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(ICARDA)

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COVER PHOTO: Faba bean infested with broomrape (*Orobanche*).

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Breeding and Genetics

Genetic Behavior of Yield and Quality Traits of Vicia faba L.

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Abstract

An experiment was conducted with 25 diverse genotypes of faba bean (*Vicia faba* L.) during the winter seasons of 1984–85 and 1985–86 to study the genetic behavior of seed yield/plant, physical characters of the seed, and nutritional traits. A wide range of variation was recorded in almost all the characters. Phenotypic and genotypic variation were highest for hydration coefficients among physical characters of the seed, carbohydrate content, and hemagglutinin activity unit among nutritional attributes. Genotypic coefficients of variation ranged from 6.15 (catyledons percentage) to 27.49 (protein/seed) for physical characters of the seed; 4.36 (manganese content) to 38.91 (magnesium content) for nutritional attributes; and 30.63 (stachyoze content) to 44.89 (hemagglutinin activity unit) for antinutritional traits. All the observed characters had high heritability (> 85%). Seed yield/plant had nonsignificant association with all the observed qualitative traits.

Introduction

Seed yield is a complex character, controlled by several genes. The genetic improvement in yield and quality is dependent on the nature and magnitude of genetic variability, and association of yield with quantitative and qualitative characters. Therefore, a critical survey of genetic variability is a prerequisite for successful planning and evaluating a breeding program for quality improvement. This investigation was performed to study the relationships between quality characters and seed yield/plant in faba bean.

Materials and Methods

Using a randomized complete block design with four replications and a plot size of 5 × 2 m, 25 genotypes of faba bean were grown during the winter seasons of 1984–85 and 1985–86 at the Livestock Farm, J. N. Agricultrual University, Jabalpur (M.P.) India (29.3°N, 79.58°E. Altitude: 411.87 m). At maturity, 10 competitive plants of each replication were selected for observations on seed yield/plant (g); 100-seed weight (g); hydration coefficient; swelling coefficient; hull (%); cotyledon (Dal) percentage; cooking time (min.); hard seed (%); protein/seed; protein (%) (AOAC 1965); carbohydrate (%) (Hassid and Abrahim 1957); total amino acid (Lee and Takahashi 1966); oil (%) (AOAC 1965); phosphorus (Jackson 1967); potassium (flame photometer), calcium, and magnesium (Motiramani and Wankhde 1964); zinc, iron, manganese, and copper (atomic absorption spectrophotometer); phenol (Bray and Thorpe 1954); tannin (Burns 1971); sucrose and raffinose (Shelter and Masters 1957); stachyose (Cerning 1975); phytic acid (Holt 1955); trypsin inhibitor unit (TIU) (Kakade et al. 1969); and hemagglutinin activity unit (HAU) (Liener 1955).

The data were statistically analyzed for expected genetic advance (Johnson et al. 1955), genetic coefficient of variation (Burton 1952), and heritability. Genetic constants were calculated by adopting standard statistical procedure (Burton 1952). Correlation coefficients of seed yield per plant with all the observed characters were also computed.

Results and Discussion

Mean squares showed significant variation among the genotypes for all the observed characters except protein/seed. A wide range of variation was recorded for all the observed characters (Table 1). Among the nutritional characters, protein and carbohydrate contents had the maximum ranges. HAU had the maximum range among antinutritional characters. Table 1 shows that sufficient genetic variability is present in the germplasm for all the characters observed. It is in agreement with the report of El-Tabey et al. (1985) for physical characters of the seed; Jalal et al. (1984) for protein; Newton and Hill (1983) for carbohydrates; Sosulski and Dabrowski (1984) for phenol; Gorski et al. (1985) for tannin; Valdebouze et al. (1980) for trypsin-inhibitor activity; Grant et al. (1983) for hemagglutinin activity; and Elkowicz and Sosulski (1982) for phytic acid.

Attributes observed as physical characters of the seed (Table 2) had high phenotypic variance, accompanied by high genotypic variance except protein/seed. The maximum variation caused by environment was observed for hard seed percentage. Estimates of genotypic variance over environmental variance for hydration coefficient, swelling coefficient, and hard seed percentage indicate that these variations are higher than variations due to nongenetic causes. Maximum heritability was observed for hull percentage and cooking time; all the remaining characters also had high heritability. Additionally, 100-seed weight, hull percentage, protein/seed, cooking time,

Table 1. Range, mean, standard deviation and mean sum of squares of observed seed characters of *Vicia faba* L.

Character	Range of variations: Minimum	Range of variations: Maximum	Mean	SE±	Mean sum of squares
Seed yield/plant (g)	15.05	28.00	20.59	8.90	79.24
Physical Characters:					
100-seed wt. (g)	12.30	29.75	19.36	8.60	74.08
Hydration coeff. (%)	48.50	225.25	177.55	42.60	1815.32
Shelling coeff. (%)	161.00	250.75	185.54	41.57	1728.16
Hull (%)	9.72	19.52	13.79	6.05	36.60
Dal recovery (%)	67.93	92.07	84.62	11.15	124.44
Protein/seed (%)	0.021	0.064	0.046	0.008	7.2×10^{-4}
Cooking time (min.)	34.25	66.00	57.32	19.08	364.33
Hard seed (%)	32.25	94.75	65.95	35.40	1253.53
Nutritional Characters:					
Protein (%)	17.60	30.12	23.92	7.24	52.56
Oil (%)	0.91	2.01	1.32	0.62	0.3828
Carbohydrate (%)	36.50	62.50	42.94	12.38	153.49
Total amino acid (%)	0.74	1.49	0.99	0.44	0.1984
Potash (%)	0.81	1.49	1.05	0.39	0.1596
Phosphorus (%)	0.42	0.88	0.65	0.29	0.0846
Ca (%)	0.60	1.12	0.83	0.25	0.0612
Mg (%)	0.91	1.61	1.18	0.39	0.1554
Cu (ppm)	0.90	1.39	1.009	0.20	0.0402
Fe (ppm)	3.00	5.17	4.42	0.73	0.5352
Mn (ppm)	12.83	16.67	15.43	1.50	2.2528
Zn (ppm)	4.05	7.19	5.79	2.05	4.2360
Antinutritional Characters:					
Phenol (mg/g)	0.14	1.00	0.61	0.51	0.2648
Tannin (mg/g)	0.39	0.89	0.58	0.37	0.1441
Raffinose (mg/g)	0.065	0.27	0.16	0.12	0.0152
Stachyose (mg/g)	0.21	0.77	0.53	0.32	0.1065
Sucrose (mg/g)	1.03	2.79	1.66	1.10	1.2225
TIU/mg	0.57	3.02	1.70	1.54	2.3852
Phytic acid (mg/g)	0.33	0.99	0.50	0.36	0.1336
HAU/mg	1.08	6.87	2.92	2.72	7.4504

Table 2. Genetic parameters of variation for physical characters of *Vicia faba* L. and their association with seed yield/plant.

Character	Variances			Heritability (%)	Expected genetic advance	G. A. as % of mean	PCV (%)	GCV (%)	Correlation		
	Phenotypic	Genotypic	Environmental						Phenotypic	Genotypic	Environmental
Seed yield/plant (g)	19.81	13.41	6.40	0.37	6.80	30.10	21.62	17.78	—	—	—
100-seed wt. (g)	18.52	17.17	1.34	0.93	8.23	42.49	22.22	21.40	0.161	0.238	0.274
Hydration coefficient (%)	453.83	424.61	29.22	0.94	41.06	23.12	12.00	11.61	-0.062	-0.120	0.007
Swelling coefficient (%)	432.04	403.49	28.56	0.93	39.99	21.55	11.20	10.83	0.083	-0.003	0.167
Hull (%)	9.15	8.75	0.40	0.96	5.96	43.20	21.93	21.44	-0.034	-0.164	-0.095
Dal recovery (%)	31.11	27.11	4.00	0.87	10.01	11.82	6.59	6.15	0.179	0.250	0.016
Protein/seed (g)	0.00018	0.00016	0.002	0.88	0.025	52.87	29.16	27.49	-0.038	-0.027	-0.099
Cooking time (min.)	91.08	86.84	4.24	0.95	18.74	32.69	16.64	16.25	-0.151	-0.169	-0.107
Hard seed (%)	313.38	281.20	32.18	0.89	32.72	49.61	26.84	25.42	-0.317	-0.284	-0.197

and hard seed percentage had high heritability accompanied by high genetic advance, indicating the major contribution of additive gene effect with least environmental influence. Association analysis of seed yield/plant, with observed physical characters of the seed, indicates the possibility of improvement of the physical quality of seed without significantly altering the plant's yield, and vice versa.

Protein, carbohydrate, zinc, manganese, and iron content were the nutritional traits with high phenotypic and genotypic variability with negligible environmental influence (Table 3). Oil percentage expressed maximum, and manganese had minimum phenotypic and genotypic coefficient of variation. All the observed nutritional characters of the seed had high heritability. High heritability of protein percentage suggests the possibility of its improvement through direct selection, which is in agreement with the finding of Mohamud et al. (1984). The oil, total amino acid, potash, phosphorus, magnesium, and zinc content in seed had high heritability with high genetic advance as percentage of mean, indicating that improvement for these characters by selection is possible. Protein, carbohydrates, calcium, and iron content had high heritability and medium genetic advance as percentage of mean, indicating more sensitivity to the environment. All the observed nutritional characters had nonsignificant association with seed yield per plant, suggesting that these characters are under the control of different sets of genes.

Antinutritional traits exhibited low amount of phenotypic and genotypic variance (Table 4) with maximum phenotypic and genotypic variance for hemagglutinin activity. Environment effect on antinutritional characters of the seed was negligible. Genotypic and phenotypic coefficient of variation was high for all the observed antinutritional characters, and a parallel trend was observed for relative magnitude of variability at both the genotypic and phenotypic levels. All antinutritional factors had high heritability (ranges from 0.80% to 0.99%) with high genetic advance as percentage of mean indicating that they can be reduced by direct selection. There was no association of these factors with seed yield/plant.

Wide variability, less influence of environment, high heritability with high genetic advance as percentage of mean, and nonsignificant association of all the qualitative characters with seed yield per plant revealed that direct selection can be adopted for the improvement of both qualitative and quantitative traits without significantly altering each other.

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Table 3. Genetic parameters of variation for nutritional characters of *Vicia faba* L. and their association with seed yield/plant.

Character	Variances			Heritability (%)	Expected genetic advance	G. A. as % of mean	PCV (%)	GCV (%)	Correlation		
	Pheno-typic	Geno-typic	Environ-mental						Pheno-typic	Geno-typic	Environ-mental
Protein (%)	13.14	12.63	0.51	0.96	7.18	30.01	15.16	14.86	-0.133	-0.184	0.043
Oil (%)	0.09	0.09	0.0001	0.99	0.64	48.53	23.48	23.46	-0.185	-0.067	0.038
Carbohydrate (%)	38.37	36.790	1.58	0.95	12.24	28.50	14.43	14.13	-0.265	-0.248	0.002
Total amino acid (%)	0.05	0.05	0.0001	0.99	0.46	46.19	22.37	22.35	-0.019	-0.032	0.002
Potash (%)	0.04	0.04	0.0003	0.99	0.41	39.01	19.03	18.95	0.172	0.239	0.009
Phosphorus (%)	0.02	0.02	0.0002	0.99	0.30	35.32	22.75	22.64	0.196	0.246	0.007
Ca (%)	0.02	0.02	0.008	0.94	0.24	28.70	14.74	14.48	0.038	0.229	0.065
Mg (%)	0.04	0.04	0.0002	0.95	0.38	32.05	16.63	16.22	0.036	0.110	-0.207
Cu (ppm)	0.01	0.009	0.0002	0.97	0.20	19.80	9.95	9.85	0.122	0.139	0.149
Fe (ppm)	0.38	0.38	0.009	0.99	1.27	28.74	14.03	14.00	0.096	0.235	-0.016
Mn (ppm)	0.56	0.56	0.0001	0.99	1.54	9.98	4.87	4.86	-0.200	-0.162	-0.060
Zn (ppm)	1.06	1.06	0.0012	0.99	2.12	36.61	17.77	17.76	0.098	0.069	0.088

Table 4. Genetic parameters of variation for antinutritional characters of *Vicia faba* L. and their association with seed yield/plant.

Character	Variances			Heritability (%)	Expected genetic advance	G. A. as % of mean	PCV (%)	GCV (%)	Correlation		
	Pheno-typic	Geno-typic	Environ-mental						Pheno-typic	Geno-typic	Environ-mental
Phenol (mg/g)	0.07	0.06	0.0008	0.98	0.52	85.82	42.18	41.92	0.046	0.054	-0.112
Tannin (mg/g)	0.04	0.03	0.0006	0.98	0.38	65.18	32.19	31.92	0.081	-0.078	-0.149
Raffinose (mg/g)	0.003	0.003	0.0001	0.97	0.12	74.49	37.22	36.73	0.113	-0.185	-0.141
Stachyose (mg/g)	0.03	0.02	0.0002	0.99	0.33	62.87	30.75	30.63	0.083	0.030	0.084
Sucrose (mg/g)	0.31	0.30	0.0042	0.98	1.12	67.48	33.22	32.99	-0.149	0.324	0.042
TIU/mg	0.59	0.48	0.1141	0.80	1.28	75.44	45.27	40.72	0.138	0.336	0.044
Phytic acid (mg/g)	0.03	0.03	0.0002	0.99	0.37	74.11	36.33	36.18	-0.179	0.315	0.251
HAU (mg/g)	1.86	1.72	0.1420	0.92	2.60	88.87	46.65	44.89	-0.024	-0.153	0.063

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السلوك الوراثي للغلة وصفات الجودة في الفول

الملخص

خلال الموسمين الشتويين 1984 – 85 و 1985 – 86 نفذت تجربة باستعمال 25 طرازا وراثيا متنوعا من الفول .*Vicia faba* L، وذلك لدراسة السلوك الوراثي للغلة البذرية/النبات، والخواص الفيزيائية للبذرة، والصفات الغذائية. وتم تسجيل مدى واسع من الاختلافات في جميع الصفات تقريبا. وكانت الاختلافات المظهرية والوراثية على أشدّها فيما يخص معاملات التميّه بين الخواص الفيزيائية للبذرة، ومحتواها السكري، ووحدة نشاط الهيماغلوتينين بين الصفات الغذائية. وقد تراوحت معاملات الاختلاف للطرز الوراثية بين 6.15 (كنسبة مئوية للكاتيليدون) إلى 27.49 (بروتين/الحبة) للصفات الفيزيائية للبذرة، ومن 4.36 (محتوى منغنيزي) إلى 38.91 (محتوى مغنيزيومي) للصفات الغذائية، ومن 30.63 (محتوى ستيكوزي) إلى 44.89 (وحدة نشاط الهيماغلوتينين) للخواص الغذائية المضادة. وظهر لجميع الصفات المدروسة قدرة عالية على التوريث (أكبر من 85 ٪)، ولم ترتبط الغلة البذرية/النبات معنويا بالخواص النوعية المشاهدة.

Protein Polymorphism among Genotypes of Faba Bean from Afghanistan and Ethiopia

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Abstract

Electrophoretic analyses (SDS-PAGE) on 64 faba bean genotypes identified in accessions from Afghanistan and Ethiopia and characterized by specific storage protein "patterns" are presented. The investigation aimed at assessing a better identification among genotypes and their uniformity. Differences among genotypes were found, but a high uniformity level was observed within them. Preliminary information on genetic control of some single protein fractions was also obtained.

Introduction

Food legumes are of special social, nutritional, and economic significance as they supply vegetable protein, oil, and calories to the diets of millions of people (Al-Jibouri 1988). In the past, faba bean's nutritional contribution could be improved through increased yields, increased protein content, or improved protein quality (Sjodin, 1982). However, the close relationship among these three factors limits this improvement. According to Bond (1987), the major objective of most breeders was to try to increase or stabilize yield. More recently, the emphasis has shifted somewhat toward quality improvement.

To improve protein quality, it is necessary to change the amino-acid composition since faba bean and like legumes are deficient in the sulphur amino-acids methionine and cystine. Muntz et al. (1986) reviewed the structure, molecular polymorphism and genetics of *Vicia faba* L. proteins. A knowledge of the genetic variability of the different protein fractions (albumins, globulins, etc.) and possibly subfractions, such as legumin, and their variation in relation to changes in protein content is essential to maximize progress in breeding for quality (Cubero 1984).

At Bari Gene Bank, a recent investigation by Polignano et al. (1990) on a set of entries from Ethiopia and Afghanistan has revealed a wide variation in seed protein electrophoretic "patterns." The object of the present investigation was to obtain on the basis of protein patterns a better characterization among some genotypes selected in our previous studies and to get preliminary information about heritability of particular protein.

Materials and Methods

The material analyzed consisted of 64 genotypes selected from Ethiopian (23) and Afghani (41) accessions. Also, hybrid seed from a cross between two genotypes, MG 109295/3 (P_1) and MG 109272/1 (P_2) differing in protein patterns were used. According to previous results (Polignano et al. 1990) the two patterns J and M characterize respectively the parental genotypes P_1 and P_2. The selfed genotypes were grown in 1987–88 under bee-proof cages at Valenzano near Bari in southern Italy; crosses were made during spring 1989.

For the electrophoretic analyses, samples of three S_2 seeds for each genotype were utilized. Protein extracts were done as described in our previous work (Polignano et al. 1986). The protein subunits were electrophoretically separated by one-dimensional sodium dodecyl sulphate polyacrilamide gel electrophoresis (SDS-PAGE). The procedure for SDS-PAGE was similar to that described previously (Polignano et al. 1986, 1990) and according to Laemmli (1970), using 17% polyacrylamide gel slabs overlaid with a 3% stacking gel. Patterns were compared on the basis of relative mobility (Rf), presence or absence, and density of the bands with intermediate mobility as previously reported (Polignano et al. 1990).

Results and Discussion

Representative banding patterns of proteins from individual seeds of *V. faba* selfed genotypes from Afghanistan and Ethiopia are shown in Figures 1 and 2, respectively. A total of 11 different protein patterns were identified in the material examined. A wide range of polymorphic levels characterizes the intermediate zone with Rf 0.43–0.56.

Table 1 reports the frequency distributions of the different seed protein patterns in the 64 tested genotypes according to the 16 patterns described by Polignano et al. (1990). Both origins revealed high frequencies of patterns A, M, and O. Low frequencies were recorded for patterns E, F, and G. Patterns B, J, and P were detected only in genotypes from Afghanistan; by contrast, the patterns K and H were present in a few samples from Ethiopia. Patterns C, D, I, L, and N were absent in both origins.

Pattern variants, A, M, and O characterized by one or two major subunits with Rf 0.50 and 0.51 are quite common among faba bean genotypes in both origins. The slower-moving band with Rf 0.46 characterizes the pattern M. As can be seen in the protein patterns, the heaviest-staining arrowed polypeptide group is present in the intermediate region. Reports by several authors indicate that this group corresponds to the major globulin fraction, particularly legumin (Muntz et al. 1986; Rao and Tucci 1988; Polignano et al. 1990). Very recently Polignano et al. (1990) have shown a wide distribution of electrophoretic variants for this group of medium moving subunits.

Visual examination of electrophoretic patterns (Figures 1 and 2) limited to the intermediate region having Rf 0.43–0.56 showed appreciable variation among different genotypes, whereas high uniformity was observed within them. The main difference among genotypes is evident for the presence or absence and intensity of medium moving subunits, particularly the slowest ones (Rf 0.45–0.47). With a few exceptions, the majority of genotypes appeared to be uniform in their protein patterns.

Preliminary data on the genetic control of a single major globulin subunit with intermediate mobility (Rf 0.43–0.56) are shown in Figure 3. Analysis of single hybrid seeds of both-way F_1 combinations (M × J and J × M)

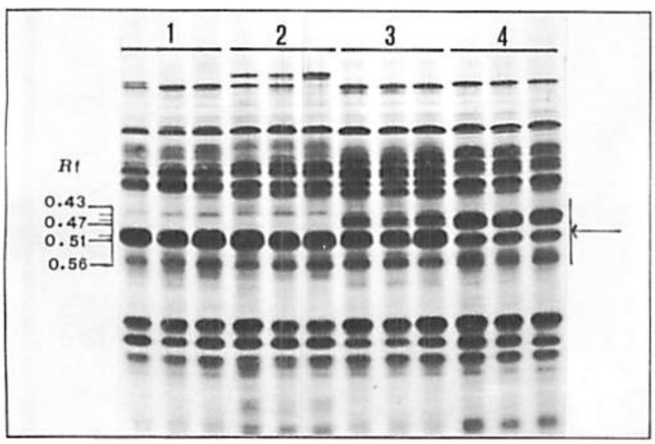

Figure 1. Electrophoretic "patterns" of seed storage proteins in some genotypes of faba bean from Afghanistan; (1) MG 109307/2, (2) MG 109310/3, (3) MG 109498/2, (4) MG 109499/1.

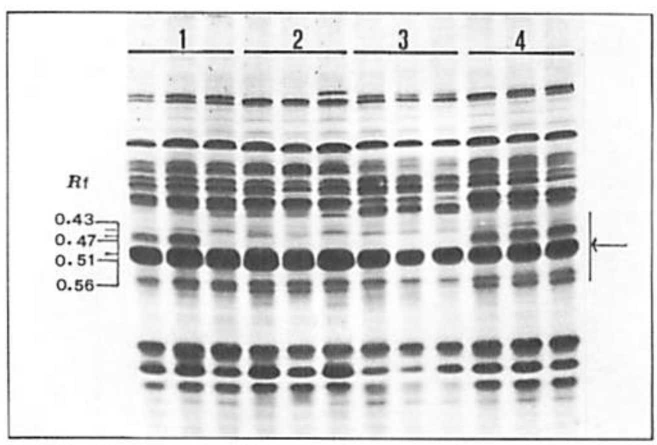

Figure 2. Electrophoretic "patterns" of seed storage proteins in some genotypes of faba bean from Ethiopia; (1) MG 106476/2, (2) MG 108335/3, (3) MG 108957/3, (4) MG 108972/3.

showed a banding pattern intermediate between the two parental patterns J (P_1) and M (P_2). Clear distinction between these patterns is evident for the largest subunits (arrowed bands) that correspond to the major portion of globulin fraction rich in ∝-legumin. Hybrids J × M and M × J display an identical intermediate pattern.

The variation for seed protein patterns observed in the investigated 64 genotypes of *V. faba* L. confirms the usefulness of the Afghani and Ethiopian gene pools in breeding for protein characters. This was shown previously by surveying the whole collection of faba bean from both origins mentioned (Polignano et al. 1990). The wide variation for seed storage protein in these materials contrasts with the limited variation observed in Mediterranean region (Polignano et al. 1986); this evidence seems to indicate that domestication process in Mediterranean area has induced a genetic drift of these proteins.

In all genotypes, most polymorphism was detected among the polypeptides with molecular weights greater than 45,000 KD. Most subunits are relatively constant within single pattern; however, some heavily-staining polypeptides are present and stain strongly only in certain

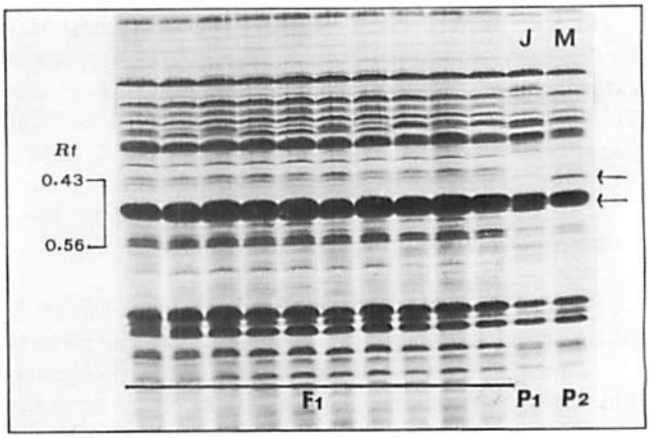

Figure 3. Electrophoretic "patterns" of seed storage proteins in hybrids (F_1) and parental lines P_1 (MG 109295/3) and P_2 (MG 109272/1) characterized by contrasting "patterns"; J (P_1) and M (P_2).

Table 1. Frequency distributions of seed protein patterns in selfed genotypes of faba bean from Afghanistan and Ethiopia (after Polignano et al. 1990).

Patterns (1)	Origin				Total	
	Ethiopia		Afghanistan			
	Number	%	Number	%	Number	%
A	15	22.4	28	21.8	43	22.0
B	—	—	3	2.4	3	1.5
C	—	—	—	—	—	—
D	—	—	—	—	—	—
E	1	1.5	3	2.4	4	2.0
F	1	1.5	3	2.4	4	2.0
G	1	1.5	3	2.4	4	2.0
H	1	1.5	—	—	1	0.5
I	—	—	—	—	—	—
J	—	—	—	4.1	5	2.6
K	1	1.5	—	—	1	0.5
L	—	—	—	—	—	—
M	14	20.9	33	26.8	47	24.0
N	—	—	—	—	—	—
O	33	49.3	45	36.6	78	40.0
P	—	—	6	4.9	6	3.1
Total	67	100.0	129	100.0	196	100.0

patterns. In particular, the presence of a strongly stained band with Rf 0.46–0.47 is unusual; its globulin components are unknown. In particular, it would be interesting to reveal the presence of methionine-containing legumin A component; this could be of real importance for quality breeding.

The stable uniformity of the electrophoretic variants together with the intermediate pattern observed in the hybrids (F1) suggest the need for additional works on seed storage protein diversity, particularly in relation to the aminoacid composition of single fractions (globuline, legumin, etc.) and its genetic control. As yet, we have no F_2 segregation data; however, our observations on F1 seeds indicate that few genes are responsible for presence or absence of a single subunit.

In conclusion, the most notable result of this investigation was the identification (and selection) of some genotypes with a different and specific protein pattern to be utilized for biochemical characterization and genetic analysis in the improvement of the nutritional quality of faba bean proteins.

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تعدد أشكال البروتين بين الطرز الوراثية للفول المستقدَم من أفغانستان وإثيوبيا

الملخص

في هذه الورقة عرض لتحاليل بالفصل أو الرحلان الكهربائي (SDS-PAGE) أجريت على 64 طرازا وراثيا من الفول، جرى تحديدها كمدخلات من أفغانستان وإثيوبيا، ومميزة "بأشكال" نوعية من البروتين المخزون. توخت الدراسة تقدير أفضل تحديد للطرز الوراثية، ومدى تجانسها. وقد وجدت فروق بين الطرز الوراثية، غير أنه لوحظ مستوى عالٍ من التجانس فيما بينها. كما تم الحصول على معلومات أولية عن التحكّم الوراثي في بعض أجزاء منفصلة من البروتين.

Studies on Mutations Induced by EMS and DES in Faba Bean: I. Chlorophyll and Sterile Mutations

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Abstract

Frequencies of different types of chlorophyll and sterile mutations induced by ethyl methane sulphonate (EMS) at 0.05%, 0.125%, and 0.25%; and diethyl sulphate (DES) at 0.25%, 0.50%, and 0.75% have been described. Chlorophyll mutations induced included *Xantha, Viridis, Xanthoviridis, Viridoxantha,* and *Straita* types while the sterile mutations included flowerless, cliestogamous, fruitless, seedless, and types with underdeveloped seeds. Sterile mutants in different treatments were several times more frequent than the chloromutations. Concentrations of DES induced much higher frequencies of chlorophyll and sterile mutants than those of EMS.

Introduction

Nonviable mutations due to faulty chlorophyll development or due to sterility caused by various factors have often been taken as an index of mutagen sensitivity for different doses of mutagens (Chandra 1979; Sharma and Sharma 1979; El-Shouny and El-Hosary 1983; Tripathi and Dubey 1990; Vandana 1990). In an experiment designed to study the mutagenic effects of varying doses of ethyl methane sulphonate (EMS) and diethyl sulphate (DES) on a local cultivar of faba bean (*Vicia faba* L.), a number of chloromutations as well as some sterile mutations were induced. The present paper reports the frequencies and spectra of such chlorophyll and sterile mutants.

Materials and Methods

Seeds of a local cultivar of *Vicia faba* L. var. *minor* were soaked in distilled water for six hours to initiate the germination process. Then the seeds were removed and soaked for another six hours in the solutions containing different concentrations of the mutagens ethyl methane sulphonate (0.05%, 0.125%, and 0.25%) or diethyl sulphate (0.25%, 0.50%, and 0.75%) after which the treated seeds were thoroughly washed using tap water. Two control treatments, unsoaked seeds and seeds soaked in distilled water, were also applied in this study.

Of each treatment, 150 seeds were sown in the field in randomized row design with three replications. Each replication consisted of 50 seeds. Timely irrigations were applied to ensure good stand. Seeds of the M_1 plants were collected individually, treatment wise. M_2 populations were raised from these seeds in the next crop season in a plant-to-family manner. There were five rows (replications) for each M_2 family. M_2 populations were screened for mutations at regular intervals from seedling stage up to maturity of the crop. Various macromutants were identified and tagged. Frequencies of chlorophyll and sterile mutants per 1000 M_2 plants are presented in Tables 1 and 2, respectively.

Results and Discussion

Chlorophyll mutants

In the control, not a single plant having chlorophyll deficiency could be traced while all the mutagenic treatments showed some plants having whole or partial chlorophyll deficiency. These have been categorized below as suggested by Gustafsson (1940) in barley and Vishnoi and Gupta (1980) in *Vicia faba* L., and their frequencies are presented in Table 1.

Xantha. This type of mutant characterized by total absence of chlorophyll and predominance of carotenoid pigments, appeared in all the treatments except in the lowest dose of EMS, although their number was very small. These yellow colored mutants survived for only two to three days.

Viridis. These pale-green colored mutants appeared in all the mutagenic treatments except the middle concentration of EMS. The mutants had a thin and weak plant body and did not survive beyond the four-leaf stage.

Xanthoviridis. The *xanthoviridis* mutants survived up to the three- or four-leaf stage and dried up within 15–17 days of emergence. These mutants were characterized by yellow color near the tips and light green color in the leaf base. These mutants appeared in all the treatments of DES and the highest concentration treatments of EMS.

Viridoxantha. These mutants were characterized by pale color in most of the leaf while the tips were light green. Such seedlings also dried up within 10–15 days of germination.

Straita. These mutants had light-green color plant body with yellow colored bands across the leaf blade. The survival period of these mutants ranged from 25 to 31 days. Straita mutants were recorded under all the three doses of DES and the lowest dose of EMS.

Sterile mutants

Those mutants which did not produce viable seeds and hence could not be carried into the M_3 generation were grouped under the class "sterile mutants." Frequencies of sterile mutants per 1000 M_2 plants are presented in Table 2. Such mutants could be further classified into five categories.

Flowerless mutants. Where no flower buds were formed and the plants dried up in a vegetative stage as the crop matured. Such mutants were observed in all the mutagenic treatments except the middle dose of EMS.

Cliestogamous mutants. In this category of mutant flower buds were formed but the buds failed to blossom into flowers and remained cliestogamous up to the end. No fruit formation took place in these mutants. Mutants of this category appeared in all the mutagenic treatments.

Fruitless mutants. In this category of mutants flowering took place normally but some of the flowers developed into fruits. This type of mutant also appeared in all the mutagenic treatments.

Seedless mutants. In this category of sterile mutants, the flowering was also normal and several flowers developed

Table 1. Frequency of chlorophyll mutants per 1000 M_2 plants in different mutagen treatments of faba bean.

Treatments	Total plants studied	Xantha	Xanthoviridis	Straita	Viridoxantha	Viridis	Total
Control	1109	—	—	—	—	—	—
EMS (%)							
0.05	988	—	—	1.01	—	1.01	2.02
0.125	969	1.03	—	—	—	—	1.03
0.25	826	1.21	1.21	—	1.21	1.21	4.84
DES (%)							
0.25	948	1.05	1.05	2.10	1.05	3.16	8.41
0.50	819	1.22	1.22	1.22	—	1.22	4.88
0.75	817	1.22	1.22	1.22	1.22	3.67	8.56

Table 2. Frequency of sterile mutations per 1000 M_2 plants in different mutagen treatments of faba bean.

Treatments	Total plants studied	Flowerless	Cliestogamous	Fruitless	Seedless	Underdeveloped seeds	Total
Control	1109	—	—	—	—	—	—
EMS (%)							
0.05	988	1.01	1.01	3.03	1.01	1.01	7.07
0.125	969	—	1.03	1.03	—	—	2.06
0.25	826	2.42	1.21	1.21	1.21	2.42	8.47
DES (%)							
0.25	948	1.05	2.11	1.05	3.16	2.11	9.49
0.50	819	3.60	1.22	2.44	1.22	2.44	10.99
0.75	817	3.67	3.67	1.22	2.447	1.22	12.23

into pods. But these pods were smaller in size and did not contain any seeds. This type of mutant occurred in all the treatments except the middle concentrations of EMS.

Mutants with underdeveloped seeds. In the last category of sterile mutants, flowering was normal and most of the flowers developed into fruits. But these fruits contained underdeveloped and nonviable seeds which were either dried papery white structures or small, shrivelled brown colored seeds.

Concentrations of DES used in the present study induced much higher frequencies of both chlorophyll and sterile mutations. Frequencies of sterile mutants under different treatments were found to be several times higher than those of chlorophyll mutants in the respective treatments.

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دراسات على طفرات مُستحدَثة بسلفونات إيثيل الميتان (س إ م) وبكبريتات ثنائي الإيثيل (ك ث إ) في الفول: 1. طفرات يخضورية وعقيمة

الملخص

تم وصف تكرار طرز مختلفة من الطفرات اليخضورية والعقيمة المستحدثة بوساطة (س إ م) تركيزه 0.05 ٪ و 0.125 ٪ و 0.25 ٪، و (ك ث إ) بتركيز 0.25 ٪ و 0.50 ٪ و 0.75 ٪. وقد شملت الطفرات اليخضورية المستحدثة الطرزَ التالية: Xantha, Viridis, Xanthoviridis, Viridoxantha, Straita، في حين تضمنت الطفرات العقيمة طرزا عديمة الأزهار، أو ذات أزهار غير متفتحة، أو عديمة الثمار، أو عديمة البذور، أو طرزا أخرى ذات بذور غير مكتملة. وكان عدد الطافرات العقيمة في المعاملات المختلفة أكثر تكرارا بكثير من الطفرات اليخضورية. كما أن تراكيز (ك ث م) أحدثت تكرارا بالطافرات اليخضورية والعقيمة أعلى بكثير من تلك التي أحدثتها تراكيز (س إم).

Catalogue of Chromosomal and Morphological Mutants of Faba Bean In the Gatersleben Collection, 1991

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Abstract

The catalogue describes 149 karyotype reconstructions and morphological mutants held in the Gatersleben collection in 1991.

Reading the Catalogue

1. Each entry has a five-digit number. The first two positions of each number denote the type of mutation, e.g., 01 "primary reciprocal translocations", and 11 "morphological mutants." The last three positions serialize individual mutations in that class. The following abbreviations have been used in describing each mutation:

t = primary reciprocal translocation
inv = inversion
I-VI = symbols for the six pairs of standard chromosomes according to Michaelis and Rieger (1959)
s = short arm
l = long arm

2. The **primary karyotype reconstructions** (reciprocal symmetric translocations and inversions) are ordered according to the involvement of arms of chromosomes I-VI in structural changes; they are symbolized by Latin letters according to the chronology of their origin. Arabic numbers in brackets denote chromosomal segments (1-28) involved in chromosomal reconstructions (I: 1-8, II: 9-12, III: 13-16, IV: 17-20, V: 21-24, VI: 25-28). Reconstructed chromosomes are symbolized by the Latin letters representing the individual reconstruction and the Roman number denoting the chromosome that provided the centromere.

Sjödin (1971c) reported 193 primary reciprocal translocations, including those obtained in Gatersleben. Of these, 109 were analyzed as to the chromosomes and 76 as to the chromosome arms involved.

The primary reconstructions compiled in this catalogue represent stocks available in the Gatersleben Collection. They are characterized as to the chromosomal segments involved and were sued for derivation of diverse secondary (03, 04, 07) and combinative (04, 05, 06) reconstructions. They were also a source of polyploids (09) and morphological mutants (11).

3. **Secondary karyotype reconstructions** result from two primary ones, either two translocations or a translocation and an inversion, with one chromosome involved in both of them. This occurs via crossing-over between partially homologous regions of the reconstructed chromosomes in meiocytes of double heterozygotes (see Schubert et al. 1982, 1986, 1991, and Figure 1). These secondary reconstructions are symbolized by Latin letters denoting the primary reconstructions involved in the secondary reconstruction; a dash above these letters is used to figure out their connection. Latin letters in brackets, sometimes combined with Roman numbers, represent old symbols used in previous publications (Schubert et al. 1981, 1982). Multiple secondary reconstructions (04) may also be obtained via crossing-over. When these involve both arms of one metacentric chromosome simultaneously (Schubert and Rieger 1990a), the resulting karyotype is symbolized by the corresponding Latin letters connected by dashes above and below (e.g., $\overline{\underline{DM}}$). Theoretically, multiple

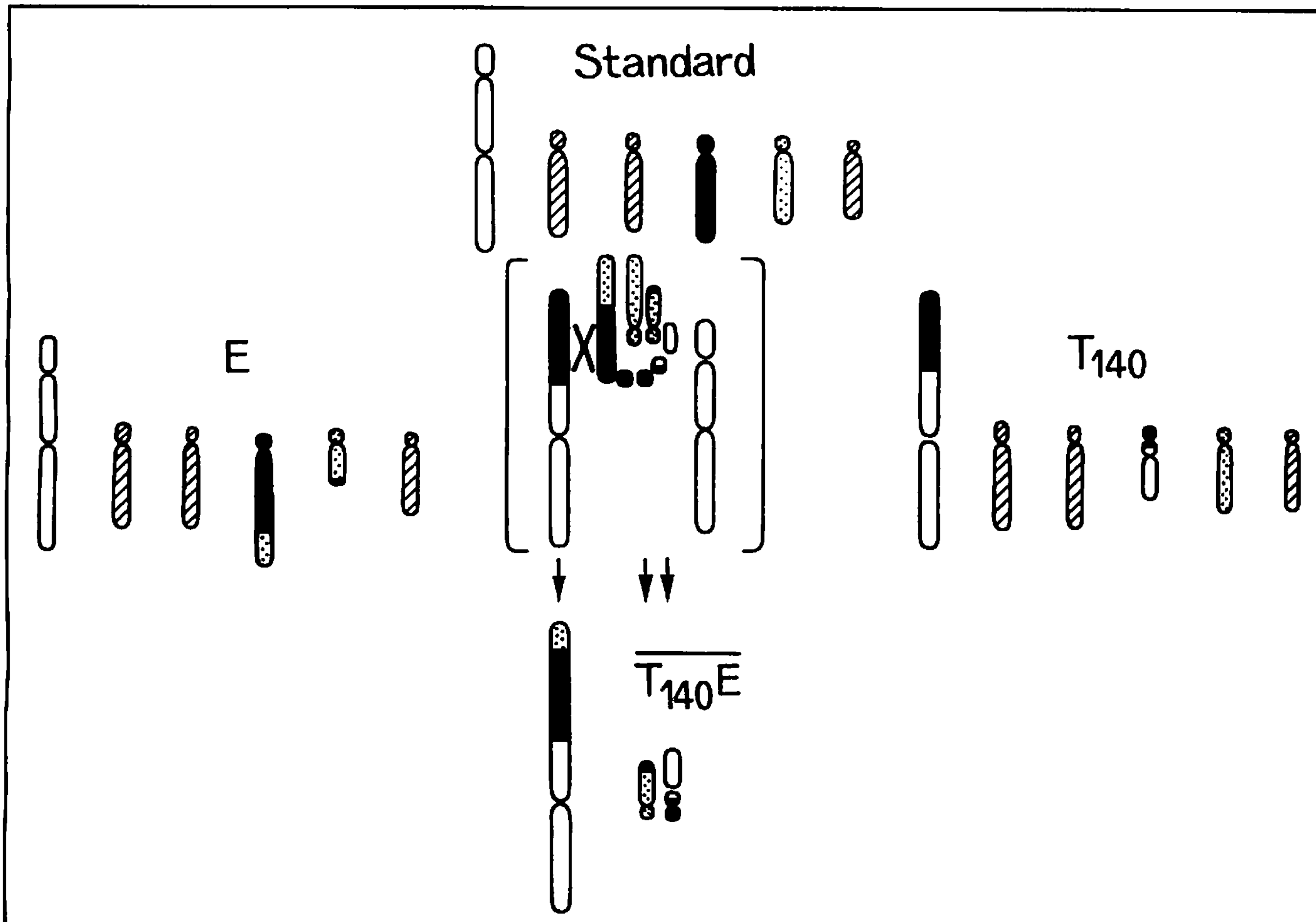

Figure 1. Secondary karyotype reconstruction, schematically. Above: Standard karyotype of *V. faba*; left: Translocation karyotype E (tIVI–VI); right: Translocation karyotype T140 (tIs–IVI); in brackets: Meiotic hexavalent in individuals heterozygous for both translocations formed by translocated chromosomes and their standard homologues. Cross-over between homologous regions of translocated chromosomes (marked by cross) results in a secondarily reconstructed chromosome ($\overline{\text{T140E}}$ I) and in restoration of a standard chromosome (IV). Arrows indicate segregation of those chromosomes forming the new karyotype, while the corresponding standard chromosomes segregate to the opposite pole (not shown).

secondary reconstructions may irreversibly connect a multitude of primary reconstructions such as $\overline{\text{GJCFHEN}}$ or $\overline{\text{GCFHPEN}}$. Without the knowledge of their origin it would be nearly impossible, even by means of Giemsa banding, to homologize chromosome segments of such karyotypes with chromosomes of the standard karyotype.

The intentional use of secondary karyotype reconstruction provides a tool for arbitrary modification of genetic linkage groups and for rearrangement of chromatin, e.g., into mega- and mini-chromosomes.

4. A special variant of karyotype reconstructions is represented by **pseudoaneuploid** increase and decrease of chromosome number (07). These reconstructions may result from mis-segregation of chromosomes from meiotic multivalents of individuals heterozygous for two translocations with one (metacentric) chromosome involved in both of them (see Schubert and Reiger 1985, 1991, and Figure 2). Another possible origin of pseudoaneuploidy is centric fusion of telocentrics or centric fission of metacentrics. The latter was described for *Vicia faba* by Schubert and Rieger (1990b).

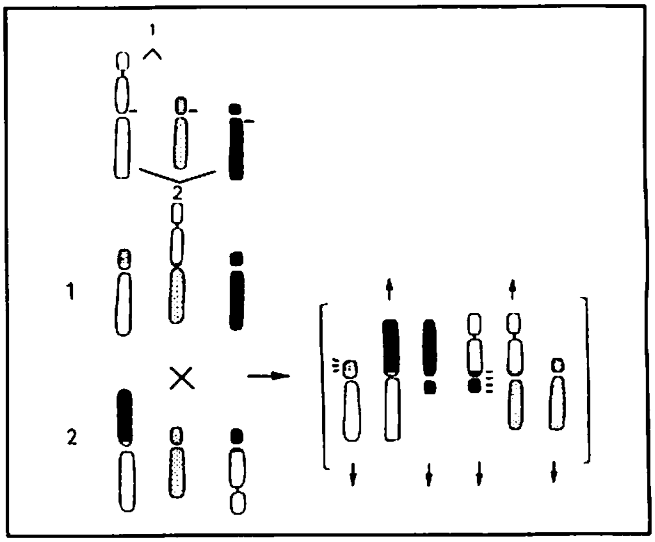

Figure 2. Origin of pseudoaneuploidy, schematically. Left: A metacentric and two acrocentric chromosomes (above). Bars mark breakpoints resulting in translocation 1 (middle) and 2 (below). Right: meiotic multivalent in individuals heterozygous for both translocations in brackets. Arrows indicate balanced mis-segregation resulting in n−1 (upward) and n+1 (downward) gametes. Regions duplicated in hyperploid and deleted in hypoploid gametes are labelled by bars. Since deletions were not tolerated, only an increase in chromosome number was achieved up to now in *V. faba* by this way.

Catalogue

01000	**Primary reciprocal translocations**	
01001	tIs – III (3 – 11)	G
01002	tIs – IIIs (4 – 13)	D
01003	tIs – IIIl (4 – 14)	A
01004	tIs – IVl (3 – 18)	T140 (from Dr J. Sjödin, Svalöf)
01005	tIs – Vs (4 – 21)	J
01006	tIs – VIl (4 – 26)	K
01007	tIl – VIl (8 – 28)	C
01008	tIIs – IIIl (9 – 14)	F
01009	tIIl – AIIIl (11 – 1)	L† extinct
01010	tIIIl – IVl (16 – 18)	H
01011	tIIIl – BVs (15 – 22)	P†
01012	tIVl – Vl (20 – 23)	E

02000	**Inversions**	
02001	invIs (1 – 3)	N
02002	invIs – I (1 – 8)	M
02003	invGIII (1 – 3)	O† extinct
02004	invVs – I (21 – 22)	B

† Involving at least one reconstructed chromosome. One additional inversion involving chromosome I was described by Sjödin (1971a).

03000	**Simple secondary reconstructions**	

(all those which are possible on the basis of the above-mentioned primary reconstructions)

03001	tIs – IIl (3 – 11)/tIs – Vs (4 – 21)	$\overline{\text{GJ}}$
03002	tIs – IIl (3 – 11)/tIIs – IIIl (9 – 14)	$\overline{\text{GF}}$
03003	tIs – IIl (3 – 11)/invIs (1 – 3)	$\overline{\text{GN}}$ (QII)
03004	tIs – IIl (3 – 11)/tIl – VIl (8 – 28)	$\overline{\text{GC}}$‡
03005	tIs – IIIs (4 – 13)/tIl – VIl (8 – 28)	$\overline{\text{DC}}$
03006	tIs – IIIs (4 – 13)/invIs (1 – 3)	$\overline{\text{DN (T)}}$
03007	tIs – IIIs (4 – 13)/tIs – IVl (3 – 18)	$\overline{\text{DT140}}$‡
03008	tIs – IIIs (4 – 13)/tIIs – IIIl (9 – 14)	$\overline{\text{DF}}$ only in $\overline{\text{DF}}$ E
03009	tIs – IIIs (4 – 13)/tIIIl – IVl (16 – 18)	$\overline{\text{DH}}$
03010	tIs – IIIs (4 – 13)/tIIIl – invBVs (15 – 22)	$\overline{\text{DP}}$
03011	tIs – IIIl (4 – 14)/tIl – VIl (8 – 28)	$\overline{\text{AC}}$
03012	tIs – IIIl (4 – 14)/tIIIl – IVl (16 – 18)	$\overline{\text{AH}}$
03013	tIs – IIIl (4 – 14)/invIs (1 – 3)	$\overline{\text{AN}}$ (QIII)
03014	tIs – IIIl (4 – 14)/tIIIl – invBVs (15 – 21)	$\overline{\text{AP}}$ 1984
03015	tIs – IVl (3 – 18)/tIl – Vs (4 – 21)	$\overline{\text{T140J}}$
03016	tIs – IVl (3 – 18)/tIs – VIl (4 – 26)	$\overline{\text{T140K}}$‡
03017	tIs – IVl (3 – 18)/tIl – VIl (8 – 28)	$\overline{\text{T140C}}$‡
03018	tIs – IVl (3 – 18)/tIIIl – IVl (16 – 18)	$\overline{\text{T140H}}$
03019	tIs – IVl (3 – 18)/tIVl – VI (20 – 23)	$\overline{\text{T140E}}$‡
03020	tIs – Vs (4 – 21)/tIl – VIl (8 – 28)	$\overline{\text{JC}}$‡
03021	tIs – Vs (4 – 21)/tIVl – VI (20 – 23)	$\overline{\text{JE}}$
03022	tIs – Vs (4 – 21)/invIs (1 – 3)	$\overline{\text{JN}}$

03023	tIs – VII (4 – 26)/invIs (1 – 3)	$\overline{KN}$ (QVI)
03024	tII – VII (8 – 28)/invIs (1 – 3)	$\overline{CN}$
03025	tIIs – IIII (9 – 14)/tIIII – IVI (16 – 18)	$\overline{FH}$
03026	tIIs – IIII (9 – 14)/tIIII – BVs (15 – 22)	$\overline{FP}^{\ddagger}$
03027	tIIII – IVI (16 – 18)/tIIII – BVs (15 – 22)	$\overline{HP}^{\ddagger}$
03028	tIIII – IVI (16 – 18)/tIVI – VI (20 – 23)	$\overline{HE}^{\ddagger}$
03029	tIIII – BVs (15 – 22)/tIVI – VI (20 – 23)	$\overline{PE}^{\ddagger}$
03030	tIVI – VI (20 – 23)/invVs – I (21 – 22)	$\overline{EB}$ (R)

‡ Not yet produced.

04000	**Multiple secondary reconstructions**	
04001	tIs – IIIs (4 – 13)/invIs–I (1 – 8)	$\overline{DM}^{\S}$
04002	tIs – VII (4 – 26)/tII – VII (8 – 28)	$\overline{KC}^{\S}$
04003	tIs – IIIs (4 – 13)/tII – VII (8 – 28)/invIs (1 – 3)	$\overline{DCN}$
04004	tIs – IIIs (4 – 13)/tIIs – IIII (9 – 14)/invIs (1 – 3)	$\overline{DFN}$ (in E$\overline{DFN}$ only)
04005	tIs – IIIs (4 – 13)/tIIII – IVI (16 – 18)/invIs (1 – 3)	$\overline{DHN}$
04006	tIs – IIIs (4 – 13)/tIIII – BVs (15 – 22)/invIs (1 – 3)	$\overline{DPN}$
04007	tIs – IIII (4 – 14)/tIIII – BVs (15 – 22)/invIs (1 – 3)	$\overline{APN}$
04008	tIs – IVI (3 – 18)/tII – VII (8 – 28)/tIVI–VI (20 – 23)	$\overline{T140CE}^{\ddagger}$
04009	tIs – IVI (3 – 18)/tIIII – IVI (16 – 18)/tIVI–VI (20 – 23)	$\overline{T140HE}^{\ddagger}$
04010	tIIs – IIII (9 – 14)/tIIII – IVI (16 – 18)/tIVI–VI (20 – 23)	$\overline{FHE}^{\ddagger}$

§ Arisen by two crossings-over involving the short and long arm of one metacentric chromosome and two reconstructed acrocentrics with partially homologous regions.

05000	**Additive combinations of the above-mentioned primary reconstructions without cross over or quantitative changes.**	
05001	tIs – III (3 – 11) + tIIII – IVI (16 – 18)	GH‡
05002	tIs – III (3 – 11) + tIIII – BVs (15 – 22)	GP
05003	tIs – III (3 – 11) + tIVI – VI (20 – 23)	GE
05004	tIs – III (3 – 11) + invVs – I (21 – 22)	GB‡
05005	tIs – IIIs (4 – 13) + tIVI – VI (20 – 23)	DE
05006	tIs – IIIs (4 – 13) + invVs – I (21 – 22)	DB
05007	tIs – IIII (4 – 14) + tIVI – VI (20 – 23)	AE

05008	tIs – IIII (4 – 14) + invVs – I (21 – 22)	AB
05009	tIs – IVI (3 – 18) + tIIs – IIII (9 – 14)	T140 F‡
05010	tIs – IVI (3 – 18) + tIIII – BVs (15 – 22)	T140 P‡
05011	tIs – IVI (3 – 18) + invVsI (21 – 22)	T140 B‡
05012	tIs – Vs (4 – 21) + tIIs – IIII (9 – 14)	JF
05013	tIs – Vs (4 – 21) + tIIII – IVI (16 – 18)	JH‡
05014	tIs – VII (4 – 26) + tIIs – IIII (9 – 14)	KF
05015	tIs – VII (4 – 26) + tIIII – IVI (16 – 18)	KH
05016	tIs – VII (4 – 26) + tIIII – BVs (15 – 22)	KP
05017	tIs – VII (4 – 26) + tIVI – VI (20 – 23)	KE
05018	tIs – VII (4 – 26) + invVs – I (21 – 22)	KB
05019	tII – VII (8 – 28) + tIIs – IIII (9 – 14)	CF
05020	tII – VII (8 – 28) + tIIII – IVI (16 – 18)	CH‡
05021	tII – VII (8 – 28) + tIIII – BVs (15 – 22)	CP‡
05022	tII – VII (8 – 28) + tIVI – VI (20 – 23)	CE
05023	tII – VII (8 – 28) + invVs – I (21 – 22)	CB
05024	tIIs – IIII (9 – 14) + tIVI – VI (20 – 23)	FE
05025	tIIs – IIII (9 – 14) + invIs (1 – 3)	FN‡
05026	tIIs – IIII (9 – 14) + invIs – I (1 – 8)	FM‡
05027	tIIs – IIII (9 – 14) + invVs – I (21 – 22)	FB
05028	tIIII – IVI (16 – 18) + invIs (1 – 3)	HN
05029	tIIII – IVI (16 – 18) + invIs – I (1 – 8)	HM‡
05030	tIIII – IVI (16 – 18) + invVs – I (21 – 22)	HB
05031	tIIII – BVs (15 – 22) + invIs (1 – 3)	PN
05032	tIIII – BVs (15 – 22) + invIs – I (1 – 8)	PM‡
05033	tIVI – VI (20 – 23) + invIs (1 – 3)	EN‡
05034	tIVI – VI (20 – 23) + invIs – I (1 – 8)	EM
05035	invIs (1 – 3) + invVs – I (21 – 22)	NB
05036	invIs – I (1 – 8) + invVs – I (21 – 22)	MB‡
05037	tIs – VII (4 – 26) + tIIs – IIII (9 – 14) + tIVI – VI (20 – 23)	KFE (EFK)
05038	tIs – VII (4 – 26) + tIIs – IIII (9 – 14) + invVs – I (21 – 22)	KFB (BKF)

05039	tIs – VII (4 – 26) + tIIII – IVI (16 – 18) + invVs – I (21 – 22)	KHB (BKH)
05040	tIIs – IIII (9 – 14) + tIVI – VI (20 – 23) + invIs (1 – 3)	FEN
05041	tIIII – IVI (16 – 18) + invIs (1 – 3) + invVs – I (21 – 22)	HNB (BHN)

06000	**Additive combination of primary and secondary reconstructions**	
06001	tIs – III (3 – 11)/invIs (1 – 3) + invVs – I (21 – 22)	$\overline{\text{GN}}$ B
06002	tIs – III (3 – 11)/invIs (1 – 3) + tIIII – BVs (15 – 22)	$\overline{\text{GN}}$ P
06003	tIs – IIIs (4 – 13) + tIVI – VI (20 – 23)/invVs – I (21 – 22)	D $\overline{\text{EB}}$
06004	tIs – IIIs (4 – 13)/tII – VII (8 – 28) + tIVI – VI (20 – 23)	$\overline{\text{DC}}$ E
06005	tIs – IIIs (4 – 13)/tIIs – IIII (9 – 14) + tIVI – VI (20 – 23)	$\overline{\text{DF}}$ E
06006	tIs – IIIs (4 – 13)/tIIII – IVI (16 – 18) + invVs – I (21 – 22)	$\overline{\text{DH}}$ B
06007	tIs – IIIs (4 – 13)/tIIII – IVI (16 – 18)/invIs (1 – 3) + invVs – I (21 – 22)	$\overline{\text{DHN}}$ B
06008	tIs – IIIs (4 – 13)/invIs (1 – 3) + tIVI – VI (20 – 23)	$\overline{\text{DN}}$ E
06009	tIs – IIIs (4 – 13)/invIs (1 – 3) + invVs – I (21 – 22)	$\overline{\text{DN}}$ B
06010	tIs – IIIs (4 – 13)/tIIs – IIII (9 – 14)/invIs (1 – 3) + tIVI – VI (20 – 23)	$\overline{\text{DFN}}$ E
06011	tIs – IIIs (4 – 13)/invIs (1 – 3) + tIVI – VI (20 – 23)/invVs – I (21 – 22)	$\overline{\text{DN}}$ $\overline{\text{EB}}$
06012	tIs – IIII (4 – 14)/invIs (1 – 3) + invVs – I (21 – 22)	$\overline{\text{AN}}$ B
06013	tIs – IIII (4 – 14)/tII – VII (8 – 28) + tIVI – VI (20 – 23)	$\overline{\text{AC}}$ E
06014	tIs – IIII (4 – 14)/tII – VII (8 – 28) + invVs – I (21 – 22)	$\overline{\text{AC}}$ B
06015	tIs – VII (4 – 26)/invIs (1 – 3) + invVs – I (21 – 22)	$\overline{\text{KN}}$ B
06016	tIs – VII (4 – 26)/invIs (1 – 3) + tIIII – IVI (16 – 18)	$\overline{\text{KN}}$ H
06017	tIs – VII (4 – 26)/invIs (1 – 3) + tIIII – BVs (15 – 22)	$\overline{\text{KN}}$ P
06018	tIs – VII (4 – 26) + tIVI – VI (20 – 23)/invVs – I (21 – 22)	K $\overline{\text{EB}}$

07000	**Pseudoaneuploids** (with 14 chromosomes)		
07001	DI KVI II III IV V VI	dupl.[1] 4p, 13q, 25 (3.6%)	DK 14
07002	DI KVI BV II III IV VI	dupl. 4p, 13q, 25 (3.6%)	DKB 14
07003	DI KVI PIII PV II IV VI	dupl. 4p, 13q, 25 (3.6%)	DKP 14
07004	DI KVI FII FIII IV V VI	dupl. 4p, 13q, 25 (3.6%)	DKF 14
07005	DI KVI FII FIII EIV EV, VI	dupl. 4p, 13q 25 (3.6%)	DKFE
07006	DI $\overline{\text{KN}}$VI II III IV V VI	dupl. 4p, 13q, 25 (3.6%)	D $\overline{\text{KN}}$ 14
07007	JI AIII II III IV V VI	dupl. 13, 21q (1.8%)	AJ 14

07008	JI KVI II III IV V VI	dupl. 21q, 25 (0.8%)	JK 14
07009	JI KVI FII FIII IV V VI	dupl. 21q, 25 (0.8%)	JKF 14
07010	DI $\overline{\text{FD}}$III II III IV V VI	dupl. 9q, 13, 14p (5%)	$\overline{\text{FD}}$ 14 extinct
07011	Is II II III IV V VI	dupl. telomere	St 14 Peru

¶ Dupl. denotes those segments (and their share in the total genome) which became duplicated by the corresponding reconstruction.

08000 Reserved for **primary translocations in pseudoaneuploids**

09000 Polyploids

09001	V.f.	4 n	(from Dr M. H. Poulsen, Denmark, see Poulsen and Martin 1977)
09002	G	4 n	1989–90
09003	F	4 n	1989–90
09004	E	4 n	1991
09005	$\overline{\text{AC}}$ B	4 n	extinct
09006	KFE	4 n	1991
09007	FE	4 n	1991
09008	FEN	4 n	extinct

Other ploidy variants (haploids, triploids, hexaploids) did not survive or were completely sterile.

10000 Aneuploids

Permanent stocks of aneuploids are not available since transmission rate is poor. However definite aneuploids may be produced at a reasonable frequency by crossing of suitable translocation lines (Schubert et al. 1983, 1986).

10001 *Vicia faba* cv minor + VI (from Dr A. Martin, Cordoba, see Martin 1978)

11000 Morphological mutants within standard or reconstructed karyotypes

'3 × white' (white flowers, unpigmented testae and stipulae; monogenic, recessive, located on chromosome II)

11001 *V. faba* cv major (from Dr F. Steuckert, Gotha-Friedrichswerth)

'vio' (violet testae, monogenic dominant, located on chromosome II)

11002 *V. faba* cv minor

11003 translocation line F

11004 translocation line K

11005 translocation line J

11006 translocation line G

11007 pseudoaneuploid line JK 14

beige testae with violet spots (dominant over beige testae)

11008 *V. faba* cv minor 1198

11009 translocation line F

violet testae with light spots

11010 translocation line F

variants with black or light hilum (black is dominant over light)

11011 translocation line K (black hilum)

11012 translocation line K (light hilum)

11013 translocation line J (light hilum)

11014 translocation line J (black hilum)

Further morphological mutants concerning seed coat color, stem color, hilum color, flower color, leaf and pollen shape mutants, maturing, growth, chlorophyll and asynaptic mutants within the standard karyotype are described by Sjödin (1971b) and Ricciardi et al. (1985).

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فهرس الطافرات الصبغية والشكلية من الفول في مجموعة جيترسليبن، 1991

الملخص

يحوي الفهرس وصفا لـ149 طرازا مجموعيا من الطافرات الصبغية والشكلية، الموجودة في مجموعة جيترسليبن Gatersleben 1991.

Agroclimatological Zoning of Faba Bean Production Areas in China

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Abstract

Faba bean (*Vicia faba* L.) is an important legume crop with a high economic value in China. It is used in human food, animal feed, and as a green manure to improve the organic matter of soil.

China is the world's largest producer of faba bean. The area under the crop is about 1,800,000 ha with a total yield of 2,250,000 t, representing about 54.7% of the world's faba bean area and 55.7% of production, respectively. Because faba bean is grown throughout the country in areas that vary considerably in their climatic conditions, several attempts to zone the faba bean producing regions have been made in China in the past. However, these attempts were incomplete. This report aims at zoning different faba bean producing areas within China based on some indexes (i.e., sowing time, average annual temperatures, and average temperatures of January and July). The Fuzzy cluster analysis was used as means for classification.

Based on the differences in climatic conditions between the north and south of China and sowing and harvesting dates, faba bean producing areas were divided into two major zones, i.e., the winter-sowing faba bean zone and the spring-sowing zone. The winter-sowing zone is located in South China, including the Yunan and Sichuang provinces, which are the largest producing areas followed by the provinces Hubei, Hunan, Jiangsu, and Guizhu. Whereas the spring-sowing zone is in North China, including the Gansu, Inner Mongolia, and Qinghai provinces. The winter-sowing zone is larger with more plains and more rice growing areas than the spring-sowing zone.

Zoning of Faba Bean Producing Areas in China

Because faba bean producing areas are scattered all around the country with great differences in agroclimatic conditions, latitude, and altitude, it was important to consider the similarity of more than one factor for the classification of these areas into zones and subzones. Therefore, different indexes (i.e., growing area, thermal index, and sowing time) were used.

Indexes

1) Growing area: Any province or district in which the faba bean area is more than 667 ha was considered within the scope of division.

2) Thermal index: It included: (a) the average annual temperature; and (b) the average temperatures of January in the winter-sowing zone (> 0°C is considered fit for growing faba bean) and July in the spring-sowing zone(< 20°C fit for growing the crop).

3) Sowing time: October–November for winter sowing, and March–April for spring sowing.

Data collected on different indexes are presented in Table 1.

Cluster Analysis

Using the data presented in Table 1, cluster analysis was carried out. The Fuzzy-indicated relationship is shown in Figure 1.

Major Faba Bean Zones and Subzones in China

Based on the results of this study, we classified the different faba bean producing regions in China into 2 major zones, 6 subzones, and 11 sub-subzones (Table 2 and Figure 2).

Winter-sowing zone (A1):

This zone accounts for about 1,540,000 ha under faba bean. Sowing is October–November, and harvesting is during April–May. The average annual temperature is 16°C, with 1500–1800 total sunny hours. The annual rainfall is between 700 and 1200 mm. The main rotation south of 30°N is rice (for two successive seasons) and then faba bean (for one season). However, along the Changjiang Valley and the southwest provinces faba bean

Table 1. Sowing date and agroclimatological data collected from different faba bean growing regions in China.

Winter sowing				Spring sowing			
Region	Sowing date	Average annual temp. (°C)	Average Jan. temp. (°C)	Region	Sowing date	Average annual temp. (°C)	Average July temp. (°C)
Kunming	10 Oct	14.7	7.7	Wunanhaote	10 Apr	3.4	22.5
Chengdu	10 Oct	16.2	5.5	Linxia	01 Apr	6.8	18.1
Wuhan	08 Oct	16.3	3.0	Xining	03 Apr	5.7	17.2
Hangzhou	20 Oct	16.2	3.8	Jiuquan	01 Apr	7.3	21.8
Shanghai	16 Oct	15.7	3.5	Wulumuqi	11 Apr	5.6	24.0
Nantong	10 Oct	15.0	3.1	Yinchuan	11 Apr	5.7	23.5
Hanzhong	1 Oct	14.3	2.1	Taiyuan	11 Apr	8.5	23.4
Putian	10 Nov	19.6	10.5	Lasha	11 Apr	9.5	23.5
Nanning	10 Nov	21.6	12.8	Zhangjiakou	20 Mar	7.5	15.1
Guangzhou	20 Nov	21.8	13.3	Chengde	10 Apr	7.8	23.2
Guiyang	20 Oct	15.3	4.9	Yuning	10 Apr	8.9	24.2
Nanchang	22 Oct	17.5	5.0	Shihezi	10 Apr	8.1	23.4
Hefei	01 Oct	15.7	2.1				
Fuzhou	05 Nov	19.6	10.5				
Changsha	15 Oct	17.2	4.7				
Nanjing	14 Oct	15.3	2.0				

is mainly grown after a single season of rice, or rotated with rape, cotton, sugarcane, sesame, or corn. This zone covers the provinces falling in the southern parts of the country, and includes the following subzones:

- South hilly (B1): This subzone includes Guang Dong, Guang Xi, and Fujian province. The annual nonfrost period is 300–325 days, and the average annual temperature is 18°–22°C. The average temperature of January is

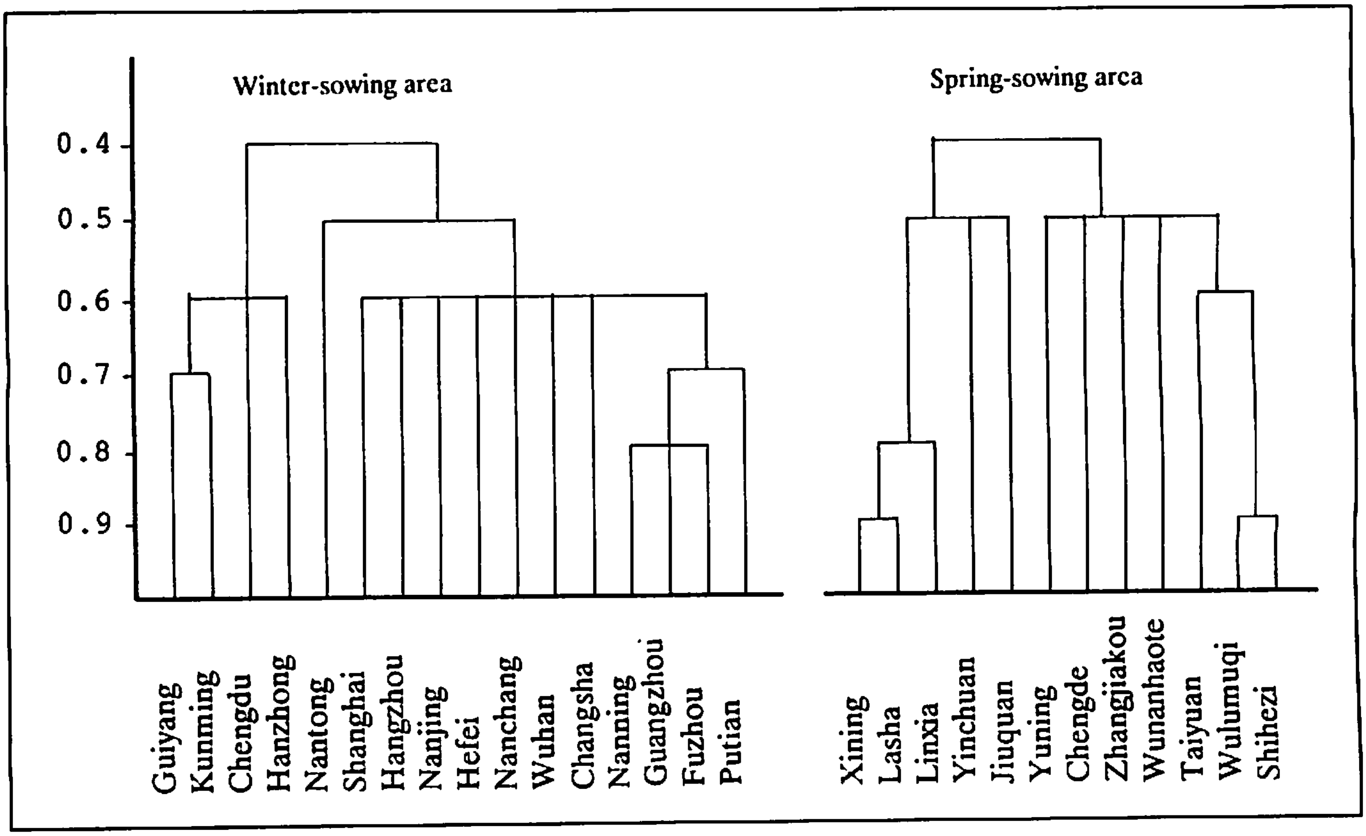

Figure 1. Clustering of faba bean areas in China.

Table 2. Classification and agroclimatological characteristics of different faba bean production regions in China.

Subzone	Sub-subzone	Annual temp. (°C)	Average meteorological data	
			Rainfall (mm)	Nonfrost (days)
Winter-sowing zone (A1)				
South hilly subzone (B1)		18.0–22.0	1300–2000	310–340
Middle & lower reaches of Changjiang River (B2)	C1	15.0–18.0	1100–1600	250–160
	C2	15.0–16.0	1000–1400	260–280
	C3	14.0–15.0	800–900	240–250
Southwest mountain and hilly areas (B3)	C1	14.0–15.5	900–1200	266–296
	C2	14.0–16.6	800–1000	280–290
	C3	14.0–15.0	800–1000	230–240
Spring-sowing zone (A2)				
Southwest Gansu-Tibet plateau (B1)	C1	3.0–4.0	200–400	129
	C2	4.0–8.0	300–500	130–180
	C3	8.0–9.0	200	170–180
North inland region (B2)	C1	8.0–10	400–500	180–200
	C2	7.0–9.0	< 100	180–190
Northern Xingjiang (B3)		5.0–11	200	165

8°–15°C. Although the average annual rainfall is over 1000 mm in this subzone, the faba bean growing season coincides with the drought period. Thus, irrigation is needed for good crop.

In general, sowing is on 11 November and harvesting is during the first two weeks of April. The faba bean cultivars 'Tudouzi', 'Laxin 73', and 'Guangpu 3', which are early maturing and semishort straw types, are used. Recommended rotation is rice-faba bean.

- <u>The middle & lower reaches of Changjiang (Yangtze) River (B2)</u>: This subzone accounts for about 37.4% of the total faba bean growing area in China. It includes provinces and cities within latitude of 28°–32°N (Shanghai, Zhejiang, Jiangsu, Jiangxi, Anhui, Hubei, Hunan, Nantong, and Yancheng). The annual nonfrost period is 220–280 days, and the average annual temperature is between 14° and 18°C. The average temperature of January is about 15°C. The average annual rainfall is between 1000 and 1600 mm, and the index of aridity is K < 1.

Sowing is during 10–20 October, and harvesting is during the last 10 days of May (the growing season is about 200–230 days). Cultivars such as 'big white beans of Ciqi', 'Tianjiqing', 'Sanbaican', 'Qingyidou', and 'Xiaoqingdou' used in this region are early- to medium-maturing types. The commonly used crop rotations in this region are; rice–faba bean, faba bean–cotton, and faba bean–wheat. However, in provinces Hunan, Hubei, and Jiangxi, faba bean is rotated with rape (<u>Brassica campectris</u> L.), or intercropped with wheat.

Due to some differences existing among different areas covered by this subzone, it was further divided into three sub-subzones, namely Fu-Hang (including Shanghai, Jiangsu, Jiangxi, and Zhejiang; C1), the middle reaches of the Changjiang River (including Hubei, Hunan, and Anhui; C2), and the northern part of Jiangsu (including Nantong and Yancheng; C3).

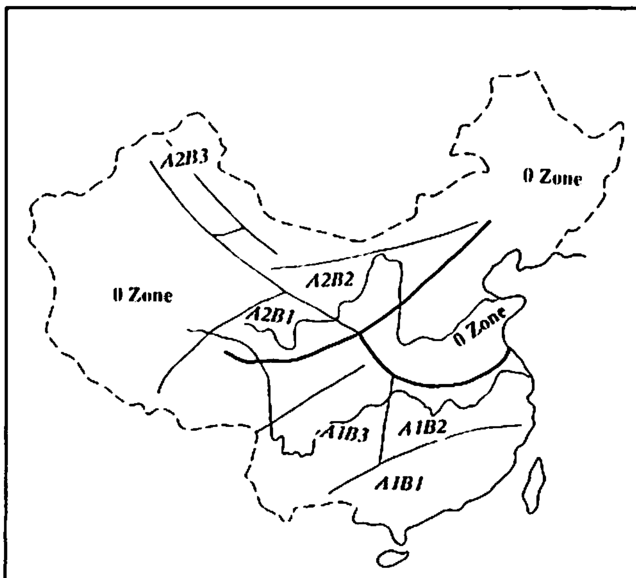

Figure 2. Faba bean production zones in China.

Here it should be noted that the two districts Nantong and Yancheng (located north of Jiangsu), are on the margin of the winter-sowing zone, but with lower temperatures. Thus, it was named North Jiangsu sub-subzone, and treated as a single unit in the clustering figure.

- Southwest mountain and hilly areas (B3): This subzone accounts for about 42% of the total area under faba bean in China. The annual nonfrost period is 220–300 days, with an average annual temperature of 14°–15.5°C. The average temperature of January is 2.1°–7.7°C.

Sowing is during 10–20 October, and harvesting is in May. The whole growing season is about 210 days. The faba bean cultivars used in this subzone, such as 'Chenhu 9', 'white bean of Kunming', 'Xiangyundou', and 'Fugu bean', are early- to medium-maturing types.

This subzone was also divided into sub-subzones, namely Yungui (including Yunnan and Guizhou; C1), Sichuang Basin (C2), and Hanzhong (C3).

Spring-sowing zone (A2):

The faba bean sowing area in this zone is about 120,400 ha. Sowing is during February–April, and harvesting is between August and September. The average annual temperature ranges between 3° and 10°C, with 2500–3000 total sunny hours. The annual rainfall is 300–1000 mm. In this zone faba bean is usually rotated with either wheat, corn, or rape. This zone covers provinces falling in the northern parts of the country. It includes the following subzones:

Southwest Gansu and Qinghai-Tibet plateau (B1): This subzone includes provinces and cities (e.g., Tibet, Qinghai, Southwest Gansu, and Longzhong district) located within the latitude of 34°–37° N, with an elevation of 1500–4300 m above sea level. The annual nonfrost period is between 100 and 180 days, and the average annual temperature is 2.5°–8°C. The average temperature of July is 15°–18°C. The annual rainfall ranges between 200 and 500 mm.

Sowing is during 15 February–10 April, and harvesting is during August–September. The growing season is 150–180 days. Cultivars sown in this subzone are 'Linxia Maya', 'Huany Yuan Maya', 'Lasha 1', 'Qinghai 3', 'Ga Da', 'Shenli', and 'Zheng'. Crop rotations include faba bean–wheat or faba bean–wheat–faba bean.

This subzone was further divided into three sub-subzones, namely Qinghai-Tibet plateau (including only part of the plateau; C1), Western loess plate (including Southwest Gansu and east of Qinghai; C2), and Hetao (including Hetao area of Ningxia; C3).

Northern inland region (B2): This subzone includes provinces and cities located along the Great Wall, within latitude 38°–44°N and an elevation of 800–1600 m above sea level. The average annual temperature is 4°–10°C, while the temperature of the hottest month is less than 24°C. The annual rainfall is between 400 and 500 mm, but in some areas, e.g., Hexi corridor, it is less than 100 mm with an aridity index $K < 1.5$.

Sowing is from mid-March to mid-May, whereas harvesting is July–August. The whole growing season is about 97–130 days. Among cultivars used in this region are 'Big Maya' and 'Daban Maya'.

This subzone was further divided into two other sub-subzones, namely Great Wall-line (including Inner Mongolia, Shanxi, and outside of Zhang Jiakou; C1) and Hexi corridor (C2).

Northern Xingjiang great subzone (B3): This subzone, including the northern and southern Tianshan mountains, has continental arid and semiarid climate. Wheat and corn are the main crops, whereas faba bean is grown on a small scale.

التحديد الزراعي-المناخي لمناطق إنتاج الفول في الصين

الملخص

يعتبر الفول .Vicia faba L محصولا بقوليا مهما، وأهميته الاقتصادية كبيرة في الصين لأنه يستخدم كغذاء للإنسان وعلف للحيوان وكسماد طبيعي أخضر لتحسين المادة العضوية في التربة.

والصين أكبر منتجي الفول في العالم؛ إذ تقدّر المساحات المزروعة به بحوالي 1.800.000، وإجمالي الإنتاج 2.250.000 طن، وهذا يمثل حوالي 54.7 ٪ من الرقعة العالمية المزروعة بالفول و 55.7 ٪ من الإنتاج العالمي على التوالي. ونظرا لانتشار زراعة الفول في عموم الصين ضمن مناطق تتباين في ظروفها المناخية كثيرا فقد جرت محاولات عديدة قاصرة في الماضي لتحديد مناطق إنتاج الفول في الصين بالاعتماد على بعض المؤشرات (مثل: موعد الزراعة، والمعدل السنوي لدرجات الحرارة، ومتوسط درجات الحرارة في شهري كانون2/يناير وتموز/يوليو). وتم استخدام تحليل Fuzzy العنقودي كطريقة للتحديد.

قُسِّمت مناطق إنتاج الفول على أساس الاختلافات في الظروف المناخية بين شمالي وجنوبي الصين وكذلك بين موعدي الزراعة والحصاد إلى منطقتين رئيسيتين: منطقة الزراعة الشتوية ومنطقة الزراعة الربيعية للفول. وتقع منطقة الزراعة الشتوية في جنوبي الصين، وتشمل إقليمي يونان وسيشوانغ وهما أكبر المناطق إنتاجا للفول، تليهما أقاليم هوبي وهونان وجيانغسو وغويزهو. أما منطقة الزراعة الربيعية فتقع في شمالي الصين، وتشمل أقاليم غانسو ومنغوليا الداخلية وكينغاي. إن منطقة الزراعة الشتوية أكبر من منطقة الزراعة الربيعية، وذات سهول أوسع، ويُزرَع فيها الأرز على نطاق واسع.

Performance of Faba Bean and other *Rabi* Legumes in Different Cropping Systems in Haryana (India)

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Abstract

The feasibility of faba bean sole cropping and intercropping system with chickpea in comparison to traditional *rabi* (winter season) legumes was compared at Haryana Agricultural University, Hisar (India). The study revealed that growing of faba bean as both sole crop and as intercrop in chickpea (2:2) is a viable approach for sustainable productivity in terms of total grain yield and chickpea equivalent/ha. Although intercropping of faba bean with chickpea (2:2) reduced the yield of chickpea by 51.4%, the chickpea equivalent yield was higher in this combination than the yield of chickpea as a pure crop.

Introduction

The conventional *rabi* legumes chickpea, peas, and lentil are generally grown under limited water supply or rainfed conditions in Haryana, India. However, because of increased irrigation facilities in the state, area and consequently the production of these legumes, particularly of chickpea, are decreasing. This situation necessitates the search for an alternate food legume; Rao et al. (1984) recommended adoption of faba bean (*Vicia faba* L.) due to its better performance in this region. Because it may take some more time to get farmers acquainted to this crop and to develop adaptable varieties in faba bean, agronomic work is planned to identify a feasible cropping system for the farming community of Haryana. This study was an attempt in this direction with a view to assess the feasibility for incorporation of faba bean in existing cropping systems.

Materials and Methods

A field experiment was conducted during the winter seasons of 1988-89 and 1989-90 at the research farm of Haryana Agricultural University, Hisar, under rainfed conditions. The soil of experimental plot was sandy loam in texture, low in available N (130 kg/ha) medium in available P (16.2 kg/ha) and high in K (304.5 kg/ha) with a pH value of 8.4. A basal dose of 100 kg diammonium phosphate (18:46:0) was placed below the seed at the time of sowing. Eleven treatments consisting of chickpea (*Cicer arietinum*, L.), peas (*Pisum sativum* L.), lentil (*Lens culinaris* Medik.) and linseed (*Linum usitatissimum* Lin.) as sole as well as intercrop, were replicated thrice in randomized block design. The seeds of chickpea (H-208), faba bean (local), field pea (Aparna), lentil (PL-639) and linseed (K2) were sown as sole crops (pure stand) in the second week of November by using seed rates of 50, 100, 30, and 50 kg/ha, respectively. All the crops were sown 30 cm apart as a sole crop except chickpea in paired-row treatments where 30/60 cm combination was used. In the intercropping treatments with all crops two rows were adjusted in between two pairs of chickpea sown in paired row systems (30/60 cm). In case of intercropping with field peas an additional treatment was used where three rows of peas were adjusted in between two pairs of chickpea sown in paired-row system (30/60 cm). The recommended package of practices for main crop was adopted. The total rainfall during the crop period was 23.5 and 62.1 mm in 1988-89 and 1989-90, respectively.

Results and Discussion

Faba bean in pure stand yielded significantly higher than other conventional crops during both years (Table 1). Field pea (Aparna), an erect and dwarf variety, stood at second position and produced significantly higher yield than all crops in 1988-89 but remained at par with chickpea in paired row planting in 1989-90. The higher yield of faba bean over other *rabi* legumes has also been reported by Singh and Tomar (1986).

All the intercrops adversely affected the yield of chickpea crop. Considerable reduction (52%) in yield of

Table 1. Seed yield of individual components, total productivity, and chickpea equivalent yield (kg/ha) of different cropping systems.

Treatments	Pure/main crop			Associated crop			Total productivity (mean)	Chickpea equivalent yield		
	1988–89	1989–90	Mean	1988–89	1989–90	Mean		1988–89	1989–90	Mean
Chickpea (30 cm)	1170	1681	1426	—	—	—	1426	1170	1681	1426
Chickpea in paired rows (30/60 cm)	1389	1827	1608	—	—	—	1608	1389	1827	1608
Fieldpea	2135	2017	2076	—	—	—	2076	1255	1153	1204
Lentil	1389	1111	1250	—	—	—	1250	1389	1111	1250
Faba bean	5556	3948	4752	—	—	—	4752	2722	1879	2300
Linseed	1214	1302	1258	—	—	—	1258	714	744	729
Chickpea 30/60 + pea (2:3)	1067	1219	1143	936	1753	1345	2538	1618	2220	1919
Chickpea 30/60 + pea (2:2)	804	1467	1136	1199	1274	1237	2872	1509	2196	1853
Chickpea 30/60 + lentil (2:2)	833	1432	1133	658	686	672	1805	1491	2119	1805
Chickpea 30/60 + faba bean (2:2)	687	876	782	3143	2418	2781	3562	2227	2027	2127
Chickpea 30/60 + linseed (2:2)	804	1108	956	290	358	324	1280	976	1312	1144
LSD (5%)	334	325	—	—	—	—	—	222	327	—

main crop was noticed when faba bean was intercropped. All the intercrops except field pea (2:3) in 1988–89, reduced the chickpea yield to a significant level as compared to its sole crop in paired planting. However, the combinations of chickpea + pea (2:2), chickpea + lentil (2:2), chickpea + linseed (2:2) were found at par with each other during both the years except in 1988–89, when chickpea + pea (2:2) was significantly better than chickpea + linseed (2:2). Significantly more reduction in chickpea yield due to intercropping with faba bean as compared to other crops may probably be because of its shading effect due to dense and tall growing nature. The more reduction in yield of chickpea due to dense canopy of associated crop was also observed by Singh et al. (1988).

It is clear from the data (Table 1) that faba bean as intercrop also produced maximum yield (2400–3100 kg/ha). Linseed produced minimum, whereas field pea was intermediate in this respect. In regard to total productivity of the system, averaged over two years, faba bean as a sole crop as well as in intercropping system produced maximum grain/ha, followed by intercropping with field pea.

In 1988–89, faba bean in pure as well as intercropping system recorded significantly higher chickpea equivalent (2200–2700 kg/ha) than other treatments, whereas chickpea + pea (2:3) was significantly better in this regard in 1989–90. However, on the basis of average value over two years faba bean proved its superiority over others in both systems of cropping.

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كفاءة الفول وبقوليات شتوية أخرى تحت نظم زراعية مختلفة في هاريانا (الهند)

الملخص

جرت في جامعة هاريانا الزراعية في هيسار (الهند) دراسة الجدوى من الزراعة الأحادية للفول وزراعته بشكل متداخل مع الحمص ومقارنة ذلك ببقوليات شتوية تقليدية (الموسم الشتوي rabi). أظهرت الدراسة أن زراعة الفول، سواء كمحصول أحادي أو متداخل مع الحمص (2 :2)، تُعتبر طريقة ناجحة لاستقرارية الإنتاج، من حيث إجمالي الغلة الحبية، والمكافىء من الحمص/هـ. ومع أن تداخل زراعة الفول مع الحمص (2 :2) قد خفض غلة الحمص بنسبة 51.4 ٪، إلا أن غلة الحمص المكافئة كانت أعلى في الزراعة المتداخلة منها في الزراعة الأحادية.

Pests and Diseases

Transmission of Broad Bean Mottle Virus by the Larvae of *Spodoptera exigua*

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Abstract

The relationship between field infestation with the larvae of lesser army worms (*Spodoptera exigua*) and the spread of broad bean mottle virus (BBMV) early in the season was speculated from several field surveys in Shambat area, Sudan, during the 1988–89 and 1989–90 growing seasons. In several glasshouse transmission tests the larvae transmitted BBMV to as much as 31% of the faba bean plants tested emphasizing the need for control of the lesser army worms as pests of faba bean and vectors of BBMV. The viruliferous larvae lost the virus after the first inoculation feeding tests.

Introduction

In the Sudan, broad bean mottle virus (BBMV) is an important pathogen that could reach high infection levels and cause considerable reductions in the yield of faba bean (*Vicia faba* L.) (Ahmed and Hussein 1988; Makkouk et al. 1988). The identification of vectors of BBMV has been of great concern not only in the Sudan but also in different parts of the world. Bawden et al. (1951) failed to transmit the virus using aphids and the bean weevil *Sitona lineatus*. Successful transmissions of the virus were achieved later using three chrysomelid beetles (Walters and Surin 1973) and two weevil species, *Apion vovax* and *A. arrogans* (Cockbain 1983; Makkouk and Kumari 1989). None of these beetles or weevils were reported infesting field-grown faba bean in the Sudan (Siddig 1982).

The larvae of lesser army worms *Spodoptera exigua* HB (= *Laphygma exigua*) attack several plant species in the Sudan and cause extensive damage to the seedlings of the early sown faba bean (Schmutterer 1969; Siddig 1982). As BBMV is an important virus which is not aphid transmitted, but yearly affects faba bean in the Sudan, the present work was initiated to elucidate the role of *S. exigua* larvae in the transmission of BBMV.

Materials and Methods

The field surveys were carried out in five faba bean fields in Shambat area, Sudan, during the 1988–89 and 1989–90 growing seasons. In each season, 16 surveys were conducted at weekly intervals, and the faba bean plants were inspected for *S. exigua* larvae infestation and BBMV infection. Virus-free seeds of the faba bean cultivar 'BF 2/2' were used in the glasshouse experiments. A known Sudanese isolate of BBMV was maintained on the cultivar 'BF 2/2' and used in the present tests.

The larvae of *S. exigua* were obtained from *Medicago sativa* fields and reared on the healthy faba bean plants for the next generation. The identity of *S. exigua* was confirmed by Professor Imam El Khidir (Professor of Entomology, Faculty of Agriculture, University of Khartoum). The larvae were starved for two hours before allowed actual feeding on BBMV-infected faba bean plants for a few minutes. They were then transferred to the healthy plants and allowed to feed for a few minutes before being removed. For each transmission test, nonviruliferous larvae were fed on an equal number of healthy control plants.

Results and Discussion

The field surveys which were conducted during the present study revealed an early appearance of BBMV on faba bean, which could be attributed to seed transmission as the virus is known to be seed transmitted when it occurred in complex infection with BYMV (bean yellow mosaic virus) (Murant et al. 1974). A further increase in BBMV infection was associated with the infestation of *S. exigua* larvae. In previous observations Siddig and Abu Salih (1972) reported a similar relationship between the Sudanese broad bean mosaic virus (SBBMV) in the field and the larvae of *S. exigua* and the aphid infestation. In subsequent glasshouse transmission tests Siddig and Abu Salih (1972) transmitted SBBMV using both *Aphis craccivora* and the larvae of *S. exigua*. However, the SBBMV reported by Siddig and Abu Salih (1972) was later confirmed to be a virus complex containing both BBMV and BYMV (Murant et al. 1974). Further increases in the number of infected plants was closely related to the larvae of *S. exigua* infestation and few peaks of BBMV infection were observed three to four weeks after the peaks of the larvae infestation.

The larvae of *S. exigua* and their feeding damage on BBMV-infected faba bean are shown in Plate 1. The efficiency of the larvae in the transmission of BBMV was confirmed by several glasshouse transmission tests which

Plate 1. Larva of *S. exigua* and its feeding damage on faba bean leaf (left). Leaf on the right is undamaged.

are summarized in Table 1. The table shows that when one larvae was fed on a BBMV-infected faba bean plant and then transferred to a healthy one, the virus was transmitted to 22 out of 71 plants tested (31% transmission). However, increasing the number of viruliferous larvae per test plant did not increase the transmission frequency (Table 1). These results could be attributed to the feeding habit of the larvae because when we increased the number of larvae per test plant they consumed whole leaves and left no chance for virus transmission. Similar observations were mentioned by Schmutterer (1969) who reported that the caterpillars of *S. exigua* may defoliate the plants completely. In serial transmission tests the viruliferous larvae failed to transmit BBMV to more than one plant, and in similar transmission tests the larvae failed to transmit BYMV to faba bean.

The present study confirms the transmission of BBMV by the larvae of *S. exigua* in the Sudan and can explain the role of such larvae in the spread of the virus early in the season. As these larvae are important pests of faba bean and efficient vectors of BBMV, their control is highly recommended.

Table 1. Efficiency of *S. exigua* larvae as vectors of BBMV in glasshouse transmission tests.

No. of viruliferus larvae/test plant	Plants infected/plants exposed	Plants infected (%)
1	22/71	31
2	10/71	14
3	15/71	21
5	22/71	31

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إنتقال فيروس تبرقش الفول عن طريق يرقات الدودة الخضراء

الملخص

دُرست العلاقة بين الإصابة الحقلية بيرقات الدودة الخضراء *Spodoptera exigua*، وانتشار فيروس تبرقش الفول BBMV في مطلع الموسم، والتي رصدتها عدة دراسات حصر حقلية بمنطقة شمباط في السودان خلال الموسمين الزراعيين 1988 – 89 و 1989 – 90. وضمن عدد من الاختبارات التي أجريت في الدفيئة نقلت اليرقاتُ الفيروسَ إلى ما يصل إلى 31 ٪ من نباتات الفول المختبرة، مما يؤكّد الحاجة إلى مكافحة الدودة الخضراء كآفة على الفول، وكناقل للفيروس المذكور. وتفقد اليرقات الفوعية الفيروسَ بعد اختبارات التغذية للتلقيح الأول.

Pathogenicity of *Fusarium* spp. Associated with Foot-rot of Faba Bean

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Abstract

By studying morphological traits, 15 *Fusarium* species were identified in 176 *Fusarium* isolates from 156 faba bean (*Vicia faba* L.) plants collected in different areas of Zhejiang, eastern China and showing foot-rot symptoms. Eleven of these species were studied for their pathogenicity to faba bean plants. *Fusarium acuminatum, F. oxysporum, F. moniliforme, F. moniliforme* var. *subglutinans, and F. solani* were shown to be the most important pathogens infecting the bean plants in Zhejiang based on the frequency of their occurrence in the collected isolates (29%, 20.5%, 12.5%, 8.5%, and 4.6%, respectively) and on their pathogenicity indexes (52.8, 47.7, 34.1, 40, and 30, respectively). *F. moniliforme* var. *subglutinans, F. semitectum,* and *F. tricinctum* were confirmed to be pathogens of the bean crop for the first time, and *F. acuminatum* was newly recorded as a main pathogen of the crop in China.

Introduction

Faba bean (*Vicia faba* L.) is widely cultivated in China; consequently, this crop's diseases are also given a high priority in research (Ruan et al. 1986; Ruan et al. 1987; Yu 1979). Foot-rot of faba bean, caused mainly by *Fusarium* spp., is one of the most important diseases on the crop in China. This disease causes an average of 10%–30% crop loss each year during flowering and podding stages during March–May. It was not known which *Fusarium* species were associated with the disease in the eastern part of China, though *F. avenaceum, F. oxysporum, F. solani,* and *F. moniliforme* were shown to be the chief pathogens in Yunnan, located in southern China (Ruan et al. 1986; Ruan et al. 1987; Yu 1979). This study investigated the pathogenicity of *Fusarium* spp. isolated from faba bean plants with foot-rot symptoms in different areas of Zhejiang, in eastern China.

Materials and Methods

Isolation and identification of *Fusarium* spp.

Beginning in 1981, diseased bean plants showing foot-rot symptoms were collected in different areas of Zhejiang, China, during March–May each year; 176 *Fusarium* isolates were obtained by excising the infected part of hypocotyl or root, surface sterilizing it in 0.1% mercuric chloride for 15–30 seconds, and placing it on potato sucrose agar (PSA). Isolate purifications were made using the dilution plate technique to obtain single-spore cultures for identification and further studies. Morphological traits of *Fusarium* species that had been studied for their identification were chiefly based on the taxonomy systems proposed by Booth (1971) and Nelson et al. (1983) Media used for identification were mainly PSA, modified Bilai medium (Booth 1971), and rice medium.

Inoculum for pathogenicity tests was prepared by culturing the fungi on PSA medium in petri dishes for seven days at 25°C, and homogenizing the fungi colonies in distilled water. Soil medium used comprised three parts field soil + one part sand; the mixture was autoclaved for 90 minutes (121°C) and placed in 3-l pots. Before sowing, faba bean seeds were surface-sterilized by first being immersed in water at 25°C for 20 hours, washed for 10 minutes in tap water and then immersed, consecutively, in 51°C water for one minute, in 54°C water for five minutes, and in 0.1% mercuric chloride for one and one-half minutes. Sterilization was concluded by washing the seeds with sterilized water three times. Five or six surface-sterilized seeds were sown in each pot.

Pathogenicity was tested using two inoculation procedures. The first was soil inoculation. Inoculum prepared from one dish colony of test fungi was mixed in one pot of soil, and left for 24 hours before the seeds were sown. The second was inoculating the roots. Plants were inoculated at the two-leaf stage by adding in the rhizosphere the same inoculum as used in the soil inoculation.

Plants were watered with nutrient solution two times a week after they attained two-leaf stage. The incidence of foot-rot was assessed on plants after 45 days growth in the soil inoculation treatment and after 55 days growth in the root-inoculation treatment. Disease severity on plants was assessed according to the key shown in Table 1.

Disease Severity Index: The indexes were derived from the following formula:

$$\text{Disease Index} = \frac{\Sigma\,(N \times DR)}{T \times HDR} \times 100$$

in which N is the plant number within a given disease rating, DR is the given disease rating corresponding to the plant number, T is the total plant number tested, and HDR is the highest disease rating in the disease assessment key. HDR here is 4.

Table 1. Disease assessment key: categories of foot-rot severity.

Disease rating	Disease symptoms
0	None
1	Lesions on side of foot-stem, less than 1 cm in diameter.
2	Lesions nearly girdling foot-stem, 1-2 cm in diameter.
3	Lesions girdling foot-stem conspicuously, more than 2 cm in diameter.
4	Plant wilting.

Results

Distribution and isolate frequency of *Fusarium* species.

Among the 176 *Fusarium* isolates obtained, 15 *Fusarium* species were identified (Table 2). *Fusarium* species that were most frequently isolated and their isolate frequencies were *Fusarium acuminatum* (29%), *F. moniliforme* (including *F. moniliforme* var. *subglutinans* and *F. moniliforme* var. *intermidium*) (25%), *F. oxysporum* (20.5%), and *F. solani* (including *F. solani* var. *redolens* and *F. solani* var. *coerulens*) (13.6%). These species accounted for 88.1% of all *Fusarium* isolates and were clearly the majority in *Fusarium* population on faba bean plants. Isolation frequency distribution ranges over different areas were 0%–39.3% for *F. acuminatum*, 0%–33.3% for *F. moniliforme* and its varieties, 14.3%–100% for *F. oxysporum*, and 14.3%–66.7% for *F. solani* and its varieties.

Pathogenicity tests of *Fusarium* spp.

The results were expressed as the average disease rating of the assessable plants in each fungus/host treatment (Table 3). Although disease severity induced by various *Fusarium* species differed, 11 *Fusarium* species tested for their pathogenicities to faba bean showed that all of them had the pathogenic ability. Based on pathogenic severity index and on isolate frequency of different *Fusarium* species, *F. acuminatum, F. oxysporum, F. moniliforme, F. moniliforme* var. *subglutinans* and *F. solani* were the most important pathogens in causing foot-rot of faba bean; respectively, their severity indexes in root-inoculation treatments were 52.8, 47.7, 34.4, 40, and 30. *F. graminearum* could also be considered one of high pathogenic fungi on *V. faba* according to its pathogenic severity index (40), but its isolate frequency was not high (5.1%). Other *Fusarium* species shown in Table 2 were not important pathogens on faba bean as neither their severity indexes nor isolate frequencies could match with those of the species mentioned above.

Table 2. Distribution of *Fusarium* species associated with faba bean.

	Location and number of *Fusarium* isolates						
Fusarium species	Giaxin Huzhou	Hangzhou	Ningbo Shaoxin Zhoushan	Wunzhou Lishui	Jinghua Tiazhou	Total	Percent
acuminatum	3	44	—	2	2	51	29
equiseti	—	3	—	—	—	3	1.7
graminearum	3	6	—	—	—	9	5.1
moniliforme	1	16	3	2	—	22	12.5
—var. *subglutinans*	2	8	2	3	—	15	8.5
—var. *intermidium*	—	5	—	—	—	5	2.8
oxysporum	1	16	8	8	3	36	20.5
semitectum	1	2	—	1	—	4	2.3
—var. *majors*	1	—	—	—	—	1	0.6
solani	—	2	4	—	2	8	4.6
—var. *redolens*	—	5	1	1	1	8	4.6
—var. *coerulens*	2	—	3	—	3	8	4.6
tricinctum	—	4	—	—	—	4	2.3
udum	—	1	—	—	—	1	0.6
xylarioides	—	—	—	1	—	1	0.6

Table 3. Pathogenicity of *Fusarium* spp. on faba bean.

Fusarium species	Soil inoculation (Modified percent of dead plants	Root inoculation			Reisolation
		Incidence (%)	Dead plant (%)	Severity indexes	
acuminatum	61.7	88.8	22.2	52.8	+
graminearum	16.7	80	0	40	+
moniliforme	55.5	63.6	9.1	34.1	+
—var. *subglutinans*	85.3	73.3	6.7	40	+
oxysporum	33.3	81.8	9.1	47.7	+
semitectum	55.5	38	0	12.9	+
solani	50	91.6	8.3	30	+
—var. *redolens*	66.6	NT	NT	NT	+
—var. *coerulens*	NT	66.7	0	19.4	+
tricinctum	70	40	0	11.4	+
xylarioides	11.5	NT	NT	NT	+
Check	0	20	0	7.2	M*

* *Penicillium* spp. and *F. moniliforme* could be isolated from the diseased plants; NT = not tested.

Discussion

Previous research works showed that different important *Fusarium* species were associated with foot- or root-rot on faba bean in different areas (Abdel-Hafez 1984; Clarkson 1978; Harrison 1981; Lamari and Bernier 1985; Salt 1983). Strikingly, this study revealed that *Fusarium avenacium*, one of the most important pathogens of foot-rot on *V. faba* in Yunnan in South China, a subtropical-tropical mountain area, did not appear on the bean in Zhejiang, the subtropical-temperate land area, suggesting that climatic conditions may affect the distribution of a particular species of *Fusarium*. Such a specific climatic dependence might also account for *F. acuminatum* appearing more frequently in temperate and temperate-cold areas (Booth 1971).

The results of this study may provide the first confirmed records that *F. moniliforme* var. *subglutinans*, *F. semitectum*, and *F. tricinctum* are pathogens of faba bean; additionally, *F. acuminatum* was reported for the first time as a main pathogens on the crop in China.

Acknowledgement

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القدرة الإمراضية لفطر *Fusarium* spp. المترافقة بمرض التعفن القاعدي في الفول

الملخص

في دراسة على الصفات الشكلية تم تحديد 15 نوعا من فطر الفيوزاريوم *Fusarium* في 176 عزلة أخذت من 156 نبتة فول *Vicia faba* L. جرى جمعها من مناطق مختلفة في زهيجيانغ بشرقي الصين وظهرت عليها أعراض العفن القاعدي. وقد دُرست القدرة الإمراضية لأحد عشر نوعا منها على إصابة نباتات الفول بالمرض، فتبين أن *F. oxysporum, F. moniliforme, F. moniliforme* var. *subglutinans, F. solani* هي أهم مسببات المرض التي تصيب نباتات الفول في زهيجانغ، وذلك بالاستناد إلى تكرار حدوث الإصابة في العزلات المجموعة (29 ٪، 20.5 ٪، 12.5 ٪، 8.5 ٪، 4.6 ٪ على الترتيب)، وإلى مؤشرات قدرتها الإمراضية (52.8 ٪، 47.7 ٪، 34.1 ، 40، 30 على الترتيب). وجرى التأكيد لأول مرة على أن *F. moniliforme* var. *subglutinans, F. semeticum, F. tricinctum* من العوامل المرضة لنباتات الفول، كما سُجّل النوع *F. acuminatum* حديثا كعامل مُمرض رئيسي لذلك المحصول في الصين.

Preliminary Attempts to Produce Genetically Engineered *Azotobactor chrococcum* Transformants Able to Produce *Orobanche* Stimulant(s)

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Broomrape, *Orobanche* spp. is considered one of the important agricultural problems in many parts of the world. *Orobanche crenata* Forsk. parasitizes the roots of almost all food legumes, including faba bean, chickpea, lentil, and pea; and also certain fodder legumes in many arid or semiarid areas. Traditional methods and chemical compounds used for controlling *Orobanche* parasitism are inadequate. One way to control *Orobanche* parasitism may be to manipulate the seed germination stimulant(s) for *Orobanche*. However, attempts to identify the chemical structure of *Orobanche* germination stimulant(s) from the host and nonhost plants has not so far been successful. The stimulant might be utilized or degraded by specific microorganisms in the soil, as is the case with strigol, the stimulant for *Striga* spp. seeds. These difficulties have delayed development of a synthetic stimulant which, once identified, would probably be cheaper to produce and more practical to use than the natural stimulant.

In recent years considerable interest has been directed to biological control and breeding resistant cultivars for controlling *Orobanche* infestation. The present work was based on controlling *Orobanche* spp. biologically by developing genetically engineered *Azotobacter* strains which might produce stimulants for *Orobanche crenata* seed germination together with an ability to fix nitrogen.

A complete medium (CM), composed of 0.5 g K_2HPO_4, 0.2 g $MgSO_4$, 0.1 g NaCl, 10 g mannitol, 3 g yeast extract, and distilled water up to 1 l (Allen 1959) was used to grow *Azobacter*. When necessary, the medium was solidified with 2% agar and sterilized at 121°C for 20 minutes. DNA was isolated from 10-day-old seedlings of faba bean, alfalfa, lupins (hosts), and flax (nonhost); and purified by the method described by Bendich et al. (1967). *Azotobacter chroococcum* wild type strain was transformed, using each type of isolated DNA as a donor, by the method described by Cohen et al. (1972). Transformants can be selected by their ability to stimulate the germination of *Orobanche crenata* seeds. The biological activity of *Azotobacter chroococcum* was examined on the germination of *O. crenata* in vitro, by using bioassay technique as mentioned by Khalaf (1982).

Unfortunately, the results showed that *Azotobacter chroococcum* did not have stimulatory action on the germination of *Orobanche crenata* in vitro, irrespective of DNA transformants from different plants; this might be attributable to either transformation not occurring or lack of expression in genes controlling stimulant production. However, efforts will continue to develop and produce genetically engineered *Azotobacter chroococcum* transformants capable of producing *Orobanche* germination stimulant(s).

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Occurrence of a Seed-transmitted Strain of Bean Yellow Mosaic Virus on *Vicia faba* L. in Hungary

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Abstract

In the course of phytopathological and virological studies on faba bean plants, seed-transmitted bean yellow mosaic virus (BYMV) was observed in some cases. The virus was mechanically transmissible, and was identified both serologically and by host-range. To the authors' best knowledge, this is the first report on seed-transmitted BYMV disease in Hungary.

Introduction

The productivity of faba bean (*Vicia faba* L.) is affected by the more than 40 viruses known worldwide (Bos 1982; Cockbain 1983; Makkouk et al. 1988; Schmidt et al. 1980; Simay 1986). Bean yellow mosaic virus (BYMV) is one of the most important viruses infecting fields and is rather widely distributed in Hungary; however, its seed-transmissible strains are less known on faba bean (Fiedorow 1981; Kaiser et al. 1968; Phatak 1974) and such strains were not observed previously in Hungary on this host.

Materials and Methods

Seed transmission of BYMV was suspected in cvs Anka and Bakony I during growing of test plants for other virological and mycological studies. Later 500 seeds were sown and the diseased plants were selected for studying host range and the serological relationships of the causal virus. During the host range investigation, 21 species of five genera were infected using mechanical transmission.

Mechanical transmission of the virus was carried out using Soörrensen's phosphate-buffer (0.067 M, pH 7) and abbrazivum. Aphid transmission of the virus was studied with *Aphis fabae* and *Acyrthosiphon pisum* propagated on virus-free *Chenopodium quinoa* and *Pisum sativum*, respectively. The aphids were starved for six hours before being allowed to feed on the leaves of seed-infected plants for one hour. The aphids were then transferred to symptomless faba bean plants for 30 minutes, after which they were killed with 'Pirotox' spray (containing a pyrethroid).

Leaves of seed-infected plants were also used for serological tests. The antisera were made in the Plant Protection Research Institute against different strains of BYMV. The tests were carried out by drop-precipitation method under paraffin-oil and using direct double-sandwich ELISA.

Results

From 500 seeds sown, 473 faba bean seedlings emerged. Symptoms were observed not on the first pair of bifoliate leaves but on the subsequent multifoliate leaves. The first symptoms were vein-bandings; typical green-landed mosaic developed later on plants selected from seedlings (Figure 1). Six seedlings (1.33%) were observed with symptoms.

Figure 1. Mosaic pattern on leaves of *Vicia faba* L. caused by faba bean strain of bean yellow mosaic virus (BYMV).

Twenty-one host species belonging to five families were studied for testing host range. Plants belonging to families *Chenopodiaceae* and *Fabaceae* only were diseased (Table 1). The observed host range and the symptoms were similar to other BYMV isolates collected from faba bean (Simay 1984).

The virus was successfully transmitted by both vectors used. Vein clearing and mosaic were developed after a week following the infection.

BYMV was well-identifiable by serological technique from leaves of seed-infected plants. Antisera made against other faba bean viruses observed in Hungary earlier (Beczner et al. 1983; Simay 1984) were also tested but no other viruses were detected.

Discussion

BYMV is a worldwide-distributed virus of faba bean (Cockbain 1983; Simay 1986) and its occurrence is known in Hungary (Beczner et al. 1983; Simay 1984). It can cause loss in yield (Blaszczak and Jamróg-Janiczka 1973; Frowd and Bernier 1977; Makkouk et al. 1988) and increase susceptibility to chocolate spot disease caused by *Botrytis fabae* (Omar et al. 1986), which was also observed in Hungary (Simay 1987). Seed-transmitted BYMV has been reported earlier from elsewhere (Fiedorow 1981; Kaiser 1973; Kaiser et al. 1968; Phatak 1974), but with its presence demonstrated in Hungary as well, studies are needed to investigate the economic importance of the virus in this country.

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ظهور سلالة محمولة على البذور من فيروس الموزاييك الأصفر للفاصولياء على الفول *Vicia faba* L.

الملخص

في سياق دراسات على الأمراض والفيروسات التي تصيب الفول لوحظ في بعض الحالات فيروس الموزاييك الأصفر للفاصولياء المحمول على البذور. وكان الفيروس قابلا للانتقال بصورة ميكانيكية، وجرى تحديده مصليا، وبوساطة طيف النبات العائل. وحسب معلومات المؤلف فإن هذا أول تسجيل لذلك المرض الفيروسي في هنغاريا.

Table 1. Host range of BYMV transmitted mechanically from seed-infected faba bean plants.

Hosts	Symptoms: Local infection	Symptoms: Systemic infection
Amaranthaceae		
Amaranthus retroflexus	No infection	No infection
Chenopodiacea		
Beta vulgaris	No infection	No infection
Chenopodium album	Local lesion, chlorotic	Vein-chlorosis; chlorotic spots
Chenopodium quinoa	Local lesion, chlorotic	No infection
Fabaceae		
Cicer arietinum	Latent local infection retested on faba bean	Vein-clearing; mosaic, mild
Glycine max 'IR16'	Latent local infection retested on faba bean	No infection
Lens culinaris	Latent local infection retested on faba bean	Vein-clearing; mosaic, mottling
Medicageo sativa	Latent local infection retested on faba bean	Latent systemic infection retested on faba bean
Melilotus albus	Latent local infection retested on faba bean	No infection
Onobrychis vicii-folia	Latent local infection retested on faba bean	Latent systemic infection retested on faba bean
Phaseolus vulgaris 'Cherokee'	Local lesion, chlorotic	No infection
Pisum sativum 'Petit Provencal'	Latent local infection retested on faba bean	Vein-clearing; mosaic, mottling
Pisum sativum 'Ujmajori Középkorai'	Latent local infection retested on faba bean	Vein-clearing; mosaic, mild
Trifolium pratense 'Tápiói tetra'	Latent local infection retested on faba bean	Latent systemic infection retested on faba bean
Vicia ervilia	Latent local infection retested on faba bean	Vein-clearing; mosaic, mild
Vicia faba 'Bakony I'	Latent local infection retested on faba bean	Vein-clearing; mosaic, mottling
Vicia lutea	Latent local infection retested on faba bean	Vein-clearing; recovery, obvious symptoms not observable, but the retests on faba bean are positive
Vicia sativa	Latent local infection retested on faba bean	Vein-clearing; recovery, obvious symptoms not observable, but the retests on faba bean are positive
Vicia villosa	Latent local infection retested on faba bean	Latent systemic infection retested on faba bean
Oxalidaceae		
Oxalis europea	No infection	No infection
Portulacaceae		
Portulaca oleracea	No infection	No infection

ERRATA

Variation in Testa Fraction with Some other Seed Quality Attributes Of Faba Bean Grown in the New Production Areas in the Sudan

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Editor's note: In Issue no. 27 of *FABIS*, pages 30–31, the above article was published with omission of the two accompanying tables, which appear on the following two pages. The last line in the first paragraph of the Introduction should read "Grain yields of more than 2 tons/ha were obtained in farmers' fields." In the third paragraph of the Introduction, first sentence, 40–45 g refers to the 100-seed weight. We regret the omissions.

Table 1. Testa fraction percentages (Tf), 100-seed weight (HSW), hard-seed percentages (HSp), protein content (P), and tannice acid (TA) of 10 faba bean breeding lines grown at four locations in the new production areas (south of Khartoum).

Seed quality attributes by location	Breeding lines											
	Mass Selection Giza 1	00310	00281	0094	00301	00198	00104	317/99/81	557/80	H.72	S.E.	Average
Shambat												
Tf	11.7	11.9	11.5	12.1	12.1	12.0	11.9	12.5	12.9	13.1	0.29	12.1
HSW	41.7	41.3	44.3	45.5	44.3	45.1	46.7	35.7	42.5	42.4	0.64	42.9
HSp	11.4	15.8	12.8	17.2	17.2	9.8	10.8	14.8	22.6	19.0	1.15	15.1
P	28.23	30.15	30.61	29.06	29.24	27.55	25.32	25.61	29.06	27.77	0.85	28.26
TA	0.041	0.042	0.043	0.056	0.057	0.060	0.061	0.052	0.051	0.053	0.0017	0.052
Wad Medani												
Tf	15.7	17.1	17.6	18.8	16.8	16.6	16.7	17.8	21.0	20.4	0.55	17.8
HSW	39.2	38.3	36.5	41.8	40.6	40.5	38.2	39.0	40.9	37.9	1.11	39.3
HSp	4.4	6.4	8.2	6.2	5.8	5.0	7.6	8.8	7.4	7.8	0.92	6.8
P	25.50	26.30	26.31	25.95	25.33	26.85	25.20	24.20	25.44	26.75	0.68	25.79
TA	0.061	0.065	0.057	0.050	0.067	0.054	0.064	0.059	0.066	0.061	0.0006	0.060
El Rahad												
Tf	14.9	14.1	16.0	15.6	15.9	11.7	11.2	12.9	14.5	15.0	0.75	14.2
HSW	39.1	40.4	41.1	44.6	40.2	41.6	42.1	40.9	38.0	41.2	0.89	40.9
HSp	7.6	6.3	6.4	7.2	13.0	3.6	7.2	5.8	9.4	4.2	0.87	7.1
P	28.39	27.45	29.39	29.05	28.28	28.24	28.50	27.95	28.67	28.96	0.50	28.49
TA	0.039	0.047	0.044	0.042	0.050	0.069	0.060	0.064	0.060	0.065	0.0017	0.054
New Halfa												
Tf	18.8	17.9	18.0	17.2	15.9	17.2	18.1	17.6	17.0	17.8	0.064	17.5
HSW	42.1	40.9	40.3	42.0	43.1	42.0	44.8	42.9	45.3	39.3	0.67	42.3
HSp	5.4	2.8	6.6	3.4	6.0	2.2	5.8	3.4	7.2	4.4	0.61	4.7
P	25.40	28.18	28.54	28.55	26.65	26.60	26.38	26.66	28.08	27.03	0.47	27.21
TA	0.012	0.012	0.050	0.090	0.050	0.060	0.053	0.050	0.060	0.050	0.0017	0.049
Average across all locations for each attribute												
Tf	15.3	15.2	15.8	15.9	15.2	14.4	14.5	15.2	16.4	16.6	0.29	15.4
HSW	40.5	40.2	40.5	43.5	42.0	42.3	42.9	39.6	41.7	40.2	0.42	41.3
HSp	7.2	7.8	8.5	8.5	10.5	5.1	7.8	8.2	11.6	8.8	0.45	8.4
P	26.88	28.02	28.71	28.15	27.37	27.31	26.35	26.10	27.81	27.63	0.32	27.44
TA	0.038	0.041	0.048	0.059	0.056	0.061	0.059	0.056	0.059	0.057	0.0007	0.053

Table 2. Correlation coefficients between testa fraction percent and four other seed quality attributes for the average of the four locations.

Variable	Testa fractions	100-seed weight	Seed tannic acid %	Seed protein %
100-seed weight (g)	-0.270			
Tannic acid %	-0.012	0.560		
Protein %	0.537	0.077	-0.158	
Hard seed %	0.633	0.004	0.170	0.231

For 8 d.f 5% r = 0.632
1% r = 0.765

NEWS

Publications

Vorst, James J. (ed). 1990. *Experiments in Crop Science.* Crop Science Society of America, 677 South Segoe Road, Madison, Wisconsin, USA 53711-1086. 62 pp.

The overall objective of this publication is to provide teachers with experiments they may use to demonstrate that learning basic plant biology is important, exciting, and relevant to a world that is placing more demands on safe and efficient food and fiber production systems. Student participation in the experiments will encourage the students' interest and retention of information learned.

The experiments were developed through the efforts of the Crop Science Society of America. Each experiment is independent of the other experiments so teachers may select a specific experiment that relates directly to the lesson plan. A teacher guide and student guide are included with each experiment. Students are also presented with a series of questions to assist them in fully understanding each experiment. Teachers will find the list of vendors to be quite useful when ordering supplies.

Westerman, R. L. (ed). *Soil Testing and Plant Analysis, Third Edition.* Soil Science Society of America, 677 South Segoe Road, Madison, Wisconsin 53711-1086, USA.

Soil testing and plant analyses have proven to be invaluable tools in the diagnosing of nutritional deficiencies and problems related to plant growth. Each advance in our basic understanding of plant physiology and soil chemistry, coupled with advances in instrumentation, leads to improvements in methodology and interpretation.

Soil Testing and Plant Analysis was first published in 1967 by the Soil Science Society of America. This edition set the standards for understanding the significance of plant analysis as a diagnostic tool and soil testing as a guide for fertilizer use. In 1973, the second edition further enhanced the overall understanding of soil testing and plant analysis. Since the second edition, there has been tremendous progress in the development of methodology for analysis of soil and plants and interpretation of analytical results for best management practices that promote efficient fertilizer use and optimum yield, yet minimizes the potential of groundwater, lake, and stream pollution.

The third edition summarizes the current knowledge and experiences on the use of soil testing and plant analysis as a diagnostic tool for assessing nutritional requirements of crops, efficient fertilizer use, saline-sodic conditions, and toxicity of metals. Discussions on analytical instrumentation used in soil testing, plant analysis, and data processing are included. In addition to college students and teachers, this edition will also be useful to laboratory personnel, industrial and extension agronomists, and researchers focusing on soils, crops, forestry, horticulture, ecology, botany, and the environment.

Amine, Maria (ed). 1991. *Ley Farming* (in French). Actes Editions, Institut Agronomique et Vétérinaire Hassan II, B. P. 6202, Rabat-Instituts, RABAT (MAROC).

This book contains the proceedings of the National Seminar on ley farming organized by the Moroccan Ministry of Agriculture and Agrarian Reform, Rabat, Morocco, 1–2 February 1990, with financial support from ICARDA. Including recommendations, this book should be of interest to anyone exploring the benefits and constraints of ley farming in the semiarid zones.

D. A. Sleeper, T. C. Barker, and P. J. Bramel-Cox (eds). 1991. *Plant Breeding and Sustainable Agriculture: Considerations for Objectives and Methods.* Crop Science Society of America and American Society of Agronomy, 677 South Segoe Road, Madison, Wisconsin, USA 53711-1086. 93 pp.

This publication offers the opportunity for discussion of the important topics related to the contributions of plant breeding under alternative production systems and under selection criteria in which sustainability of the system is paramount. This softcover publication is the result of a symposium designed to address sustainable agriculture issues that affect plant breeding. This will be of interest to plant breeders, agronomists, policymakers, farmers, and others interested in sustainable agriculture.

Other releases

A new journal *Ecological Engineering — The Journal of Ecotechnology* will be available on a quarterly basis, beginning in 1992. The journal will be read and contributed to by applied ecologists, environmental managers and regulators, natural resource specialists (e.g., foresters, fish, and wildlife specialists), environmental and civil engineers, agroecologists, and landscape planners and designer. It is meant to serve as a bridge between ecologists and engineers, and ecotechnology is not wholly defined by either field. The journal is meant for ecologists who, because of their research interests or occupation, are involved in designing, monitoring, or constructing ecosystems. The journal is also for engineers who, as a result of training and/or experience in biological and/or ecological sciences, are involved in designing and building ecosystems. The journal is of particular interest to practicing environmental managers due to its multidisciplinary approach to practical problems and opportunities.

Ecological engineering has been defined as the design of ecosystems for the mutual benefit of humans and nature. Specific topics covered in the journal include: ecotechnology; synthetic ecology; bioengineering; sustainable agroecology; habitat reconstruction; restoration ecology; ecosystem conservation; ecosystem rehabilitation; biomanipulation; stream and river restoration; wetland restoration and construction, reclamation ecology; non-renewable resource conservation.

For further information, contact: Elsevier Science Publishers, P.O. Box 181, 1000 AD Amsterdam, The Netherlands; or P.O. Box 882, Madison Square Station, New York, NY 10159, USA.

Visuals

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

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

ICARDA publications and services

ICARDA Investing in the Future
ICARDA's historical background and research objectives are outlined in English and Arabic. For your copy, contact CODIS.

***FABIS* (Faba Bean Information Service)**
This service was established in June 1979 when *FABIS* Newsletter No. 1 appeared. Now produced biannually, it publishes up-to-the-minute short scientific papers on the latest research results and news items. For further information, write: *FABIS*.

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

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

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

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

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

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

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

When you contact any of the programs, departments or services cited above for your copy, please indicate that you saw the announcement in the *FABIS* newsletter.

Forthcoming Events

1992

***3rd International Legume Conference*, Kew, UK, 1992.** Contact: The Royal Botanic Gardens Kew, Richmond, Surrey TW9 3AB, UK.

***International Meetings on Biology Molecular and Cellular Techniques in Plant Breeding*, I. A. M. Z. Zaragoza, Spain, 13–31 January 1992.** Contact: Instituto Agronomico, Mediterraneo de Zaragoza, Apartado 202, 50080, Zaragoza, Spain.

***Symposium on Durability of Disease Resistence*, Wageningen, The Netherlands, 24–28 February 1992.** Contact: Symposium Durability of Disease Resistence, IAC-section OCC, P.O. Box 88, NL-6700 AB Wageningen, The Netherlands.

***International Food Legume Research Conference*, Cairo, Egypt, 12–16 April.** Contact: A. L. Slinkard (306)966-4978.

***International Congress of Integrated Pest Management*, Panamerican School of Agriculture, Tegucigalpa, Honduras, 22–26 April.** Contact: Abelino Pitty Tel: 504/76-6140/6150.

***1st European Conference on Grain Legumes*, Angers, France, 1–3 June 1992.** Contact: Secretariat, UNIP, 12 Avenue George V, 75008 Paris, France.

XIIIth EUCARPIA Congress, *Reproductive Biology and Plant Breeding*, Angers, France, 6–11 July 1992. For registration and hotel accommodation, contact: XIIIth EUCARPIA Congress, Centre de Congrèd d'Angers, France. (2nd announcement) Tel: (33) 41 60 32 32; Fax: (33) 41 43 42 70. For poster titles and abstracts, contact: XIIIth EUCARPIA Congress, GEVES, La Minière, 78285 Guyancourt Cedex, France. Fax: (33) 130 833629.

***First International Crop Science Congress*, Ames, Iowa, USA, 14–22 July 1992.** The program will consist of plenary sessions, symposia, and voluntary poster papers and professional tours organized so as to (a) present knowledge pertinent to crop scientists from all regions of the world, (b) emphasize integration of knowledge from crop science to solve global and regional problems and issues, and (c) focus on global research needs. Opportunities for work group sessions will be provided on the congress program. Contact: K. Frey, International Crop Science Congress, c/o Agronomy Department, Iowa State University, Ames, IA 50011, USA.

***9th International Biotechnology Congress*, Virginia, USA, 16–21 August 1992.** Contact: Congress Office, American Chemical Society, 1155 Sixteenth Street, N. W, Washington, D.C., USA.

***6th International Symposium on microbial Ecology (ISME 6)*, Barcelona, Spain, 6–11 September 1992.** Contact: Prof. Ricardo Guerrero, ISME-6, Apartado 16009, E-08080 Barcelona, Spain.

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

1993

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

***XII International Plant Nutrition Colloquium/Symposium — Zinc in Soils and Plants*, Perth, Western Australia, 21–26/27–28 September 1993.** Contact: Plant Nutrition Secretariat, The Conference Office University of Western Australia, Nedlands, WA 6009, Australia.

1994

***7th International Congress of Bacteriology, Applied Microbiology and Mycology*, Prague, Czechoslovakia, 3–8 July 1994.** Contact: Dr B. Sikyta, Institute of Microbiology, Czechoslovak Academy of Sciences, Videnska 1083, CS-142 20, Prague 4, Czechoslovakia.

Second International Food Legume Research Conference 12–16 April 1992, Cairo, Egypt

The First International Food Legume Research Conference (IFLRC-I) on pea (*Pisum sativum*), lentil (*Lens culinaris*), and chickpea (*Cicer arietinum*) was held at Spokane, Washington, U.S.A in 1986. It was a resounding success with over 500 registrants from 50 countries. The program consisted of 91 papers coauthored by 202 contributors from 40 countries. The Conference Proceedings were published as Summerfield, R. J. (ed.). *World Crops: Cool Season Food Legumes, 1988.* Kluwer Academic Publishers, Dordrecht, The Netherlands.

The success of IFLRC-I has promoted development of the Second International Food Legume Research Conference (IFLRC-II), which will be held 12–16 April 1992 in Cairo, Egypt. Recent success in development of low neurotoxin lines of grass pea (*Lathyrus sativus*) has resulted in the addition of this promising cool season food legume to the list of species covered.

The objectives of IFLRC-II are to (1) review and assess recent results from national and international research programs on cool season food legumes and (2) develop strategies for increasing production per unit area and increasing use of these cool season food legumes in various cropping systems. Both basic and applied research will be addressed and multidisciplinary research efforts will be emphasized.

For further information please contact:

Dr A. E. Slinkard
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University of Saskatchewan
Saskatoon
Saskatchewan, S7N 0W0
CANADA

Document Collection

ICARDA is building up its document collection on faba bean. The collection will be used to supply needed documents to scientists in developing countries.

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

FABIS
ICARDA
P.O. Box 5466
Aleppo, Syria

Agricultural libraries receiving ICARDA publications

ICARDA publications are deposited in the following agricultural libraries to make them available to other users under normal inter-library loan and photocopy procedures.

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Ottawa K1A OC5
CANADA
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Helsinki University
Library of Agriculture
Viikki
SF-00710 Helsinki
FINLAND
Telex: 122352 humk sf
Telefax: (90) 708 5011

J-F. Giovannetti
Chef du Service Central IST
Avenue du Val de Montferrand
BP 5035
34032 Montpellier Cedex
FRANCE
Telex: 480 762f

Ms Apolena Roubinkova
Faculte des Sciences Agronomiques
de Gembloux - Bibliotheque Centrale
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B-5800 Gembloux
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UNITED KINGDOM
Telephone: 0634 880088

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Director
US Department of Agriculture
National Agricultural Library
Serials Unit, Room 002
Beltsville, Maryland 20705
USA

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