
Mean	2.137	2.458	2.665	2.700	
L.S.D. at 0.05	F = 0.188	D = 0.217		FxD = 0.375	

* F_1: Frequent irrigations - 80% field capacity
F_2: Intermediate irrigations - 65% field capacity
F_3: Infrequent irrigations - 50% field capacity

** D_1: Very light applications to 30 cm depth.
D_2: Light applications to 45 cm depth.
D_3: Moderate applications to 60 cm depth
D_4: Heavy applications to 75 cm depth.

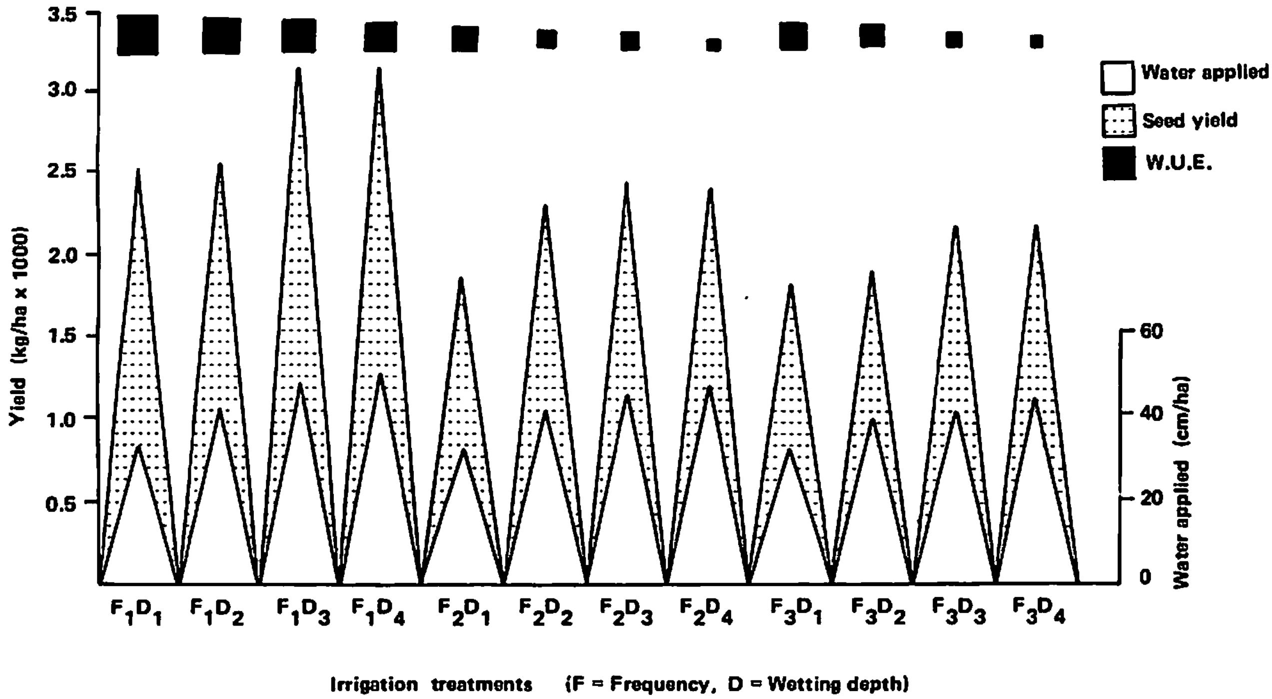

Fig. 1. Water use efficiency (kg/ha/cm) by faba beans as affected by irrigation frequency and depth

Irrigation frequency had a significant effect on seed yield and highest yields were obtained from frequent irrigations, watered at 80% field capacity. With wetting depth, the highest seed weight was recorded from D_4 with no significant differences between it and the D_3 treatment.

Data for wetting depth were different at different sites. For example, at Sids, the highest seed yields were recorded for treatments watered to a depth of 60 cm while at Mallawi, maximum yield was recorded from treatments watered to a depth of 45 cm. At Mantana, highest seed yield was recorded for treatments irrigated to a depth of 75 cm.

In the interaction between irrigation frequency and watering depth the highest yield was produced from the F_1D_4 treatment with no significant differences between it and the F_1D_3 treatment. Therefore optimum yields resulted from frequent irrigation (80% field capacity) and moderate application (wetting depth 60 cm).

The effect of irrigation frequency and wetting depth on water use efficiency (WUE) by faba beans is illustrated in Fig. 1. Mean values indicate that frequent irrigations produced a maximum water use efficiency of 66.0 kg/ha/cm of water. Regarding the effect of wetting depth on the water use efficiency, very light applications gave the highest value (63.1 kg/ha/cm). In the interaction between irrigation frequency and wetting depth, maximum values were obtained from the treatment irrigated at 80% field capacity and wetted to a depth of 30 cm (75.7 kg/ha/cm).

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Consumptive Water Use by Faba Bean in Soba Area of the Sudan

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Abstract

Daily consumptive use of water by faba bean cv BF/2/2 was studied at Soba, Sudan under an irrigation regime of 10 days interval between waterings. The daily consumptive use showed a linear increase in the early crop establishment stage and again between the onset of flowering and seed filling. The total seasonal consumptive use was 530 mm.

Introduction

Faba bean is becoming an important crop even in non-traditional areas in Sudan, such as those south of Khartoum, due to the success achieved by the Nile Valley Project in improving yield. Some of these areas are affected by varying levels of salt accumulation. Published data on water requirement is scarce especially in salt affected areas. The following report deals with this aspect in Soba area which is affected by salts and sodicity.

Materials and Methods

Faba bean variety BF/2/2 was grown in four tanks, 3.75 x 0.9 x 0.3 m, filled with soil from Soba. The properties of the soil are shown in Table 1. After wetting the soil to a workable physical condition the seeds were sown at 15 x 70 cm spacing. Watering after seedling emergence was done at 10 day intervals and, before each watering, soil moisture was determined. The water added was measured using a metering device. Bulk density was also measured to determine soil water at the beginning and end of each 10 day interval.

After each irrigation the water used was determined using the following formula and from this the water used/day was calculated by dividing by the watering interval.

$$U = I + R + \sum_{i}^{n} \frac{(mb_i - me_i) \times A_i D_i}{100}$$

Table 1. Physical and chemical properties of the soil at different depths for the experimental site at Soba, Sudan.

Soil depth (cm)	8-30	30-60	60-100
Electrical conductivity (mmhos/cm)	2.93	10.44	10.44
Ion content (meq/l) Cl^-	6.3	19.1	23.4
Ion content (meq/l) SO_4^{2-}	27.0	102.4	88.7
Ion content (meq/l) HCO_3^-	2.0	1.5	1.4
Ion content (meq/l) Na^+	25.2	99.1	96.7
Ion content (meq/l) Ca^{2+}	8.2	19.7	12.0
Ion content (meq/l) Mg^{2+}	2.0	4.2	4.8
pH	8.2	8.2	8.4
Sodium adsorption ratio (SAR)	15.8	28.7	47.2
Exchangeable sodium percentage (ESP)	23.7	39.1	53.2
Exchangeable Na^+	8.2	15.4	22.0
Cation exchange capacity (CEC)	34.6	39.4	41.4
$CaCo_3$ (%)	9.9	9.7	9.5
Course sand (%)	24.6	19.4	15.4
Fine sand (%)	17.1	14.7	15.3
Silt (%)	13.6	15.7	16.6
Clay (%)	38.8	40.9	43.5

Where U = consumptive water use
I = irrigation water added
mbi = moisture before irrigation
mei = moisture at end of irrigation
Ai = bulk density (1.471 g/cm)
D = depth (30 cm)
R = rainfall (zero)

Results and Discussion

Water used/day by the crop is shown in Fig. 1. The water use increased during the first 15 days. After the plants were fully established water use diminished gradually until early flowering (40 days). This was also reported by Nassib *et al.* (1985), Mohammed *et al.* (1983), and Farah and Ageeb (1984). According to Nassib *et al.* (1985) excessive water after two weeks was unfavorable. Mohammed *et al.* (1983) reported maximum yield with a 10 day watering interval, and missing one irrigation during the early stages of growth did not cause any significant yield reduction. Farah and Ageeb (1984) also reported that a 7 day watering interval resulted in too wet a regime and had an adverse effect in the early growth stages. Therefore the 10 day watering interval gave better yields than the seven and 14 day intervals.

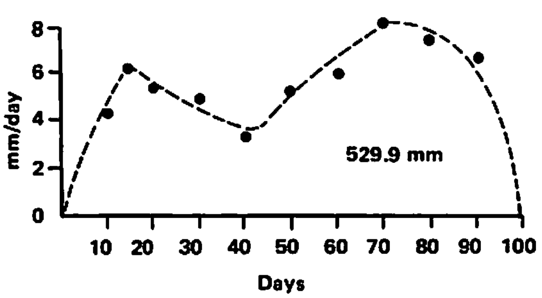

Fig. 1. Consumptive water use by faba bean.

During flowering and pod formation plants seemed to increase their water demand steadily till the early grain filling stage (70 days). However, during this stage (40 - 70 days), one irrigation may be omitted, especially at 40 - 50 days. After 70 days the crop requires much more water for grain filling. Mohammed *et al.* (1983) and Fadl (1983) reported that the grain filling stage is very critical and that any water stress at this stage would significantly decrease yield. According to Fig. 1 the stage of grain filling extended from 70 - 90 days and the plants used a steady rate of water of about 8mm/day. After grain filling, the need for water decreases steadily till plant maturity. Stopping irrigation after this stage seemed not to affect yield but its effect on quality remains to be evaluated.

In this study the cumulative water use was more than 500 mm which is similar to that reported by Lockerman *et al.* (1985) for a high watering regime which gave high yields in their study. Fadl (1983) reported that the cumulative water use by faba bean was 424 and 596 mm with 14 and 7 day watering intervals respectively. It is interesting that the value for cumulative water use with the 10 day interval occurs between these two values. It could be concluded that faba bean requires about 500 mm of water for maximum growth which is similar to flax, a little more than forage sorghum, but less than cotton grown in a similar environment (Anon.).

Acknowledgement

The author thanks Prof F.A. Salih for going through the manuscript and making suggestions. The work was sponsored by National Council for Research - Sudan and ASCAD.

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Effect of Pronamide Application and Resistant Varieties on Orobanche Infection and Faba Bean Yield

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Abstract

Five field experiments were conducted in soil naturally infested with *Orobanche crenata* in the governorates of Minia, Ismailiah, and Sharkiah, to study the effect of pronamide herbicide and the use of faba bean genotypes with differential resistance to *Orobanche* on parasite infestation and faba bean yield.

One pronamide application at 9.52 kg/ha, one month after sowing the resistant variety Giza 402, gave good control of *Orobanche*, with a strong site effect on the response to pronamide application and varietal resistance. The magnitude and direction of interaction between herbicide and faba bean genotypes in affecting the level of *Orobanche* infestation and seed and straw yields of faba beans differed with sites suggesting that the resistance of the three commercial bean varieties to the parasite was altered with environment.

Introduction

Broomrape, *Orobanche crenata*, is a parasitic plant endangering faba bean production in Egypt. Damage by this parasite is caused by withdrawal of water and nutrients from the host. The control of broomrape has been the subject of several studies which have included chemical and biological control, and use of resistant faba bean varieties. The selection and breeding of *Orobanche*- resistant varieties of *Vicia faba* has been reported by several workers (Basler and Haddad 1979; Cubero 1973; Kasasian 1973a). In Egypt, variety Giza 402 (Family 402) was the outcome of such a selection program (Nassib *et al.* 1979; 1982; 1985) and was released as a commercial variety in 1982.

Studies on chemical control of *Orobanche* in Egypt revealed that a post-emergence spray of pronamide at the rate of 4.76 kg a.i./ha before the beginning of crop flowering gave effective control of *Orobanche* in faba beans (Assad *et al.* 1982; Farag *et al.* 1982; Saber 1984; Schmitt *et al.* 1979; Zahran *et al.* 1979). The inhibitory effect of pronamide on *Orobanche* growth is related to gross anatomical abnormalities induced on the parasite's shoots (Assad *et al.* 1982) which hinder food and water translocation.

This investigation studied the effect of combining pronamide application with a resistant variety on *Orobanche* infestation and faba bean yield.

Materials and Methods

The study was carried out in naturally-infested soils at five locations in the Minia, Ismailiah, and Sharkiah governorates of Egypt during the winter, 1979/80.
The following factors were tested:

1. Pronamide application; no spray (control) and one spray at 9.52 kg/ha (product)/5001 water/ha one month after sowing.
2. Varieties; Giza 2 and Giza 4 (susceptible) and Giza 402 (resistant). At two out of five sites, only one susceptible and one resistant genotypes were used.

The experiments were laid out in a split plot design with four replicates. Pronamide application was in the main plots while the varieties were sub-plots.

The harvested plot area was 10.5 m^2 and, at harvest, the following observations were recorded; air dry weight of *Orobanche* (kg/ha), number of *Orobanche* spikes/infested faba bean plant, *Orobanche*-free faba bean plants (%), and seed and straw yields of faba beans.

Data were statistically analyzed following the procedures outlined by Steel and Torrie (1960), and treatment means were compared using the least significant difference (LSD).

Results and Discussion

Effect of pronamide

The level of natural soil infestation, as indicated by the mean *Orobanche* air dry weight, was highest at site 3 and lowest at site 4 (Table 1). Medium levels of infestation were observed at sites 1,2, and 5 (Table 1).

Table 1. Effect of pronamide application and varieties on *Orobanche* infestation at five sites during the 1979/80 season.

Treatment	Variety	Weight of *Orobanche* (kg/ha) Sites*					No of *Orobanche* spikes/plant Sites*			*Orobanche* - free plants Sites*		
		1	2	3	4	5	1	2	3	1	2	3
Control	Giza 2	173.1	251.2	ND	89.0	468.0	5.7	4.1	ND	93.4	74.9	ND
	Giza 4	230.9	ND	1549.2	228.0	1185.0	11.2	ND	5.0	91.9	ND	1.1
	Giza 402	45.6	21.6	1319.7	42.0	305.0	4.1	2.5	5.5	98.2	97.7	21.5
Mean		149.9	136.4	1434.5	119.6	652.7	7.0	3.3	5.3	94.6	86.3	11.3
Spray	Giza 2	79.8	78.2	ND	16.0	195.0	3.3	3.5	ND	97.3	91.2	ND
	Giza 4	138.9	ND	794.7	30.0	289.0	9.8	ND	3.4	97.9	ND	8.5
	Giza 402	6.8	14.5	1058.1	22.0	188.0	2.7	4.5	5.0	99.8	98.8	35.9
Mean		75.1	46.4	926.4	22.7	224.0	5.2	4.0	4.2	98.3	94.9	22.2
Mean	Giza 2	126.4	164.7	ND	53.0	331.0	4.5	3.8	ND	95.4	83.1	ND
	Giza 4	184.9	ND	1171.9	129.0	737.0	10.5	ND	4.2	94.9	ND	4.8
	Giza 402	26.2	18.1	1188.9	32.0	247.0	3.4	3.5	5.3	99.0	98.2	28.7
L.S.D. (P=0.05)												
Spray (s)		ns	44.8	ns	25.0	356.6	ns	ns	ns	ns	7.3	9.5
Variety (v)		90.3	86.5	ns	46.0	337.1	3.1	ns	ns	ns	9.0	15.2
s x v		ns	ns	ns	59.0	ns	ns	ns	ns	ns	ns	ns

* 1. Saft El-Khamar - Minia Governorate, 2. Atledam - (a)-Minia Gov., 3. Atledam - (b)-Minia Gov., 4. Abu-Swair-Ismailiah Gov., 5. El-Dabtmon-Sharkiah Gov.
ND = no data
ns = not significant

Pronamide application significantly decreased *Orobanche* weight by 65.9 and 65.7% at sites 2 and 5, averaged over all varieties. Non-significant decreases in *Orobanche* weight of 49.9 and 35.4% occurred at sites 1 and 3 respectively.

The mean percent of *Orobanche*-free faba bean plants was lowest at site 3. Pronamide was most effective at this site as it significantly increased this percentage by 96.5% compared with an increase of only 3.9 and 10% at sites 1 and 2 respectively, averaged over all varieties.

The number of *Orobanche* spikes/infested faba bean plant was, however, not significantly affected by pronamide at these sites.

Averaged over all the varieties, pronamide application increased seed yield over the contol by 4.2, 34.9, and 8.4% respectively at sites 2,3, and 4, but these increases were not significant at P=0.05 (Table 2). The effect on straw yield was also not significant.

Effect of varieties

Averaged over the herbicide treatments dry weight of *Orobanche* in Giza 402 was significantly lower by 85.8 and 89.0% compared with Giza 4 and Giza 2 at sites 1 and 2 respectively (Table 1). There was a non-significant difference between Giza 2 and Giza 4 at site 1. At site 3, where soil infestation was high, both Giza 4 and Giza 402 had almost the same *Orobanche* weight/hectare. At site 5 a significant decrease in *Orobanche* weight of 66.5% was observed in variety Giza 402 compared with Giza 4, while there was a non-significant difference between Giza 2 and Giza 402.

As an average of chemical control treatments, the percent *Orobanche*-free faba bean plants in Giza 402 increased significantly by 18.2 and 497.9% compared with Giza 2 and Giza 4 at sites 2 and 3 respectively. The number of *Orobanche* spikes/faba bean plant was not much affected by the varieties except at site 1 where the highest number was observed with Giza 4 (Table 1). Giza 402 yielded significantly higher

Table 2. Effect of pronamide application and varieties on faba bean yield at five sites during the 1979/80 season.

Treatment	Variety	Seed yield (t/ha) Sites					Straw yield (t/ha) Sites				
		1	2	3	4	5	1	2	3	4	5
Control	Giza 2	3.53	2.47	ND	2.53	1.68	4.03	6.78	ND	4.69	4.76
	Giza 4	2.89	ND	0.25	2.75	1.23	4.67	ND	2.35	4.94	3.59
	Giza 402	4.23	4.24	1.42	2.97	1.19	4.57	7.07	5.12	5.43	4.24
Mean		3.55	3.35	0.83	2.75	1.37	4.42	6.93	3.74	5.02	4.19
Spray	Giza 2	3.37	2.75	ND	3.13	1.70	3.99	6.57	ND	4.93	5.15
	Giza 4	3.89	ND	0.23	2.86	1.77	4.84	ND	2.57	5.05	5.20
	Giza 402	4.02	4.22	2.00	2.95	2.18	5.37	7.01	5.31	4.91	6.56
Mean		3.76	3.49	1.12	2.98	1.88	4.73	6.79	3.94	4.96	5.64
Mean	Giza 2	3.45	2.61	ND	2.83	1.69	4.01	6.67	ND	4.81	4.95
	Giza 4	3.39	ND	0.24	2.80	1.50	4.75	ND	2.46	4.99	4.39
	Giza 402	4.13	4.23	1.71	2.96	1.49	4.97	7.04	5.22	5.17	5.40
L.S.D. (P=0.05)											
Spray (s)		ns	ns	ns	ns	0.30	ns	ns	ns	ns	0.42
Variety (v)		0.52	0.21	0.38	ns	ns	0.39	ns	0.86	ns	0.64
s x v		0.73	ns	ns	ns	0.37	ns	ns	ns	ns	0.85

ND = No data
ns = Not significant

than the susceptible genotype at sites 2 and 3, whereas at site 4 the increase was non-significant (Table 2). Straw yields were also increased in the resistant variety when compared to the susceptible ones at most sites, but the increases were significant only at sites 1 and 3.

Effect of spray x variety interaction

Interaction between the chemical spray and genotypes in affecting *Orobanche* dry weight was significant only at site 4 (Table 1). Use of a resistant variety at site 4 resulted in a significant reduction in *Orobanche* dry weight compared to the susceptible variety when no herbicide was used. However, when herbicide was applied, the genotypic differences disappeared.

A similar interaction was significant in affecting the seed yield at sites 1 and 5 and straw yield at site 5 (Table 2). At site 1 pronamide application resulted in a significant increase in seed yield of susceptible varieties but not in the resistant one. At site 5 on the other hand, the yield improvement with herbicide application was much larger in the resistant variety than in the susceptible ones.

Discussion

The effects of pronamide application and planting the resistant variety Giza 402 were generally positive for *Orobanche* control and faba bean yield improvement. However, there was a site effect for both treatments. The inherent *Orobanche* infestation at each site, soil texture and fertility, and cultural practices (tillage level and irrigation) have been reported to modify the effects of glyphosate application and use of resistant varieties in *Orobanche* control (Nassib and Hussein 1984; Nassib *et al.* 1985). The sandy soil of Ismailiah governorate (site 4) might have increased the efficiency of pronamide at this site, resulting in significant control of *Orobanche* infestation in susceptible genotypes.

Giza 402, which has been selected because of its resistance to *Orobanche*, showed variable response to *Orobanche* infestation and chemical control at different sites. Although no attempt was made in this study to quantify the environmental stresses to which the experimental crop was subjected at different sites, there is a possibility that the reaction of Giza 402 to *Orobanche* infestation changed with environmental stress. The mechanical nature of resistance due to inherent morphological and anatomical features of the root mass in Giza 402 may have caused the variable response in different environments. This aspect needs to be further studied so that more stable resistance may be bred into the genotypes of faba beans.

To conclude, *Orobanche* control could be achieved by growing the resistant variety Giza 402 in non-stress environments. Application of pronamide could further check the parasite's growth and improve faba bean yields.

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Tolerance of Faba Beans to Three Selective Graminicides

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Abstract

Field experiments were conducted in 1982 and 1983 at Invergowrie, Scotland, to examine the selectivity of three post emergence graminicides in faba bean cultivars Medes and Maris Bead grown in weed-free plots in spring. Alloxydim-sodium, sethoxydim, and fluazifop-butyl were applied at recommended rates (1.5, 0.87, and 0.75 kg a.i./ha respectively), and twice that rate. Only alloxydim-sodium at twice the recommended rate (i.e., 3.0 kg a.i./ha) caused some discoloration and marginal necrosis of faba bean leaves, but even this did not affect plant height and yield. Thus, all three graminicides were well tolerated by the faba bean cultivars used in this study.

Introduction

The number of new selective graminicides being evaluated for control of grass weeds in growing broad-leaved crops has increased steadily over the past few years. Most of the published comparisons relate to performance on weed species (Jones and Orson 1982), while information on their relative safety to crops is less readily available. The experiments reported in this paper examined crop reaction to three of the new graminicides in weed-free plots of faba beans, *Vicia faba major* and *Vicia faba minor.*

Materials and Methods

Two adjacent experiments were laid out at Invergowrie in each of two years, 1982 and 1983. One experiment involved faba bean *major* cv Medes and the other, faba bean *minor* cv Maris Bead. Both crops were drilled on the same day in beds 4 m long by 2 m wide. Plots were laid out in a randomized block design with three replicates of eight experimental treatments.

There were three rows of faba bean *major*/plot and 10 rows of faba bean *minor*/plot. Dates of husbandry operations are shown in Table 1.

Crop heights were measured on samples of 10 plants/plot, chosen at random, and excluding outside rows. Harvest records were taken from the center row of faba bean *major* and all 10 rows of faba bean *minor.* The former were shelled by hand, while the latter were vined using a stationary viner. The experimental areas were not irrigated. Terbutryne/terbuthylazine (Opogard) at 1.4 kg a.i./ha was applied shortly after drilling to give residual control of annual weeds; any surviving weeds were removed by hand.

Table 1. Crop details.

	1982	1983
Sowing date	16 April	30 March
Treatment date	2 June	8 June
Harvest date		
Faba bean *major*	29 July	1 August
Faba bean *minor*	1 Sept	8 Sept

Experimental herbicide treatments were applied on the same day to both crops and were identical for all four experiments. The herbicides evaluated were; alloxydim-sodium, sethoxydim, and fluazifop-butyl, at application rates recommended for the control of perennial grass weeds by each herbicide, together with twice that rate (Table 2). Two untreated plots were included in each replicate. The plants of cv Medes were 15-20 cm, and those of cv Maris Bead 10-15 cm tall at the time of application, and the weather was warm and sunny. Herbicides were applied by Oxford Precision Sprayer in a water volume of 300 l/ha.

Table 2. Herbicide details.

Herbicide	Application rate (kg a.i./ha)
Alloxydim-sodium	1.50 and 3.00
Sethoxydim	0.87 and 1.74
Fluazifop-butyl *	0.75 and 1.50

* Plus Agral at 0.1% of spray solution

Results and Discussion

The only herbicide to have any visible adverse effect on crop growth was alloxydim-sodium, which caused discoloration and some marginal necrosis of treated leaves in both years, particularly in cv Medes and at the double rate (Fig. 1). New leaves were unaffected

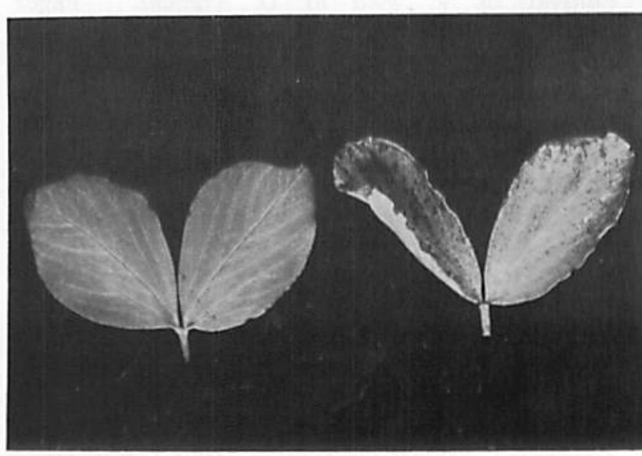

Fig. 1. Faba bean leaves: untreated (left) and treated (right) with alloxydim sodium at 3 kg a.i./ha, showing foliar necrosis three weeks after treatment.

and height records taken at intervals after treatment showed no significant effects of any herbicide or dose. Harvest records for each crop also indicated that none of the treatments adversely affected yield, or its components, in either year. No treatment had any significant effect on tenderometer readings taken on shelled beans from cv Medes, or on the percentage dry matter of seeds of cv Maris Bead, at harvest. Since the experimental treatments were applied in the absence of weeds, these results give a clear guide to the basic tolerance of the two crops to these herbicides.

Recent unpublished work by the Processors and Growers Research Organisation, Peterborough, England (C.M. Knott, personal communication) has indicated that fluazifop-butyl may be more selective than alloxydim-sodium on faba bean *major* cv Beryl and faba bean *minor* cv Herra, although all three herbicides can be phytotoxic at high rates in certain seasons. Leaf necrosis was the most common symptom, but did not necessarily lead to yield loss. Zaharan (1982) found that fluazifop-butyl was non-toxic to faba beans in trials in Egypt. However, published information on the comparative tolerance of faba beans to these three graminicides is lacking.

More comprehensive data are available on their effects on peas. Knott (1980) recorded necrotic patches and a reduction in leaf wax on peas treated post-emergence with alloxydim-sodium; injury was severe at application rates of 3-4 kg a.i./ha. Comparable rates of sethoxydim were less phytotoxic in the same experiments. In a further series of trials (Knott 1982a), she found necrotic leaf symptoms at several sites (and in one case a reduction in yield) where peas had been treated post-emergence with fluazifop-butyl at 1.0-1.5 kg a.i./ha, whereas alloxydim-sodium at these rates caused no injury. Considerably higher rates of the latter were, however, necessary to achieve equivalent levels of weed control. Knott (1982b) further compared alloxydim-sodium, sethoxydim, and fluazifop-butyl in a series of experiments on vining peas and found that all three herbicides, but especially alloxydim-sodium, tended to reduce leaf wax.

In her series of experiments on peas and faba beans, Knott found that each of three herbicides, at and above the rates required for effective weed control, caused varying levels of leaf necrosis and de-waxing, but this seldom caused yield loss. The most likely herbicide to cause such damage was alloxydim-sodium, which was the only material showing such effects in our own experiments on faba beans. Further examination of the environmental conditions conducive to this leaf injury is necessary, but the benefits of being able to selectively remove grass weeds in broad-leaved crops are considerable (Jones and Orson 1982) and all three herbicides appear to have acceptable margins of safety for commercial usage.

Alloxydim-sodium has recently been given official clearance in the United Kingdom for use in faba beans; it is recommended at rates of up to 1.5 kg a.i./ha for the control of perennial grasses (Anon. 1984). Users are warned that necrotic leaf spotting may occur if the recommended dose is exceeded. The two herbicides, although slightly less phytotoxic, are still in the development phase as far as use in these crops in the United Kingdom is concerned. Other selective graminicides are currently being evaluated so that, within a few years, a much wider range of options may become available for the control of annual and perennial grass weeds in faba beans.

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The Effect of Plant Population and Plant Orientation on Faba Bean Yield at Shambat Area of The Sudan

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Abstract

The effects of plant orientation and row number/planting ridge on faba bean yield and its componehts were investigated. Seed yield was significantly affected by plant orientation when one or two rows/ridge were planted. Increasing the plant population by increasing the number of rows/ridge increased yield. The highest yield was obtained with 3 rows/ridge, which was the highest plant density. Fewer pods/plant were formed in denser populations, although number of seeds/pod and 1000-seed weight/plant were not significantly affected by population.

Introduction

Most previous research on faba bean plant populations concentrated on inter-and intra-row spacing, and variations in number of seeds/hole (Ishag 1971; Ageeb 1976). Ageeb (1983), who studied various row and plant spacing combinations, found that planting rows 20 cm apart, with 20 cm plant spacing, gave the highest yield (2390 kg/ha) of all treatments. He also found that a population of less than 25 plants/m^2 did not give satisfactory yields.

Very little work on plant orientation in relation to plant population has been done in the Sudan. In the northern region, Taha (1981) found that faba bean yield could be increased by planting on the center and the western side of a north-south oriented ridge. The reverse was found by Mohamed (1980) at Shendi, where the lowest yield was produced from the western side of a north-south oriented ridge. At the Gezira Research Station, Ageeb (1980) reported that planting a single row on the east or west side of a north-south oriented ridge, or three rows/ridge, resulted in the lowest yields. In Egypt, Rizk (1973) found that increasing plant density through closer hill spacing, or increasing the number of plants/hill, resulted in fewer seeds/plant and lower yields. The highest yield was obtained by sowing two seeds/hole with 20 cm spacing on both sides of ridges 60 cm apart.

This trial investigated the effects of both plant orientation and plant population on the grain yield of faba bean and its components.

Materials and Methods

Treatments, which were arranged in randomized complete blocks with four replicates, are shown in Table 1. Plot size was 3x8 m, of which 1.8x7 m was harvested for grain yield. The trial was sown on 4 November 1984, using variety BF 2/2. The ridges were laid north-south at a distance of 60 cm. Seeding was done in hills 20 cm apart with two seeds/hill in a row.

Results and Discussion

Effect of plant population
Plant population was varied by number of rows/ridge (Table 1). Increasing the row number from 1 to 2 or 3/ridge significantly (P=0.01) increased seed yield. This increase mainly occured because of the increased number of plants/m^2, which more than compensated for the decreased seed yield/plant caused by increasing the number of rows/ridge. The number of seeds/pod and 1000 seed weight were not affected by plant population (Table 1).

Effect of plant orientation
This effect could be seen in the treatments having either one or two rows/ridge. When only one row/ridge was planted, seeding on either the western side or on the top of the ridge was better than seeding on the eastern side. When two rows/ridge were planted, the treatment with rows on the east and west sides of the ridge tended to be better than the other combinations. However, the differences between the 3 contrasting combinations at this population level were slight (Table 1, treatment 4, 5, and 6).

Plant orientation effects were mediated through changes in plant stand. Sowing on the eastern side of the ridge resulted in a poorer stand than when sowing was done in the center or western side of the ridge. This was most probably due to higher temperatures on the eastern side of the ridge, which could favor seedling rot and wilt in the Shambat area of Sudan. Plants reacted to this change in population through changes in the number of pods and

Table 1. The effect of plant population and plant orientation on faba bean yield and its components.

Treatments	Grain yield (kg/ha)	No. of plants/ m^2	Plant stand (%)	1000-seed weight (g)	No. of pods/ plant	No. of seeds/ pod	Grain yield/ plant (g)
1. Single row/ridge, east side	1942	21.1	63.2	451	14.3	2.33	15.3
2. Single row/ridge, west side	1942	26.3	79.1	435	11.4	2.52	12.5
3. Single row/ridge, center	2092	24.8	74.4	414	13.1	2.38	13.8
4. Two rows/ridge, east and west sides	2354	36.4	54.6	481	12.7	2.32	12.1
5. Two rows/ridge, east and center	2261	33.5	50.2	437	10.8	2.42	12.1
6. Two rows/ridge, west and center	2297	40.8	61.2	428	10.8	2.18	10.1
7. Three rows/ridge, east, west, and center	2539	59.5	59.5	457	9.8	2.34	11.7
S.E.	±76	±1.97	±4.36	±15.01	±1.01	±0.13	±0.94

seed yield/plant, which increased with reduced plant stand. This partly compensated for the yield-reducing effect of reduced plant population emanating from seeding on the eastern side of the ridge. Thus the overall effect of plant orientation remained rather small.

In conclusion, the yield of faba beans in the Shambat area of Sudan could be increased by increasing the number of rows/ridge to three, in contrast to a single or double row pattern of seeding on ridges laid out north-south, 60 cm apart.

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Pests and Diseases

Comparative Susceptibility of Seeds of Certain Faba Bean Varieties to Callosobruchus maculatus F.

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Abstract

This study examined the susceptibility of 35 promising faba bean varieties to infestation by the cowpea weevil *Callosobruchus maculatus* F. using a susceptibility index. Differences in this index were due to differences in percentage of emerged adults. Seeds of Family 379 were most resistant and those of Protein 60/78 were most susceptible.

Introduction

Considerable work has been done by the International Institute of Tropical Agriculture (Nigeria) and the University of Durham (UK) on the development of cowpea varieties resistant to Bruchidae (Reddan *et al.* 1983).

In Egypt faba bean varieties have been improved due to plant breeding programs. The new varieties are high-yielding but are very susceptible to attack by storage pests. Therefore, storage entomologists and plant breeders must breed varieties with desirable agronomical characteristics and resistance to storage pests.

The present work was carried out to determine the susceptibility of promising varieties of faba bean (*Vicia faba*) to infestation by cowpea weevil (*Callosobruchus maculatus* F.), a serious pest attacking stored faba seeds.

Materials and Methods

Thirty-five varieties of faba bean were divided into two groups of 18 and 17 varieties for the sake of convenience in laboratory screening.

Weevils were reared in the laboratory at 30°C and 65% relative humidity (RH). For each variety 25 g of seed were placed in small glass jars and two pairs of *C. maculatus* weevils added to each. There were three replicates for each variety. The jars were covered with muslin fixed in position by rubber bands and incubated at 65% RH at 27°C (group 1), and 30°C (group 2). The jars were examined daily and the number of eggs deposited/female, the percentage of emerged adults, and the developmental period were counted and recorded. The criterion for tolerance or susceptibility was calculated according to the following equation (Dobie 1974);

$$\text{Index of susceptibility} = \frac{\text{Log } S \times 100}{T}$$

where, S = percentage progeny, and T = developmental period.

Results and Discussion

Data in Table 1 indicate that seeds of Family 379 were most resistant and those of Protein 60/78 were most susceptible to *C. maculatus*. The susceptibility index varied greatly from 3.91 for Family 379 to 6.76 for Protein 60/78, which was due to differences in the percentage of emerged adults since the developmental period did not vary. The percentage of emerged adults was between 17.74 for Family 379 and 58.79 for Protein 60/78. Family 379 may be considered as a good source for developing faba bean genotypes with improved resistance to *C. maculatus* F.

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Table 1. Susceptibility of 35 faba bean varieties to infestation with the cowpea weevil *Callosobruchus maculatus* F.

Variety	Eggs/ female	Emerged adults (%)	Period of development (days)	Susceptibility index
Group I				
Family 379	10.50	17.74	31.98	3.91
Family 424	16.00	48.51	31.89	5.29
Family 402	19.83	35.52	32.07	4.83
61/521/66	11.33	53.27	33.47	5.16
91/11/72	20.50	30.43	32.30	4.59
123A/45/76	16.00	37.21	31.82	4.94
99/40/73B	26.00	40.42	33.48	4.80
108/3051/74	19.33	45.35	32.96	5.03
124/3/76	12.67	49.26	32.28	5.24
144/30/77	10.33	42.73	32.45	5.03
152/3557/78	19.33	61.28	33.13	5.39
126/21/76	49.00	30.61	31.00	4.95
132/3/77	28.67	24.36	33.87	4.09
148/3534	18.33	45.26	33.44	4.95
Radiation 2046/76	25.50	40.29	33.45	4.73
Diseases 1864/76	25.50	36.11	33.89	4.60
120/11/75	33.67	48.70	33.22	5.08
139/14/77	30.00	37.25	33.19	4.73
Group II				
150/223/78A	22.33	32.43	26.86	5.62
152/3558/78B	13.17	26.84	26.82	5.33
153/3564/78	16.33	19.71	27.14	4.77
Protein/58/78	19.00	37.79	26.50	5.95
Protein/59/78	19.17	48.43	26.38	6.38
Protein/60/78	25.50	58.79	26.18	6.76
Protein/61/78	26.50	53.01	26.41	6.53
Protein/113/78	15.50	32.57	26.49	5.71
Rebaia 40	43.50	47.74	27.50	6.10
152/3541/78	28.00	38.24	28.50	5.55
Composite 13	27.67	51.86	27.97	6.13
Composite 15	30.50	46.18	28.81	5.78
120/30/77	10.33	47.07	27.22	6.14
141/34/77	31.33	50.67	26.64	6.40
142/2170/77A	26.67	38.16	26.60	5.94
143/2182/77A	18.66	36.61	26.63	5.87
148/144/78	18.00	29.03	27.00	5.42

Study on Mosaic Caused by Broad Bean Mosaic Virus in Vicia faba

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Abstract

This study examined the sources and spread of broad bean mosaic virus in *Vicia faba*, crop losses and resistance, and the efficacy of chemical control of the aphid vector. The disease was successfully transmitted by mechanical inoculation with sap and by aphid vector. Disease incidence was lowest in crops sown on 24 October and 19 November. Controlling the aphid vector with Rogor significantly reduced disease incidence. Earliest infected plants had the greatest yield loss, and different varieties showed differences in resistance.

Introduction

Faba bean (*Vicia faba minor*) is an important legume crop with heavy yield potential. Its green pods are used as a vegetable and the dry seeds, which contain about 30% protein and have good cooking quality and taste, are used as a pulse. Occasional incidence of mosaic has been reported by Azad *et al.* (1961). Negi and Nariani (1970) established the viral nature of faba bean mosaic, and Chowla and Nariani (1975) made a detailed study on the purification, electron microscopy, and serology of the causal virus. However, information on disease occurrence under field conditions is lacking. In Madhya Pradesh, India, the disease was observed for the first time in an experimental field during the winter of 1977/78.

Infected plants are weak, pale, and stunted. Young leaves and stipules are reduced in size, develop mosaic mottling, and in some varieties, there is severe necrosis of foliage and young top leaves. Distortion of the leaf, with wavy and irregular margins occurs and young leaves of plants infected at a late stage are small, crinkled, deformed, and become pale yellow with brown margins. Internodes and petioles are considerably shortened. When plants are infected at the branching stage they have a bushy appearance due to excessive and shortened branches. Infected plants also produce fewer pods.

This study was undertaken to determine the source of the disease inoculum and to assess disease spread, to evaluate resistance in available cultivars, to estimate losses due to the disease, and to test the efficacy of two chemicals for control of the disease and the aphid vector under field conditions. Field and laboratory experiments were conducted during winter in the years 1980-83.

Materials and Methods

The virus was maintained and multiplied in local *Vicia faba* cultivar, JV 1, as suggested by Chowla and Nariani (1975). Routine practices were followed to prevent insect infestation and contamination from other sources. Virus inoculum was prepared by grinding leaf tissues of JV 1 in 0.1 M phosphate buffer (pH 7.6) and inoculations made by rubbing the upper surface of leaves with the inoculum mixed with Celite as an abrasive. Standard extract was used in all the experiments. Plants grown in a glasshouse for 20 days were used as test plants.

The virus was purified from 1 g of leaf using 1.5 ml of 0.05 M phosphate buffer (pH 7.6) containing 0.1% thioglycolic acid. Six percent n-butanol was added as solvent (Chowla and Nariani 1975).

A field experiment was conducted using the variety JV 1 and three spray treatments: Rogor (dimethioate) at 0.05%, Bavistan (benzimedazol carbamate) at 0.05%, and water (control). Planting was done at 20-day intervals, from the first week of October to December. Three sprayings of each treatment were done at 21-day intervals from the third to ninth week after sowing. Observations on disease incidence were recorded weekly by scoring five randomly selected plants on a 0-5 scale where 0 = healthy, and 5 = severe disease symptoms. Disease index was computed according to the method of Chenulu *et al.* (1979). Dry grain yield/plant was recorded.

Crop losses due to the disease were assessed in the field using variety JV 1. Disease incidence was recorded weekly and five randomly selected, diseased plants from each category were tagged with the date on which first symptoms were seen. The age of the plant on the date of tagging was also recorded. Pods from the tagged infected plants, as well as healthy plants, were harvested separately and the average yield of plants infected at different stages calculated. The percentage yield loss was calculated using the formula of Chenulu *et al.* (1979). The 100-seed weights of five diseased and five healthy plants from each planting date were recorded.

A replicated single row (3 m) trial was conducted to screen 34 promising cultivars for disease resistance in the field. Observations on disease incidence were recorded 4, 8, and 12 weeks after planting and diseased plants in different categories were counted.

Results and Discussion

Inoculation studies revealed that mosaic disease was successfully transmitted by mechanical inoculation with sap and by aphid vector (*Aphis craccivora* Koch) to faba bean and also to *Pisum sativum*, *Cyamopsis tetragonoloba*,. *Trigonella foenumgracicum*, and *Gomphrena globosa*, but not to *Vigna radiata* and *Vigna unguiculata*. White local lesions were produced on *Chenopodium amaranticolar* and *Melilotus alba*. As indicated by Chaudhary (1950), the virus also infected soybean.

Observations on the occurrence and incidence of the disease in the field indicated that the disease incidence was lowest in crops sown on 24 October and 19 November in Jabalpur, Madhya Pradesh, India (Table 1). Crops sown early (4 October) or late (4, 12 December) showed higher disease incidences resulting in significant yield losses. Rogor checked disease spread by controlling the aphid vector. Bavistin had no significant effect on disease incidence.

Earliest infected plants showed greatest yield loss (Table 2), which agrees with the findings of Capoor and Varma (1950) on *Dolichos lablab*. Seed weight was also seriously reduced by the disease.

Table 1. Effect of sowing date, and application of Rogor and Bavistin, on the incidence of broad bean mosaic virus in *Vicia faba minor*, Jabalpur, India

Treatment and date of sowing	Disease index*	Average grain yield/plant (g)
4 Oct		
Rogor, 0.05%	26.66	185
Bavistin, 0.05%	33.33	155
Water (control)	40.00	129
24 Oct		
Rogor, 0.05%	6.60	320
Bavistin, 0.05%	13.30	224
Water (control)	21.30	210
14 Nov		
Rogor, 0.05%	6.60	430
Bavistin, 0.05%	18.00	337
Water (control)	25.30	314
4 Dec		
Rogor, 0.05%	14.30	240
Bavistin, 0.05%	25.30	211
Water (control)	30.60	192
24 Dec		
Rogor, 0.05%	16.00	205
Bavistin, 0.05%	25.30	202
Water (control)	32.00	190

* Average of three replicates.

Table 2. Assessment of losses due to broad bean mosaic virus at Jabalpur, India.

Date of tagging infected plants	Age of plants at tagging (days)	Number of plants	Average yield/plant (g)	Yield loss (%)	100-seed weight (g)
24 Nov	33	5	7.13	83.14	6.35
4 Dec	43	8	8.23	80.54	7.10
14 Dec	53	10	10.46	75.27	7.80
24 Dec	63	8	15.88	62.35	8.52
5 Jan	73	5	20.09	52.50	10.10
15 Jan	83	5	19.94	52.86	11.20
Healthy		20	42.30		16.36

Table 3. Spread of broad bean mosaic virus in different cultivars of *Vicia faba minor* in the field, Jabalpur, India.

Cultivar	Number of plants affected at weeks after planting* 4	8	12	Total	Percentage	Cultivar	Number of plants affected at weeks after planting* 4	8	12	Total	Percentage
VH 118	4	8	4	16	35.00	JV 70	3	1	0	4	6.25
VH 44	5	7	3	15	33.00	JV 9	3	1	1	5	7.81
VH 67	5	3	3	11	27.50	JV 3	4	1	1	6	11.66
JV 4	2	1	0	3	4.00	JV 32	2	3	0	5	6.25
Hissar Local	0	0	1	1	1.51	JV 6	0	2	0	2	4.00
VH 131	0	2	0	2	3.57	JV 22	0	3	0	3	5.45
JV 2-1	1	1	0	2	2.77	JV 36	2	1	0	3	4.54
VH 6	3	0	0	3	3.75	JV 20	3	5	2	10	14.28
JV 5	1	1	1	3	3.94	JV 29	3	1	0	4	6.66
VH 60	1	1	0	2	2.63	JV 68	3	1	1	5	7.46
VH 130	2	0	1	3	4.28	JV 13	2	1	0	3	4.28
VH 129	1	1	0	2	2.63	JV 11	2	2	0	4	8.51
VH 132	3	0	0	3	4.68	JV 30	3	2	0	5	7.81
VH 133	2	3	2	7	10.44	Malavi Black	0	0	0	0	0
VH 134	1	1	0	2	2.94	Malavi Mutant	0	0	0	0	0
Local mutant brown	2	0	0	2	2.59	JV 2	3	1	0	4	8.51
JV 27	4	4	0	8	12.30	Malavi Giant	0	1	1	2	5.40

* Average of three replicates.

Of the 34 cultivars tested, Malavi black and Malavi mutant were resistant to the disease (Table 3). High percentages of disease incidence were recorded in the varieties VH 44, VH 118, VH 67, JV 20, JV 27, VH 133, and JV 3.

These findings indicate that there are genotypic differences in susceptibility to insect transmission of disease as suggested by Swenson (1969).

Acknowledgements

The authors acknowledge the help of Prof O.P. Sharma during the course of this study.

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In Vitro Testing With 2,3,5 Triphenyl Tetrazolium Chloride (TTC) of Orobanche crenata Seed Metabolism

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Abstract

Metabolic activity of ***Orobanche crenata*** **seeds was tested** ***in vitro*** **with 2,3,5 triphenyl tetrazolium chloride (TTC) in artificial germination and storage experiments. A method is described to test seed viability and changes in metabolic activity occurring during experiments.**

Introduction

Orobanche crenata is a devastating parasite causing severe losses to faba bean yields in the Mediterranean region. The best long-term solution is to use resistant cultivars but sources of resistance are not easily identified, especially when experimental plots are not homogeneous and environmental effects are often mistaken for resistance (Pieters *et al.* 1984). Screening for resistance under controlled conditions seems the most promising approach (Aalders and Pieters, unpublished work) but under these conditions, the germination rate or viability of the *Orobanche* seed should be known.

If in resistance screening experiments infected faba bean cultivars have only a few *Orobanche* stems/plant, this may be due to resistance but also to low viability of the *Orobanche* seeds. Viability of *Orobanche* seeds cannot be tested using the normal procedure for determining the percentage seed germination because seed germination is host-dependent. In this paper a method is described with which *Orobanche* seed viability can be tested, and some observations on the effect of storage conditions and germination tests on *Orobanche* seed metabolism are discussed.

Materials and Methods

Seed viability was estimated from the percentage of seeds with metabolic activity, which was tested with TTC (Smith 1951). The color of *Orobanche* seed testae was removed by washing in a 6% hypochlorite solution. After discoloration the seeds were thoroughly rinsed with water, placed in a 1% aqueous solution of TTC, and incubated for two to three days in the dark at 25°C. After incubation, viable seeds were stained red while dead seeds remained discolored.

The effect of 10 different storage conditions on seed longevity was tested (Table 1). The total length of the experiment was 11 months (Sept 83-Sept 84) using seeds harvested in June 1983. In the first two months, metabolic activity was tested every two weeks, and thereafter every three months.

Table 1. Tested storage conditions.

	Humidity*	Temperature °C	Light
I	low	-4	
IIa	low	8	
IIb	high	8	
IIc	moderate	8	Dark
IIIa	low	15-25	
IIIb	high	15-25	
IIIc	moderate	15-25	
IVa	low	15-25	
IVb	high	15-25	Light/dark
IVc	moderate	15-25	

* Seeds were stored in glass test tubes, which were placed in closed plastic jars containing either silica gel (low humidity), water (high humidity), or nothing (moderate humidity).

Seed metabolism was investigated in two germination experiments using root juice and live roots. In the root juice experiment *Orobanche* seeds were treated with 6% hypochlorite and placed in petri-dishes containing either three layers of moist filter paper, or moist, sterilized sand covered by one layer of filter paper. Seeds were incubated for 18 days at room temperature (15-25°C). After incubation, filtered root juice was added and seeds were tested at regular intervals from the start of the experiment until five days after the juice was added.

In the germination experiment with living roots, either hypochlorite-treated or untreated seeds were mixed with chopped agar in glass test tubes (length 18 cm, diameter 1.7 cm). The tubes were incubated in the dark for two weeks at 15-25°C. Pre-germinated faba bean seeds (varieties F 269 and F 305) were then put on top of the agar, so that their roots could grow into it, and the tubes placed in daylight. Each tube was enveloped to keep the *Orobanche* seeds dark. Treatments were duplicated and two test tubes, one with treated and the other with untreated seeds, were prepared for seed staining. Seed staining was done three times during the experiment: at the start; when the faba seeds were placed; and, only for treated *Orobanche* seeds, at the end of the experiment (four weeks after placing the faba bean seeds). The germination rate was recorded at regular intervals.

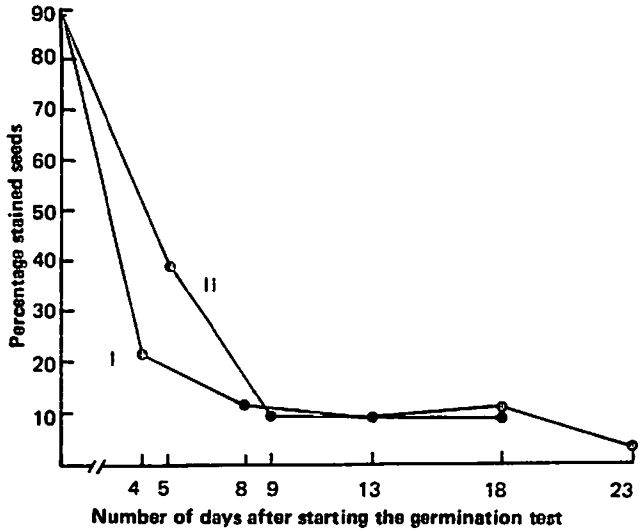

Fig. 2. Decline of percentage stained Orobanche seeds during the germination test (18 days after starting the test germination stimulant was added). I = on filter paper; II = on sterized sand.

Results and Discussion

The results of the storage experiment are presented in Fig. 1. A rapid decrease in percentage stained seeds occured in the high humidity group, which was delayed by low temperature (IIb). In the low and moderate humidity groups, staining remained constantly high, except for treatment IIIc in which molds developed. Molds developed on all seeds stored at high humidity and this may have contributed to the observed decline in seed viability. Temperature did not have a major effect on viability.

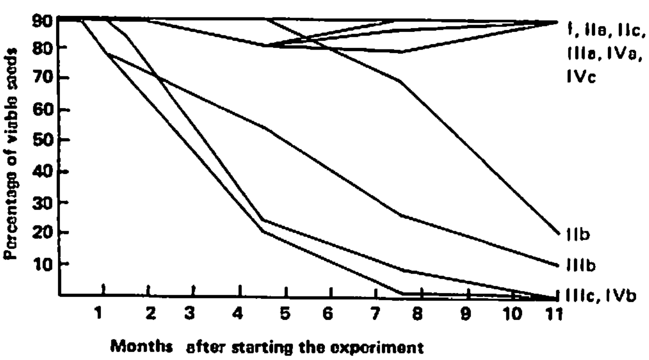

Fig. 1. The effect of different storage conditions on the longevity of Orobanche seeds.

In the germination experiment with root juice, a rapid decline in percentage stained seeds occurred (Fig. 2). In the first four days of the test, staining decreased from 88% to 25%. After eight days, staining stabilized at 10%, but five days after the addition of root juice it dropped to 2%. No significant differenes in reaction were observed between seeds placed on filter paper or on sand.

Staining at the start of the test tube experiment was 90%. After two weeks, when the pre-germinated faba bean seeds were placed, staining had dropped in the untreated and treated seeds to 15% and 1% respectively. *Orobanche* seeds started to germinate, 10-15 days later, in the upper part of all test tubes. The treated seeds seemed to germinate earlier but after two weeks no clear differences in germination rate between treated and untreated seeds were observed. Germination mainly occurred near the older root tissue (up to 35%). No germination was observed in the lower parts of the tubes, where the bean roots did not reach (Fig. 3). None of the seeds of the lower zone reacted with TTC while only 30-35% of the seeds in the upper zones of the test tubes were non-stained.

There is virtually no metabolic activity in dry *Orobanche* seeds otherwise reserves would be depleted very quickly. Contact with free water boosts metabolism (this happens in the first two days of the TTC test) but prolonged contact with free water causes a sharp drop in metabolic activity, as seen in both germination experiments. However seeds did not die but became dormant. The results of the living root experiment showed that, as soon as seeds came into contact with root exudates, their metabolism

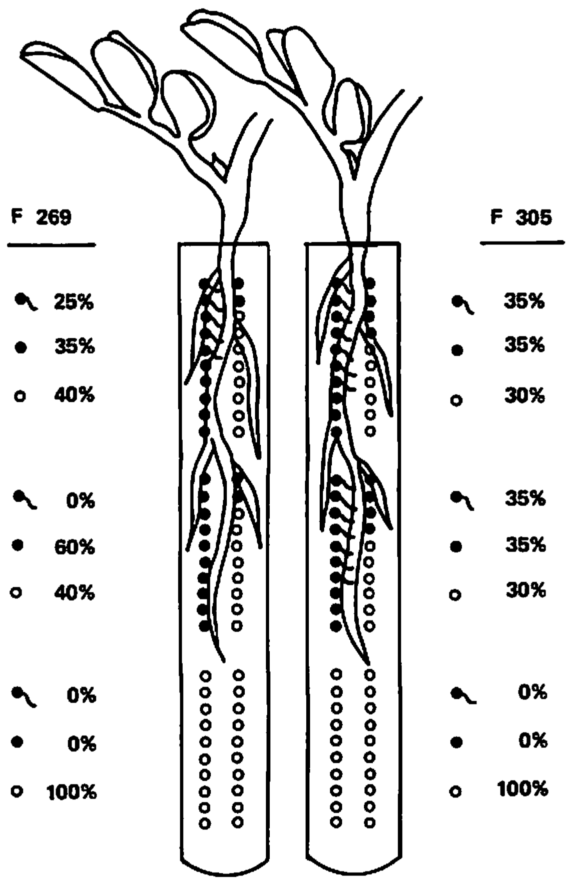

Fig. 3. The percentage germinated, non-germinated, stained (•), and non-stained (o) Orobanche seeds, at three different zones of test tubes with resp. F 269 and F 305 as host, 6 weeks after starting the experiment.

increased again and subsequently some of them germinated. Stimulating seed germination with filtered root juice obviously did not work. Pieterse *et al.* (1984) found that, when *Striga* seeds were kept under prolonged wet conditions without germination stimulants, germination rate declined and dropped almost to zero in about 12 weeks. During that time the percentage stained seeds remained more or less the same indicating that the seeds had entered into a dormant stage. Unlike *Orobanche* seeds, however, *Striga* seeds also reacted with TTC when dormant. It may be that the duration of the TTC test was too short (2 days) for dormant *Orobanche* seeds to cause detectable staining. Pieterse *et al.* (1984) incubated *Striga* seeds for 5 days.

The aim of the hypochlorite treatment was to discolor the testae and so detect embryo staining. It also resulted in the removal of the dark colored germination inhibiting compounds (Cezard 1973).

The TTC test can be useful in artificial inoculation experiments to examine the viability of seed samples and so avoid error due to a poor inoculum. During germination experiments metabolic activity of *Orobanche* seeds can be monitored, revealing their reaction to the test treatments at an early stage.

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Seed Quality and Nutrition

Correlation Between Tannin Content and Testa Color in Faba Beans (Vicia faba L.)

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Abstract

Four segregants for testa color from the faba bean variety Polycarpe and a selection of white faba beans were tested both qualitatively and quantitatively for tannins. White seed testae were found to be tannin-free while colored testae contained tannins. The darker the testa color, the greater the polyphenol content. Tannin accumulation began early in seed development of Polycarpe faba beans.

Introduction

Tannins are water-soluble compounds of relatively high molecular weight (500-3000), containing a large number of phenolic hydroxyls or other groups which form effective cross-links between protein, cellulose, and other macromolecules (Swain 1965). In this study, the term tannin refers to the condensed form that has been isolated and purified from the seed coat of faba beans (Marquardt *et al.* 1978).

The interactions of tannins with proteins may play a role in the anti-nutritional effects of tannin-containing feeds which have been observed in nonruminants (Martin-Tanguy *et al.* 1977). Tannins have also been reported to affect plant resistance to insects and other pathogens (Swain 1979). This demonstrates the significance of the tannin content of faba beans and the need for further investigation into their biosynthesis and their role within the plant.

In this paper we report our results on the correlation between the color and tannin content of the testa.

Materials and Methods

This study used four segregants for testa color from the variety Polycarpe, and a selection of white colored faba beans (presumably tannin-free) subjected to selfing for two generations. The segregants for the colored seeds were phenotypically selected.

Seed testae were tested qualitatively using the brown color developed by tannins when testae were added to 5 ml of 0.1 M NaOH and exposed to light for 1 hour (Marquardt *et al.* 1978). Subsequently, all five testa-color classes were ground (20 mesh) and tested quantitatively for phenol and polyphenol content according to the Folin-Denis and Vanillin-HCl methods respectively (Burns 1963). Standard curves were constructed with commercial tannic acid and catechin, respectively.

Tannin presence and accumulation in the seed were studied with two histochemical methods according to Tsekos (1967). Sections of white and light brown to black colored testae were placed in one drop of $FeCl_3$ and Vanillin-HCl reagents respectively, for a few minutes. The black-gray color in the first case and the red-violet in the second denoted the presence of tannins. Finally, sections of fresh seeds (15 days after pollination) were tested with Vanillin-HCl reagent.

Results

1. Qualitative method

Application of the qualitative assay of Marquardt *et al.* (1978) for tannin content showed that the white colored seeds were indeed tannin-free, while all colored testae contained tannins (Table 1).

Table 1. Tannin presence or absence based on color formation when testae were added to 0.1M NaOH.

Testa color	Tannin presence* or absence°
black	*
dark-brown	*
brown	*
light-brown	*
white	o

2. Folin-Denis method

All four segregants with colored seeds had the same phenol content, which was about 11 times the value for the white seeds (Table 2).

3. Vanillin-HCl method

Contrary to the Folin-Denis method, there were remarkable differences in polyphenols with the Vanillin-HCl method. The values for polyphenol content increased with the darkening color of the testae. Seeds with white testae contained traces of polyphenols while the polyphenol content of colored seeds varied from 1.69 to 3.13% (Table 3).

4. Histochemical analyses

The presence or absence of tannins was confirmed histochemically with $FeCl_3$ and Vanillin-HCl reagents (Table 4). White colored seeds were free of tannins while the dark colored ones gave a positive color reaction confirming the presence of tannins. Tannin accumulation began at the early stages of seed development in dark seeded types, as indicated by the intense red-violet coloration formed in sections of fresh field beans (15 days after pollination) with the addition of Vanillin-HCl reagent.

Discussion

The results indicate that tannin content is strongly correlated to testa color. The differences in polyphenol content (tannins) and the similarities in phenol content among the five testa-color classes indicate a difference in the degree of phenol polymerization. White colored seeds had traces of polyphenols and low phenol contents, which agrees with the findings of Picard (1976). He reported that the tannin-free character was controlled by two complementary recessive genes whose action affected seed-coat color.

Tannins are effective as a defense mechanism against herbivores and it has been suggested that they protect plants against fungal and bacterial attack (Swain 1979). Therefore reducing the tannin content would lower the plants' defenses. Light brown faba beans, which contain some tannin, do not cause nutritional problems so are probably the most desirable of the colored beans. Finally, as tannins

Table 2. Phenol content of different colored testae as measured by absorbance at 725 nm against a tannic acid standard.

Testa color	Tannic acid equivalents (mg)	Approximate tannin content (%)
black	0.218	11.0
dark-brown	0.216	11.0
brown	0.217	11.0
light-brown	0.215	11.0
white	0.0223	1.0

Table 3. Polyphenol content in different colored testae as measured by absorbance at 500 nm against a catechin standard.

Testa color	Catechin content (mg)	Polyphenol content (%)
black	0.313	3.13
dark-brown	0.274	2.74
brown	0.226	2.26
light-brown	0.169	1.69
white	0.022	0.2

Table 4. Presence of tannin as shown by histochemical reaction.

Testa color	Histochemical reaction with	
	$FeCl_3$	Vanillin-HCl
black	black-gray	red-violet
dark-brown	black-gray	red-violet
brown	black-gray	red-violet
light-brown	black-gray	red-violet
white	no change	no change
fresh field beans		red-violet

are present early in seed development, the tannin problem cannot be avoided by using fresh, colored faba beans.

Acknowledgements

This work was financially supported by the Greek Ministry of Agriculture.

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ICARDA's historical background and research objectives are outlined in English or Arabic. For your copy, contact Communications and Documentation.

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Field Guide to Major Insect Pests of Faba Bean in the Nile Valley
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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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Agriculture Canada
Marketing and Economics Branch,
Room 577, 930 Carling Bldg.,
Ottawa, Canada K1A OC5.

Reprints

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:

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

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We are having many items of correspondence returned, due to those on our mailing list having changed their addresses or left their place of employment without notifying us. Obviously this represents a considerable waste of money to the FABIS service.

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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International Center for Agricultural Research in the Dry Areas (ICARDA) P.O. Box 5466 Aleppo, Syria	Lentil, chickpea, and faba bean.
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Patancheru P.O. Andhra Pradesh 502 324, India	Chickpea, pigeonpea, and groundnut.
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1 March-20 June 1986

The course will cover the following topics: breeding, agronomy/crop physiology, statistical methods, nutrition, crop protection, mechanization, farming systems, and communication. There will be lectures, practical field and laboratory exercises, seminars, informal discussions, and individual experiments, supervised by the Senior Training Officer in food legumes and assisted by international scientists working on legume improvement.

Candidates should have reasonable proficiency in oral and written English. They must be nominated from the national agricultural research program and have a diploma or BSc in agriculture, with a current assignment in the national program.

Further information from
Food Legume Improvement Program,
ICARDA, P.O.Box 5466, Aleppo, Syria

Training course on Disease Epiphytotics and Identification of Resistance in Food Legumes,
Lattakia, Syria, 4-18 March 1986

The course is organized by the Food Legume Improvement Program of ICARDA and aims to improve participants' skills in artificial disease creation and use of disease scales. There will be theoretical training as well as training in laboratory and field skills. Candidates should have a university degree in agriculture and be working on food legume pathology on breeding for disease resistance.

Requests for further information and applications on the appropriate forms should be sent to:

Food Legume Improvement Program
ICARDA, P.O.Box 5466, Aleppo, Syria

This issue of **FABIS Newsletter** is the first publication entirely composed using the ICASET typesetting system developed at ICARDA for laser printers.

Contributors' Style Guide

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

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

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

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

Manuscript
Articles should be typed double-spaced on one side of the page only. The original and two other legible copies should be submitted. The contributor should include his name and initials, title, program or department, institute, postal address, and telex number if available. Figures should be drawn in India ink; send original artwork, not photocopies. Define in footnotes or legends any unusual abbreviations or symbols used in a figure or table. Good quality black and white photographs are acceptable for publication. Photographs and figures should preferably be 8.4 cm or 17.7 cm wide.

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

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

Examples of common expressions and abbreviations
3 g; 18 mm; 300 m^2; 4 Mar 1983; 27%; 50 five-day old plants; 1.6 million; 23 μg; 5°C; 1980/81 season; 1980-82; 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 differences = 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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Submission of articles
Contributions should be sent to FABIS/Documentation Unit/ICARDA/P.O. Box 5466/Aleppo, Syria.

FABIS 13/1200/December 1985