



FABIS

Faba Bean Information Service

NEWSLETTER No. 36/37
January—December 1995



INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS

(ICARDA)

ICARDA and CGIAR

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based at Aleppo, Syria, it is one of 16 centers supported by the Consultative Group on International Agricultural Research (CGIAR), which is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work.

The mission of the CGIAR is to contribute, through its research, to promoting sustainable agriculture for food security in developing countries. The CGIAR conducts strategic and applied research, with its products being international public goods, and focuses its research agenda on problem solving through interdisciplinary programs implemented by one or more of its international centers, in collaboration with a full range of partners. Such programs concentrate on increasing productivity, protecting the environment, saving biodiversity, improving policies, and contributing to strengthening agricultural research in developing countries.

In the context of the challenges posed by the physical, social and economic environments of the dry areas, ICARDA's mission is to improve, through research and training, the welfare of people in the dry areas of the developing world by increasing the production and nutritional quality of food while preserving and enhancing the resource base.

ICARDA serves the entire developing world for the improvement of lentil, barley and faba bean; all dry area developing countries for on-farm water management, small ruminants and rangelands; and the West Asia and North Africa region for production enhancement of bread and durum wheats, chickpea, and farming systems. ICARDA's research provides global benefits of poverty alleviation through productivity improvements integrated with sustainable natural resource management practices.

FABIS

FABIS Newsletter is produced twice a year by ICARDA for the Faba Bean Information Service. It is a forum for communicating research results on faba bean and other *Viciae* legumes in the genera *Vicia* and *Lathyrus*. Short research articles provide rapid information exchange and comprehensive reviews are invited regularly on specific areas. The newsletter occasionally publishes reviews of relevant books. Recent references are published in an annual supplement.

SUBSCRIPTIONS: *FABIS Newsletter* is available on subscription at US\$ 20.00 per year. However, *FABIS Newsletter* is made available free to ICARDA cooperators. To subscribe, please send US\$ check drawn on any branch of a US bank, or a US branch of any other bank, to: FABIS/CODIS, ICARDA, P.O. Box 5466, Aleppo, Syria.

FABIS Coordinating Committee

BRAZIL: Dr H. Aider, National Center for Research on Rice and Beans, BR-153, km 4—Goiania/Anapolis, Caixa Postal 179, 74000—Goiania, Goias.

CANADA: Dr C. Bernier, Department of Plant Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2.

EGYPT: Dr A. Nassib, Field Crops Institute, Agricultural Research Center, Giza 12619.

FRANCE: Dr J. Picard, 4 Rue du 8 Mai, 36100 Neuvy—Pailloux.

ITALY: Prof. C. de Pace, Istituto di Biologia Agraria, Università della Tuscia, Viterbo.

SPAIN: Dr J.I. Cubero, Escuela Técnica Superior de Ingenieros Agrónomos, Departamento de Genética, Apartado 3048, Córdoba.

SUDAN: Dr F.A. Salih, Agricultural Research Corporation, Shambat Research Station, P.O. Box 30, Khartoum North.

SYRIA: Dr L.D. Robertson/FABIS Editor, ICARDA, P.O. Box 5466, Aleppo.

THAILAND: Dr K. Kogure, JICA Team Office, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200.

UK: Dr D.A. Bond, Plant Breeding Institute, Maris Lane, Trumpington, Cambridge CB2 2LQ.

FABIS Production Team

L.D. Robertson/Technical Editor

G.R. Manners/Editor

K. Al-Jbaili and Adel Abdel Khaleq/Arabic abstracts

W. Meskine/Typesetter



Faba Bean Information Service

FABIS Newsletter 36/37

January–December 1995

CONTENTS

Research Articles

- | Page | <i>Breeding and Genetics</i> |
|------|---|
| 3 | Genotypic Differences in the Temperature Responses of the Germination of Near-isogenic Faba Beans
F. Kantar, P.D. Hebblethwaite, C.J. Pilbeam and J. Craigon |
| 8 | Inheritance of Some Seed Quality Characters in Faba Bean
M.S. El-Shazly, M.M. El-Ashry, El-Sayed M. Gaafar and Magdy M.M. Mohamed |
| | <i>Physiology and Microbiology</i> |
| 14 | Pattern of Nutrient Removal by Faba Bean Grown on Vertisol of Central India
A.K. Dwivedi and G.S. Nayak |
| 17 | Pattern of Protein Synthesis in Faba Bean as Influenced by Sulfur and Phosphorus Nutrition
G.S. Nayak and A.K. Dwivedi |
| | <i>Pests and Diseases</i> |
| 19 | Optimizing Sowing Date of Faba Bean for Grain Yield and to Counter Leaf Miner <i>Liriomyza trifolii</i> (Burg) in New Halfa, Sudan
Tag Elsir Elamin Abdalla |

- 20 *Vicia faba* Seed Infestation and Losses Due to *Bruchus rufimanus* Boh. (Coleoptera: Bruchidae)
in Morocco
 A. Boughdad and Ginette Laugé
- 25 Effect of Maleic Hydrazide (MH) as a Growth Inhibitor for Controlling *Orobanche crenata* on
Faba Bean
 Khaled A. Khalaf, G.M. Metwely and T.A. El Shahawie

News

- 31 Editors' note
- 31 Conferences
- 31 Recent faba bean publication
- 32 Agricultural Libraries Receiving ICARDA Publications
- Contributors' Style Guide

Breeding and Genetics

Genotypic Differences in Temperature Responses of the Germination of Near-isogenic Faba Beans

F. Kantar¹, P.D. Hebblethwaite²,
C.J. Pilbeam^{3,4} and J. Craighan²

¹ University of Ataturk, Faculty of Agriculture, Department of Agronomy, Erzurum, 25240, TURKEY

² University of Nottingham, School of Agriculture, Department of Agriculture and Horticulture, Sutton Bonington, Loughborough, Leicestershire LE12 5RD, UK

³ ICARDA, P.O. Box 5466, Aleppo, SYRIA

Abstract

The germination at constant temperature of five contrasting faba bean (*Vicia faba* L.) types for testa tannins was investigated between 5°C and 32.5°C on a thermal-gradient plate. Cardinal temperatures and thermal time requirements were calculated. Poor germination, substantial delays in the lag phase and a wider spread of germination occurred at 5°C in near-isogenic white-flowered (zero-tannin) types than in high-tannin lines. Furthermore, emergence of zero-tannin types was poor in cold and wet soil in spite of good emergence in favorable field conditions. However, in white-flowered cv. Albatross, germination and emergence were similar to lines with colored flowers. The data are discussed in relation to the emergence of zero-tannin types.

Key words: *Vicia faba*; faba beans; genotypes; germination; emergence; testa; tannins; temperature.

Introduction

White-flowered zero-tannin cultivars of *Vicia faba* have rectified the nutritional drawbacks arising from the presence of condensed tannins in the testae of the traditional faba beans with colored flowers (Huisman and van der Poel 1989). However, this advantage is offset by accompanying problems of poor emergence especially in cold and wet soil (Bond et al. 1986; van Loon et al. 1989).

The rate of germination and cardinal temperature requirements (Feddes 1972; Bierhuizen and Wagenvoort 1974)

الفروقات الوراثية في استجابة إنبات سلالات الفول القريبة التماثل في الصفات الوراثية لدرجات الحرارة

الملخص

تمت دراسة إنبات خمسة طرز وراثية متناقضة من الفول (*Vicia faba* L.) من حيث التانين الموجود في غلاف البذور عند درجات حرارة ثابتة ما بين 5 م° و 32.5 م° على لوحة مدرج حراري، وحُسبت المتطلبات من درجات الحرارة الرئيسية والزمن الحراري. وقد حدث إنبات سيء، تعويق كبير في المرحلة المتخلفة، وانتشار للإنبات عند 5 م° في الطرز القريبة التماثل في الصفات الوراثية ذات الأزهار البيضاء (خالية من التانين)، أوسع مما هو عليه في السلالات العالية المحتوى من التانين. وعلاوة على ذلك، كان ظهور البادرات في الطرز الوراثية الخالية من التانين سيئاً في التربة الباردة والرطبة، رغم أنه جيد في الظروف الحقلية المواتية. ومع ذلك، ففي الصنف الباتروس ذي الأزهار البيضاء، كان الإنبات وظهور البادرات مشابه للسلالات ذات الأزهار الملونة. وتدرس البيانات من حيث العلاقة بتكشف البادرات في الطرز الخالية من التانين.

of a given species are associated with seedling establishment at low temperatures.

This work investigated whether the germination responses to temperature of zero-tannin faba beans differ from those of high-tannin cultivars using lines near-isogenic for the testa tannins.

Material and Methods

The progress of germination of five lines and cultivars of *Vicia faba* was investigated on a one-way temperature gradient plate (Garcia-Huidobro et al. 1982) using the white-flowered cultivar Albatross (NIAB 1992) and two pairs of lines near-isogenic for flower color (WCI/WWI and SCI/SWI; WWI and SWI were the zero-tannin lines).

Four replicates of 20 seeds dressed with benomyl were germinated on moist sterile sand in petri dishes placed across 12 constant temperatures ranging from 5 to 32.5°C. Germinated seeds with radicle lengths of 10 mm (Mohamed et al. 1988a) were counted at 6-h intervals.

Cumulative germination data from each replicate was fitted to the Weibull equation (Dumur et al. 1990). Cardinal time

⁴ Present address: Department of Soil Science, University of Reading, Whiteknights, Reading RG6 2DW, UK.

requirements, namely base (t_b), optimum (t_o) and maximum temperatures (t_m), and thermal time requirements for germination at sub- (θ_1) and supra- (θ_2) optimal temperature were calculated from the regression of the rates for germination of the 50th percentile against temperature (Dumur et al. 1990). Confidence limits according to Feilliers Theorem (Finney 1978) were determined for base temperature only, due to poor fit of regression lines at supra-optimal temperatures.

Field emergence was assessed both in a sandy loam soil at the School of Agriculture farm at Sutton Bonington, UK, and in a sandy loam soil wetted to -0.06 MPa with 12 replicates in pots in a growth room at $5 \pm 2^\circ\text{C}$. Seeds of each line and cultivar were sown at a depth of 10 cm in 5-m plots having three rows (50 seeds per row) with three randomized blocks in the field. Winter lines (WWI and WCI) were sown on 12 October 1989 and spring lines (SCI, SWI and Albatross) were sown on 7 March 1990.

Results and Discussion

Temperature affected the final germination of all lines ($P < 0.001$) according to the analysis of deviance based on a binomial distribution with a probit link. In spite of high germination of all lines between 10 and 25°C ($>83\%$), the final germination percentage of white types was less than that of their colored counterparts at temperatures below 10°C (e.g. WWI, WCI, SWI, SCI and Albatross had 56, 75, 79, 96 and 91% germination, respectively, at 5°C ; Fig. 1). Almost no germination occurred at 32.5°C within 1074 h.

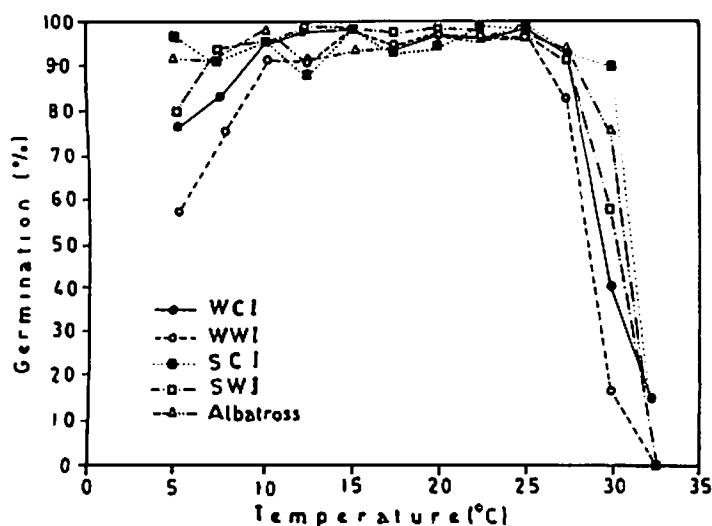


Fig. 1. Effect of constant temperature ($^\circ\text{C}$) on the final percentage germination on a temperature-gradient plate of near-isogenic faba beans.

Furthermore, although germination occurred more rapidly between 20 and 25°C (Fig. 2), near-isogenic white lines germinated more slowly at 5°C than their high-tannin counterparts WCI and SCI, as seen in the wider spread of germination of WWI and SWI (Fig. 3A, B) and the delayed lag phase of germination of WWI (Fig. 3A). However, zero-tannin cv. Albatross had germination equal to or better than the high-tannin lines.

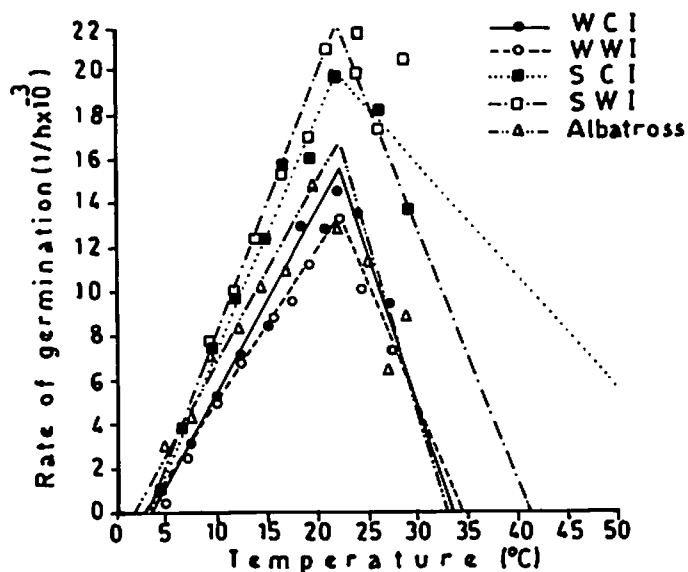


Fig. 2. Effect of constant temperature on the rate of 50% germination ($1/h \times 10^3$) calculated from Weibull function fitted to the cumulative germination percentage of near-isogenic faba beans.

Apart from the lower base temperature (t_b) of zero-tannin cv. Albatross (0.8°C), base temperatures calculated were not necessarily different between zero- and high-tannin near-isogenic lines ($t_b = 3.0$ – 3.6°C), as the 5% confidence limits overlap (Table 1). These values were higher than those reported for other cultivars (e.g. 0.6°C for cv. Alfred, Dumur et al. 1990; 0.4°C for a broad bean variety, Bierhuizen and Wagenvoort 1974; and even lower values of between -0.4 and -7.5°C for other faba bean varieties, Ellis et al. 1987).

Although the differences reported in t_b for faba beans could be partly due to the extrapolation of data beyond the experimental range (Anderson et al. 1978) and to the different stages of seedling growth at which germination was considered to have finished in the various studies (Ellis et al. 1986; Dumur et al. 1990), the genotypic responses to temperature of the cultivars may be different (Covell et al. 1986). Moreover, in a parallel study with another seed lot of near-isogenic SCI and SWI, base temperatures calculated (3.3 – 3.4°C) were similar to those reported here.

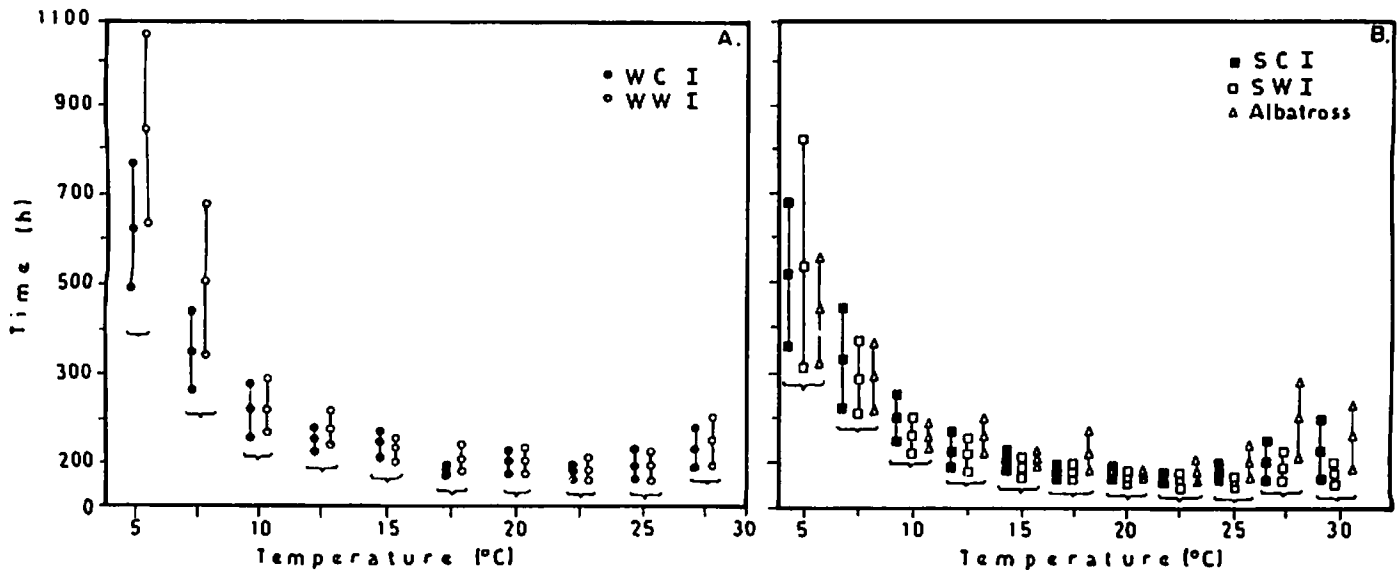


Figure 3. Time to onset and spread of germination for near-isogenic faba beans, calculated from cumulative germination percentage fitted by Weibull function. Bars represent time to 10% (bottom), 50% (middle) and 90% (top) germination.

Table 1. Estimates of cardinal temperatures (t_b , t_o and t_m) for germination of the 50th percentile derived from Weibull function, coefficient of regression (b) between germination rate (1/h) and temperature ($^{\circ}\text{C}$) and coefficient of determination (R^2) explained by the regression model at sub- and supra-optimal temperatures, and thermal time requirements (ϕ_1 and ϕ_2) ($^{\circ}\text{Cd}$).

Line/ cultivar	Temp ($^{\circ}\text{C}$)		Sub-optimal range				Supra-optimal range		
	Base (t_b) (Confidence limits)	Optimum (t_o)	Maximum (t_m)	$b (\times 10^{-3})$	ϕ_1	R^2	$b (\times 10^{-3})$	ϕ_2	R^2
WCI	3.6 (1.31–6.78)	22.4	34.1	0.84***	49.6	0.88	-1.35***	30.9	0.76
WWI	3.3 (2.29–4.80)	22.5	34.5	0.71***	58.6	0.95	-1.13***	36.9	0.89
SCI	3.1 (1.78–4.80)	22.7	40.4	1.00***	41.5	0.95	-1.04***	-	0.59
SWI	3.0 (1.35–5.08)	22.4	†	1.06***	39.4	0.93	-0.15	-	†
Albatross	0.8 (-2.17–3.71)	21.0	42.0	0.66***	63.4	0.94	-0.64**	65.5	0.39

† Biologically invalid values (i.e. over 100°C).

Optimum temperatures (20.9 – 22.7°C) were close to those estimated for other faba beans (20.5 – 26.0°C , Ellis et al. 1987; Dumur et al. 1990). Maximum temperatures (t_m) varied among the lines (34.06 to 41.82°C , anomalous values apart), which is consistent with the findings of Ellis et al. (1987) and Dumur et al. (1990) (37.0 – 64.0°C). Thermal time requirements estimated for the lines here are lower than some reported for broad beans (e.g. 148°Cd , Bierhuizen and Wagenvoort 1974; 130°Cd , Feddes 1972), but comparable to that of Dumur et al. (1990) (52.8°Cd). This may be because the latter cultivar (Alfred) and

the lines utilized here were smaller-seeded *equina* types. In laboratory tests, high germination rates were obtained from smaller seeds ($r = 0.703$, $P < 0.01$) (E. Kantar, unpublished data).

High base temperature (Table 1) and substantial delays (i.e. decreases in germination rates) coupled with a wider spread of germination (Fig. 3) of near-isogenic zero-tannin lines in spite of the lack of any discernable problem at optimal temperatures suggest that germination is sensitive to low temperature.

Earlier and faster emergence has been associated with a lower t_b and/or lower values of thermal time requirement in some crops, including faba bean (Mohamed et al. 1988b; Feddes 1972). In cold soils, low t_b and thermal time requirement are of great importance for rapid germination (Bierhuizen and Wagenvoort 1974), because emergence of seeds will be delayed until t_b is exceeded and thermal time requirement is met. Therefore, zero-tannin types with poor resistance to fungi (Pasqual-Villalobos and Jellis 1990) could suffer from poor emergence in cold seed-bed conditions, which may occur following early-spring or late-winter sowing. Under such conditions, germination may be protracted and therefore the duration of potential pathogenic attack is increased. This suggestion was substantiated with poor emergence of near-

isogenic zero-tannin members in cold and wet soil (Fig. 4B) in spite of the lack of any apparent problem under mild conditions in the field (Fig. 4A). Furthermore, zero-tannin cv. Albatross performed well under both conditions in line with its germination at a range of temperatures (Fig. 1, 3). Low base temperature requirement and rapid germination in the cold probably conferred the ability to germinate well at cold temperatures on this cultivar.

In conclusion, in order to ensure adequate levels of emergence of zero-tannin faba beans in cold seed-beds, cultivars with low base temperature and thermal time requirement and the ability to germinate well at cold temperatures should be aimed for in breeding programs.

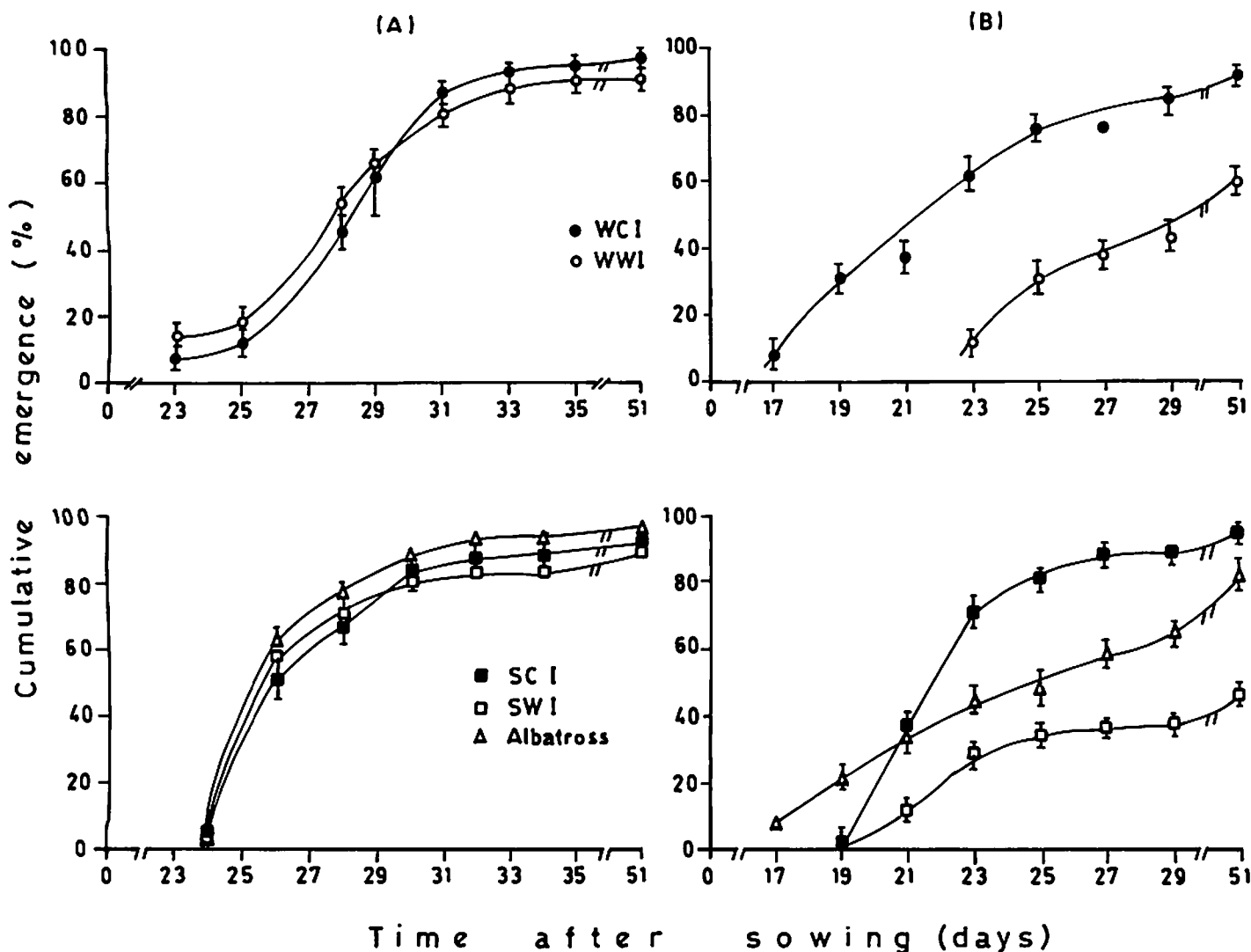


Figure 4. Cumulative emergence of the faba bean lines in the field (A) and under controlled environment conditions at 5°C (B). Bars represent SE.

Acknowledgments

We gratefully thank Dr D.A. Bond (Plant Breeding International, Cambridge) for supplying near-isogenic lines and helpful discussions; Twyford Seeds Limited, Oxon, for supplying Albatross, and Mr J. Travers and Mrs B. Manison for technical assistance. F. Kantar presented this work as part of a PhD dissertation to the University of Nottingham.

References

- Anderson, W.K., R.C.G. Smith and J.R. McWilliam. 1978. A systematic approach to the adaptation of sunflower to new environments. I. Phenology and development. *Field Crops Research* 1: 141–152.
- Bierhuizen, F. and W.A. Wagenvoort. 1974. Some aspects of seed germination in vegetables. I. The determination and application of heat sums and minimum temperature for germination. *Scientia Horticulturae* 2: 213–219.
- Bond, D.A., G. Toynbee-Clarke, M. Pope and J.A. Hall. 1986. Comparison between white and coloured-flower plants and between near-isogenic tannin-free and tannin-containing lines of *Vicia faba*. *Vorträge für Pflanzenzüchtung* 11: 137–150.
- Covell, S., R.H. Ellis, E.H. Roberts and R.J. Summerfield. 1986. The influence of temperature on seed germination rate in grain legumes. *Journal of Experimental Botany* 41: 1423–1430.
- Dumur, D., C.J. Pilbeam and J. Craigon. 1990. Use of the Weibull function to calculate cardinal temperatures in faba bean. *Journal of Experimental Botany* 41: 1423–1430.
- Ellis, R.H., S. Covell, E.H. Roberts and R.J. Summerfield. 1986. The influence of temperature on seed germination rate in grain legumes. II. Intra-specific variation in chickpea (*Cicer arietinum* L.) at constant temperature. *Journal of Experimental Botany* 37: 1503–1515.
- Ellis, R.H., G. Simon and S. Covell. 1987. The influence of temperature on seed germination rate in grain legumes. III. A comparison of five faba bean genotypes at constant temperatures using a new screening method. *Journal of Experimental Botany* 38: 1033–1043.
- Feddes, R.A. 1972. Effect of water and heat on seedling emergence. *Journal of Hydrology* 16: 341–359.
- Finney, D.J. 1978. Statistical Methods in Biological Assay. Griffin, London, UK.
- Garcia-Huidobro, J., J.L. Monteith and G.R. Squire. 1982. Time, temperature and germination of pearl millet (*Pennisetum typhoides* S. and H.). I. Constant temperature. *Journal of Experimental Botany* 33: 288–296.
- Huisman, J. and A.F.B. van der Poel. 1989. Comparisons of effects of anti-nutritional factors (ANFs) in different animal species. Pages 317–325 in Recent Advances of Research in Anti-nutritional Factors in Legume Seeds (J. Huisman, T.F.B. van der Poel and I.E. Liener, ed.). PUDOC, Wageningen, The Netherlands.
- Mohamed, H.A., J.A. Clark and C.K. Ong. 1988a. Genotypic differences in the temperature responses of tropical crops. I. Germination characteristics of groundnut (*Arachis hypogaea* L.) and pearl millet (*Pennisetum typhoides* S. & H.). *Journal of Experimental Botany* 39: 1121–1128.
- Mohamed, H.A., J.A. Clark and C.K. Ong. 1988b. Genotypic differences in the temperature responses of tropical crops. II. Seedling emergence and leaf growth of groundnut (*Arachis hypogaea* L.) and pearl millet (*Pennisetum typhoides* S. & H.). *Journal of Experimental Botany* 39: 1129–1135.
- NIAB. 1992. Recommended Varieties of Field Peas and Field Beans. National Institute of Agricultural Botany, Cambridge, UK.
- Pasqual-Villalobos, M.J.P. and G.J. Jellis. 1990. Factors influencing establishment in *Vicia faba*. *Journal of Agricultural Science (Cambridge)* 115: 57–62.
- van Loon, J.J.A., A. van Norel and L.M.W. Dellaert. 1989. Tannin-free (*Vicia faba* L.) and disease resistance; conflicting breeding objectives. Pages 301–304 in Recent Advances of Research in Anti-nutritional Factors in Legume Seeds (J. Huisman, T.F.B. van der Poel and I.E. Liener, ed.). PUDOC, Wageningen, The Netherlands.

Inheritance of Some Seed Quality Characters in Faba Bean

M.S. El-Shazly¹, M.M. El-Ashry¹, El-Sayed M. Gaafar² and Magdy M.M. Mohamed²

¹ Agronomy Department, Faculty of Agriculture, Suez Canal University, Ismailia, EGYPT

² Agricultural Research Station, ARC, Ismailia, EGYPT

Abstract

Five local and introduced faba bean (*Vicia faba* L.) parents were used to produce the following three crosses: Giza 2 × Line N2, Giza 402 × Line C4, and Aquadulce × Line N2 at the Agronomy Department, Faculty of Agriculture, Suez Canal University and the Agricultural Research Station, Ismailia, Egypt. The main objectives of this investigation were to study the magnitude of gene action controlling the inheritance of protein content, tannin content and seed-coat thickness in faba bean among F₁ and F₂ generations and their respective parents as an initial step for making selection to improve these characters.

The introduced Line C4 was the best parent in seed quality characters under investigation. It had the highest protein content (24.97%), lowest tannin content (1.90%) and the thinnest seed coat (0.125 mm). The introduced Line N2 had the lowest protein content (16.55%) and the highest tannin content (3.40%). Among the commercial varieties, Giza 402 was the best parent in both protein content (22.47%) and tannin content (1.92%), while Giza 2 was the better parent in seed-coat thickness (0.158 mm).

The inheritance of these seed quality characters indicated that both additive and non-additive gene actions were controlling these characters. The results also indicated the presence of dominance towards the best parents in protein content among the populations arising from the three crosses. This finding was emphasized by the presence of positive and significant heterosis. A high heritability combined with a large genetic variation enables breeders to select for such characters. It should, therefore, be possible to reduce tannin content and select for thin seed coat and high protein in early generations of faba bean.

Key words: *Vicia faba*; faba beans; parents; hybrids; seed; quality; protein content; tannins; testa; selection; genetic inheritance.

توريث بعض صفات جودة البذور في الفول

الملخص

استخدمت خمسة آباء محلية ومدخلة من الفول (*Vicia faba* L.) لإنتاج التهجينات الثلاثة التالية : جيزة X2 السلالة N2، جيزة X402 السلالة C4، و Aquadulce X السلالة N2، في قسم المعاملات الزراعية بكلية الزراعة في جامعة قناة السويس ومحطة البحوث الزراعية بالإسماعيلية في مصر. وكان الهدف الرئيسي من هذا البحث، دراسة مدى أهمية فعل المورثات المتحكم في توريث المحتوى البروتيني، المحتوى من التانين، وسماكة غلاف البذرة في الفول بين الجيلين الأول والثاني F₁ و F₂ وأبائها الخاصة، وذلك كخطوة أولى للقيام بعملية انتخاب لتحسين هذه الصفات. وخلال الدراسة، كانت السلالة المدخلة C4 أفضل أب في صفات جودة البذور، إذ تمتعت بأعلى محتوى من البروتين (24.97%)، وأدنى محتوى من التانين (1.90%) وأرق غلاف للبذرة (0.125 مم). أما السلالة المدخلة N2، فقد كان لها أدنى محتوى من البروتين (16.55%) وأعلى محتوى من التانين (3.40%)، ومن بين الأصناف التجارية، كان جيزة 402 أفضل أب في محتوى البروتين (22.47%) ومحتوى التانين (1.92%)، بينما جيزة 2 كان الأب الأفضل في سماكة غلاف البذرة (0.158 مم).

وقد أشارت عملية توريث صفات جودة البذور هذه إلى أن كلتا الجينات ذات الأثر المتجمع وغير المتجمع كانت تتحكمان بهذه الصفات. كما أشارت النتائج إلى وجود هيمنة نحو أفضل الآباء في المحتوى البروتيني بين المجموعات الناشئة عن التهجينات الثلاثة. وقد أكد هذه النتيجة وجود قوة هجين إيجابية وهامة. إن قابلية توريث عالية مرتبطة بتنوع وراثي كبير ستمكن المربين من القيام بعملية انتخاب للحصول على هذه الصفات. لذلك، يجب أن يتاح إنقاص محتوى التانين وإجراء انتخاب للحصول على غلاف بذرة رقيق ومحتوى عالٍ من البروتين في الأجيال المبكرة من الفول.

Introduction

Faba bean is widely cultivated for use in both human and animal nutrition. Its relatively high protein content combined with low cost makes it useful in the production of mixed feeds. The improvement of faba bean production is focused on increasing both seed yield and its stability, while research on seed quality

aims to maintain the nutritional level of the seed. The development of tannin-free cultivars of *Vicia faba* will help to enhance the nutritional quality of this legume (Cabrera and Martin 1986). Faba bean has been characterized as having a tough seed coat which causes difficulties in grinding and is responsible for seeds high in fiber and tannin content (Rowland and Fowler 1977). Tannin has been shown to reduce dry matter digestibility by about 5% *in vitro* (Bond 1976). Also, Marquardt and Ward (1979) found the same result *in vivo* when feeding chicks. The seed coat accounts for 15 to 17% of the seed dry weight, most of the seed crude fiber (89%), but little of the seed protein (2–4%) (Evans et al. 1972; Cerning et al. 1975). This study was, therefore, undertaken to study the inheritance of protein content, tannin content and seed-coat thickness among faba bean populations.

Material and Methods

The study was conducted at the experimental farm and laboratories of the Agronomy Department, Faculty of Agriculture, Suez Canal University and Agricultural Research Station, Ismailia, Egypt.

Plant material

Five faba bean parents, two local cultivars (Giza 2 and Giza 402), one imported cultivar (Aquadulce) and two lines (line N2 and line C4), were used to produce the following three crosses:

Giza 2 × Line N2 (G.2 × L.N2)
Giza 402 × Line C4 (G.402 × L.C4)
Aquadulce × Line N2 (Aqu. × L.N2)

Field plot procedure

Crosses were made after hand-emasculatation during the first winter. In the second season, crossing was repeated to increase F_1 seed. At the same time, F_1 seeds were grown and selfed by using cages to obtain F_2 seeds. In the third season, plant material consisting of F_1 and F_2 populations, and the five respective parents were arranged in a randomized complete block design with three replications. Single plants were harvested for the populations and the parents.

Sample preparation

Protein content

Protein was assayed by the Kjeldahl method (AOAC 1980) for total-N. The factor 6.25 was used to convert N to its crude-protein equivalent.

Tannin content

The tannin content was determined following the procedure used by Sjödin et al. (1981). In this procedure, 50 mg of sample was boiled with 10.0 ml of 0.1M HCl for 60 minutes and then cooled. A 1-ml aliquot of the clear supernatant was mixed with 10 ml of water, and 0.5 ml Folin-Denis reagent (Horowitz 1960) was added. After two minutes, 1 ml of saturated sodium carbonate solution was added and the absorbance was measured at 732 nm after three hours. The content of total phenolics was calculated against a calibration curve. The remaining supernatant was continuously mixed with 200 mg polyvinylpyrrolidone (PVP) for 10 minutes. After centrifugation, 1 ml of the supernatant was treated in a similar manner as above. The content of residual phenolics was calculated against a calibration curve. The condensed tannins were calculated as the difference between total and residual phenolics. The calibration curve was prepared from tannic acid ($C_{76}H_{52}O_{46}$ MW = 1701.25, BDH chemicals Ltd, Poole, England) dissolved in 0.1M HCl, making standards containing 2–10 mg tannic acid/100 ml.

Seed coat thickness

The seed-coat thickness was determined using the method of Rowland and Fowler (1977) as follows: the seeds were dried at 80°C for 14 hours after which the seed coat was removed. Seed-coat thickness was then measured with a micrometer. Ten measurements were made on each seed coat and recorded to the nearest 0.001 mm. Care was taken not to make these measurements near the hilum or lens area of the seed where the seed coat has additional layers of cells.

Genetic analysis

Data from the three replicates were pooled to calculate means and variances for each population. The theoretical means corresponding to additive and non-additive gene action were calculated from the following formulae used by Burton (1951).

Additive gene actions:

$$\text{Theoretical arithmetic } (\overline{AF_1}) = \frac{(\overline{P_1} + \overline{P_2})}{2}$$

$$\text{Theoretical arithmetic } (\overline{AF_2}) = \frac{(\overline{P_1} + 2\overline{F_1} + \overline{P_2})}{4}$$

Non-additive gene actions:

Theoretical geometric ($\overline{GF_2}$) = antilogarithm of

$$\frac{(\text{Log } P_1 + 2 \text{ Log } F_1 + \text{Log } P_2)}{4}$$

Degrees of dominance, h_1 and h_2 for the studied characters in the F_1 and F_2 populations, respectively, were calculated using the potency ratio method of Romero and Fred (1973) as follows:

$$h_1 = \frac{(\overline{F_1} - MP)}{(HP - MP)}$$

$$h_2 = \frac{2 (F_2 - MP)}{(HP - MP)}$$

Where: MP = mid-parent
HP = high parent.

To determine whether h_1 and h_2 values were significantly different from zero, the F_1 and F_2 means were compared with the corresponding mid-parent value by "t" test.

Heritability in the broad sense (H%) was estimated according to the method of variance components. For accuracy estimates of heritability three formulae were used as follows:

$$(1) \quad H\% = \frac{\sigma^2 F_2 - \sigma^2 F_1}{\sigma^2 F_2} * 100 \quad (\text{Burton 1951})$$

$$(2) \quad H\% = \frac{\sigma^2 F_2 - \sigma^2 E}{\sigma^2 F_2} * 100 \quad (\text{Allard 1960})$$

Environmental Variance ($\sigma^2 E$) was estimated from the formula:

$$\sigma^2 E = \frac{(\sigma^2 P_1 + \sigma^2 P_2 + \sigma^2 F_1)}{3}$$

$$(3) \quad H\% = \frac{\sigma^2 F_2 - \sqrt[3]{\sigma^2 P_1 * \sigma^2 P_2 * \sigma^2 F_1}}{\sigma^2 F_2} * 100$$

(Weber 1950; Fuizat and Alkins 1953)

Genotypic coefficient of variation (GCV) was estimated using the method of Burton (1952):

$$GCV = \frac{(\text{Genotypic variance})^{1/2}}{\overline{X}} * 100$$

Where:

$$\text{Genotypic variance} = \sigma^2 F_2 - \sigma^2 E$$

$$\overline{X} = \text{Phenotypic mean of } F_2$$

Phenotypic coefficient of variation (PCV) was estimated using the method of Johnson et al. (1955):

$$PCV = \frac{(\sigma^2 F_2)^{1/2}}{\overline{X}} * 100$$

Heterosis over mid-parent (MP) and high parent (HP) were calculated (Bhatt 1971) as follows:

$$\text{Mid-parent heterosis} = \frac{\overline{F_1} - MP}{MP} * 100$$

High-parent heterosis (heterobeltiosis) =

$$\frac{F_1 - HP}{HP} * 100$$

Significance of heterosis was determined by "t" test according to Wynne et al. (1970)

Results and Discussion

Protein content

There were highly significant differences among the investigated genotypes, F_1 , F_2 and their respective parents, for each of the three crosses (Table 1). Introduced genotype L.C4 had the highest protein content among parents (24.97%), and introduced L.N2 had the lowest (16.53%). The most popular variety, Giza 402, yielded 22.47% protein in this study. The same variety gave 23.9% and 23.4% protein content according to Khalil and Nassib (1986) and Sammour (1987), respectively. The gene action involved in the expression of the protein content was determined by computing the theoretical arithmetic and geometric means corresponding to additive and non-

additive gene actions. Significant differences between the observed F_1 mean and the arithmetic one ($\overline{AF}_1$) revealed the presence of non-additive effects in controlling this character in all faba bean crosses under investigation. The observed F_2 means of the crosses G.402 $\times$ L.C4 and Aqu. $\times$ L.N2 were in close agreement with both calculated arithmetic and geometric F_2 means, which made it difficult to determine the type of gene action in the F_2 generation. Therefore, it can be concluded that both additive and non-additive effects are controlling protein content in these two crosses. The G.2 $\times$ L.N2 cross revealed the major role of non-additive portion in the inheritance of protein content, since there was a significant difference between the observed F_2 mean and the $\overline{AF}_2$. Non-additive effects were also indicated by the non-significant differences between $\overline{F}_2$ and $\overline{GF}_2$ in F_2 generation (Table 2).

The h_1 value for degree of dominance for F_1 differed significantly from zero, indicating the presence of dominance effects toward the high parent in all three crosses under investigation. These results were supported by the positive and significant heterosis among the three crosses (Table 2). Furthermore, the h_2 value (degree of dominance for F_2) was non-significant. Wassimi et al. (1988) report that genes for protein content of raw and cooked beans showed partial dominance in some cases and complete dominance in others, and added that the genes controlling loss of protein were

completely dominant. Moderate to high heritability estimates for protein content were detected among the populations studied (Table 2). High heritability accompanied with great genetic variation make it possible to select for high protein content in early generations. High heritability estimates were also made by Nanda et al. (1988) and Khare and Singh (1991).

Tannin content

Tannin content differed significantly among P_1 , P_2 , F_1 and F_2 for both crosses Giza 2 $\times$ L.N2 and Aqu. $\times$ L.N2, while non-significant differences in tannin content were observed among populations (F_1 , F_2 and respective parents) of Giza 402 $\times$ L.C4 (Table 1).

Among the introduced genotypes, Line N2 had the highest tannin content (3.40%) and was characterized by diffused colored flowers (from violet standard to brown wings) and dark brown seed coat. Line C4 had 1.90% tannin content and was characterized by normal flowers (white flowers with violet spots at the base of petals) and also dark brown seed coat. These results are in harmony with those of Cabrera and Martin (1986) who demonstrate that the tannin content of lines was related more to flower color than to seed color. Also, our values which ranged from 1.90 to 3.41% were comparable with those of Cabrera and Martin (1986), who report a range from 0.0 to 3.54% tannin content among their material.

Table 1. Mean performance of three faba bean crosses for protein content, tannin content and seed-coat thickness.

Cross	$\overline{P}_1$ †	$\overline{P}_2$ †	$\overline{F}_1$ †	$\overline{F}_2$ †	LSD	
					5%	1%
Protein content (%)						
G.2 × L.N2	20.27	16.53	21.43	19.57	1.37	2.08
G.402 × L.C4	22.47	24.97	28.40	25.30	0.63	0.96
Aqu. × L.N2	20.43	16.57	21.23	19.40	1.25	1.89
Tannin content (%)						
G.2 × L.N2	2.36	3.41	2.57	2.44	0.39	0.60
G.402 × L.C4	1.92	1.90	1.99	1.93	NS	NS
Aqu. × L.N2	1.91	3.40	2.37	2.33	0.38	0.58
Seed-coat thickness (mm)						
G.2 × L.N2	0.158	0.124	0.154	0.147	0.011	0.017
G.402 × L.C4	0.183	0.125	0.161	0.160	0.019	0.030
Aqu. × L.N2	0.300	0.126	0.155	0.177	0.019	0.030

NS= Non-significant.

† $\overline{P}_1$, $\overline{P}_2$, $\overline{F}_1$, $\overline{F}_2$ denote observed mean values for P_1 , P_2 , F_1 and F_2 , respectively.

Table 2. Genetical analysis of three faba bean crosses for protein content (PC), tannin content (TC) and seed-coat thickness (SCT).

	G.2 × L.N2			G.402 × L.C4			Aqu. × L.N2		
	PC (%)	TC (%)	SCT (mm)	PC (%)	TC (%)	SCT (mm)	PC (%)	TC (%)	SCT (mm)
P $\bar{P}_1$	20.27	2.36	0.158	22.47	1.92	0.183	20.43	1.91	0.300
$\bar{P}_2$	16.53	3.41	0.124	24.97	1.90	0.125	16.57	3.40	0.126
F ₁ $\bar{F}_1$	21.43	2.57	0.154	28.40	1.99	0.161	21.23	2.37	0.155
$\overline{AF}_1$	18.40*	2.89	0.141	23.72**	1.91	0.154	18.50*	2.66	0.213**
h_1	1.62*	0.60	-0.760	3.74**	-8.00	-0.240	1.41	0.39	0.670**
F ₂ $\bar{F}_2$	19.57	2.44	0.147	25.30	1.93	0.160	19.40	2.33	0.177
$\overline{AF}_2$	19.92*	2.73	0.148	26.06	1.95	0.158	19.87	2.51	0.184
$\overline{GF}_2$	19.81	2.70	0.147	25.94	1.95	0.156	19.76	2.46	0.174
h_2	1.25	1.70	-0.710	2.53	-4.00	-0.410	0.93	0.88	0.830
H% 1	80.92	76.84	40.00	57.53	80.41	50.00	70.49	82.44	61.54
2	44.26	53.16	60.00	59.65	46.73	50.00	50.82	78.19	38.46
3	54.99	61.37	60.00	60.47	61.08	50.00	53.86	78.84	46.15
GCV	9.63	92.10	52.69	8.90	98.99	48.41	10.74	114.92	39.95
PCV	14.47	126.32	68.03	11.52	144.80	68.47	15.06	129.97	64.42
Mid-parent heterosis	16.47**	-11.07*	9.22**	19.73**	4.19	4.55	14.76**	-10.90*	-27.23**
High-parent heterosis	5.72**	8.90*	24.19**	13.74**	4.74	28.80**	3.92*	24.08**	23.02**

* and **: Significant at 0.05 and 0.01 levels of probability.

$\bar{P}_1$, $\bar{P}_2$, $\bar{F}_1$ and $\bar{F}_2$: Observed means.

$\overline{AF}_1$ and $\overline{AF}_2$: Calculated arithmetic means for F_1 and F_2 generations.

$\overline{GF}_2$: Calculated arithmetic means for F_2 generation.

h_1 and h_2 : Degrees of dominance for F_1 and F_2 generations.

H%: Heritability values estimated by three formulae (see text).

GCV and PCV: Genotypic and phenotypic coefficients of variation.

Tannin content seemed to be controlled by additive gene actions in the F_1 generation in all crosses, since non-significant differences between $\overline{AF}_1$ and the observed mean ($\bar{F}_1$) were detected (Table 2). The type of gene action in the F_2 generation in all crosses was not clear because observed, arithmetic and geometric means were non-significantly different. Therefore, it can be concluded that both additive and non-additive gene actions are involved in controlling tannin content in the faba bean material studied.

Dominance effects, h_1 and h_2 , were clear but not significant towards the unfavorable parent (high tannin content) among the two crosses which involved the colored flower parent (G.2 × L.N2 and Aqu. × L.N2). This result was compounded by negative and significant heterosis towards high tannin content (Table 2). Also, the three crosses studied showed high heritability values. Heritability values ranged from 46.75 to 82.44 among the populations using different formulae for the estimation. Therefore, reduction of tannin content in such plant

material might be possible through direct selection for low-tannin genotypes.

Seed coat thickness

There were highly significant differences in seed-coat thickness among parents, F_1 and F_2 generations in the three crosses under investigation (Table 1).

The introduced cultivar, Aquadulce, had the thickest testa among the parents (0.300 mm), while the two introduced lines L.N2 and L.C4 had the thinnest testae among the parents (0.125 mm). Rowland and Fowler (1977) found that the average seed-coat thickness of seven faba varieties ranged from 0.141 to 0.218 mm.

Additive gene actions controlled seed-coat thickness among F_1 populations for G.2 × L.N2 and G.402 × L.C4 crosses (Table 2). This result was confirmed by the insignificant differences between $\bar{F}_1$ and $\overline{AF}_1$ among those two crosses.

The $\overline{AF}_1$ was significantly different from the $\overline{F}_1$ in the Aqu. $\times$ L.N2 cross, indicating the presence of non-additive gene actions in controlling seed-coat thickness (Table 2). Otherwise, the observed F_2 means for the three crosses under study did not differ significantly from the corresponding calculated arithmetic and geometric F_2 means ($\overline{AF}_2$ and $\overline{GF}_2$), indicating the presence of both additive and non-additive gene actions.

Dominance effect h_1 was clear but non-significant towards the thick unfavorable parent among G.2 $\times$ L.N2 and G.402 $\times$ L.C4 crosses. The same result was also obtained for h_2 . Therefore, care should be taken when planning a breeding program for selection of thin seed coat, since the genetic behavior of this trait is related to the specific genetic material under study.

Reasonable estimates for heritability of seed-coat thickness were found whatever formula was used. The heritability accompanied with large generic variation makes it possible to select for thin seed coat in early generations. Positive and significant high-parent heterosis towards the thin favorable parents were found among all crosses studied.

References

- Allard, R.W. 1960. Principles of Plant Breeding. John Wiley and Sons, New York, USA.
- AOAC (Association of Official Agricultural Chemists). 1980. Official Methods of Analysis. 10th Edn. AOAC, Washington, DC, USA.
- Bhatt, G.M. 1971. Heterosis performance and combining in a diallel cross among spring wheats (*Triticum aestivum* L.). *Australian Journal of Agricultural Research* 22(3): 359–369.
- Bond, D.A. 1976. In vitro digestibility of the testa in tannin-free field beans (*Vicia faba* L.). *Journal of Agricultural Science (Cambridge)* 86: 561–566.
- Burton, C.W. 1951. Quantitative inheritance in pearl millet (*Pennisetum glaucum*). *Agronomy Journal* 43: 409–417.
- Burton, C.W. 1952. Quantitative inheritance in grasses. Pages 277–283 in Proceedings of the Sixth International Grassland Conference.
- Cabrera, A. and A. Martin. 1986. Variation in tannin content in *Vicia faba* L. *Journal of Agricultural Science (Cambridge)* 106: 377–389.
- Cerning, J., A. Saposnik and A. Guilbot. 1975. Carbohydrate composition of horse beans (*Vicia faba* L.) of different origins. *Cereal Chemistry* 52: 125–138.
- Evans, L.E., J.F. Seitzer and W. Bushuk. 1972. Horsebeans a protein crop for Western Canada. *Canadian Journal of Plant Science* 52: 657–659.
- Fuizat, Y. and R.E. Atkins. 1953. Genetic and environmental variability in segregating barley populations. *Agronomy Journal* 45: 414–420.
- Horowitz, W. (ed.). 1960. Official Methods of Analysis of the Association of Official Agricultural Chemists. 9th Edn. AOAC, Washington, DC, USA.
- Johnson, H.W., H.F. Robinson and R.E. Comstock. 1955. Estimates of genetic and environmental variability in soybeans. *Agronomy Journal* 47: 314–318.
- Khalil, S.A. and A.M. Nassib. 1986. Performance of spontaneous determinate mutations in faba bean (*Vicia faba* L.). *Biologisches Zentralblatt* 105: 163–165.
- Khare, D. and C.B. Singh. 1991. Genetic behavior of yield and quality traits of *Vicia faba* L. *FABIS Newsletter* (28-29): 3–8.
- Marquardt, R.R. and A.T. Ward. 1979. Chick performance as affected by autoclave treatment of tannin-containing and tannin-free cultivars of faba beans. *Canadian Journal of Animal Science* 59: 781–789.
- Nanda, H.C., M. Yasin, C.B. Singh and S.K. Rao. 1988. Effect of water stress on dry matter production, harvest index, seed yield, and its components in faba bean (*Vicia faba* L.). *FABIS Newsletter* 21: 26–30.
- Romero, G.E. and K.J. Frey. 1973. Inheritance of semidwarfness in several wheat crosses. *Crop Science* 13: 334–337.
- Rowland, G.G. and D.B. Fowler. 1977. Factors affecting selection for seed coat thickness in faba beans (*Vicia faba* L.). *Crop Science* 17: 88–90.
- Sammour, R.H. 1987. Chemical constituents and electrophoresis of seed proteins of some species of *Vicia*. *FABIS Newsletter* 18: 30–32.
- Sjödén, J., P. Martensson and T. Magyarosi. 1981. Selection for antinutritional substances in field bean (*Vicia faba* L.). *Zeitschrift für Pflanzenzüchtung* 86: 231–247.
- Wassimi, N.N., G.L. Hosfield and M.A. Uebersax. 1988. Combining ability of tannin content and protein characteristics of raw and cooked dry beans. *Crop Science* 28: 452–458.
- Weber, C.R. 1950. Inheritance and interrelation of some agronomic and chemical characters in an interspecific cross in soybeans, *Glycine max* $\times$ *G. ussuriensis*. *Iowa Agriculture Experiment Station Research Bulletin* 374: 767–816.
- Wynne, J.C., D.A. Emery and P.W. Rice. 1970. Combining ability estimates in *Arachis hypogaea* L. Field performance of F_1 hybrid. *Crop Science* 10: 713–715.

Physiology and Microbiology

Pattern of Nutrient Removal by Faba Bean Grown on Vertisol of Central India

A.K. Dwivedi and G.S. Nayak

Department of Soil Science & Agricultural Chemistry

J.N. Krishi Vishwa Vidyalaya

Jabalpur 482 004 (M.P.)

INDIA

Abstract

A field trial was conducted to evaluate the effect of different applications of sulfur (0, 30 and 60 kg/ha) and phosphorus (0, 40 and 80 kg P₂O₅/ha) on nutrient removal and yield potential in faba bean (*Vicia faba* L.) grown on a S- and P-deficient vertisol. The beneficial influence of S and P fertilizers was observed up to 30 kg S/ha and 40 kg P₂O₅/ha with a significant increase in the uptake pattern of nutrients as well as yield potential. The highest yield (2.32 t/ha) was recorded with a combination of 30 kg S and 40 kg P₂O₅/ha.

Key words: *Vicia faba*; faba beans; sulphur fertilizers; phosphate fertilizers; nutrient uptake; yields; India.

Introduction

Faba bean is primarily grown for its protein content as a grain legume as well as a green vegetable crop, without application of nitrogenous fertilizers. Under intensive cropping systems, proper supply of all essential nutrients to the crop assumes greater importance as the native soil nutrients are depleted much more quickly. The nutrient status of a plant is the result of several interactions occurring in absorption, translocation and plant metabolism. These interactions are not only evident among ions of similar charge, but also among ions of dissimilar charges (cations and anions). Hence, ion balance is of considerable importance for independent ion absorption.

Sulfur and phosphorus are absorbed in anionic form. Their proper balance in the soil is necessary for ion interaction and translocation for growth, yield and quality aspects of leguminous crops.

In view of the above, a study was undertaken to investigate the proper level of sulfur and phosphorus in faba bean nutrition.

نمط استخلاص المغذيات بواسطة الفول المزروع في تربة فيرتيزولية بوسط الهند

الملخص

أجريت تجربة حقلية لتقييم التأثير الناجم عن استخدام جرعات مختلفة من الكبريت (0 و 30 و 60 كغ/هـ) والفوسفور (0 و 40 و 80 كغ P₂O₅/هـ)، في استخلاص المغذيات والكفاءة الإنتاجية في الفول (*Vicia faba* L.) المزروع في تربة فيرتيزولية تعاني من عوز في الكبريت (S) والفوسفور (P). وقد لوحظ التأثير المفيد للسمادين الكبريتي والفوسفوري عندما وصل المعدل إلى 30 كغ S/هـ و 40 كغ P₂O₅/هـ، مع زيادة هامة في نمط استخلاص المغذيات وكذلك في الكفاءة الإنتاجية. وسجلت أعلى غلة (2.32 طن/هـ) عند استخدام توليفة مكونة من 30 كغ S و 40 كغ P₂O₅/هـ.

Material and Methods

The study was conducted on a black soil (typic chromustert) at the experimental field of J.N. Krishi Vishwa Vidyalaya, Jabalpur, India during *rabi* (winter) 1988/89. The soil had a pH of 7.6 (1:2 soil:water), organic carbon 0.41%, with nutrient status of 260, 12.5, 296 and 14.4 kg/ha as available nitrogen, phosphorus, potassium and sulfur, respectively. The fertilizer treatments were tested in factorial randomized block design (Panse and Sukhatome 1961) consisting of three levels of sulfur (0, 30 and 60 kg/ha) as gypsum, and three levels of phosphorus (0, 40 and 80 kg P₂O₅/ha) as calcium phosphate. Nitrogen (20 kg/ha as urea) and 40 kg potash (40 kg K₂O/ha as muriate of potash) were applied to all plots. The faba bean var. JV-2 was grown in 5 × 3 m plots which were replicated thrice.

At harvest, the grain and straw samples were processed separately. The plant samples were analyzed for total uptake of nitrogen (Piper 1967), phosphorus (Koezig and Johnson 1942), potassium (Chapman and Pratt 1961), calcium and magnesium (Piper 1967), and sulfur (Bardsley and Lancaster 1960).

Results and Discussion

Nitrogen uptake

Application of P and S significantly increased N uptake by faba bean (as measured in the grain) up to 40 kg P₂O₅/ha and 30 kg S/ha, with a non-significant increase thereafter (Table 1). A

non-significant effect of the same treatments was noted in the straw. This increase in grain N may be related to improved nodulation with fertilizer application (Dwivedi et al. 1986). The interaction of S $\times$ P was significant in grain and maximum uptake of N (94.07 kg/ha) was obtained with the S₃₀P₈₀ dose. The N content of grain was higher than that of straw, invariably due to the translocation of nitrogenous compounds from shoots to the grain for the formation of protein reserves (Dwivedi et al. 1986; Nayak and Dwivedi 1990).

Phosphorus uptake

A significant increase in grain P-uptake was observed with S and P fertilizer application (Table 1). The application of 30 kg S/ha increased uptake of P, because of a synergistic effect in releasing soil phosphorus (Morok and Dev 1980). The significant effect of phosphorus fertilizer on its relative uptake is self explanatory (Dwivedi et al. 1983, 1986; Nayak and Dwivedi 1990). The interaction of S $\times$ P was significant and highest uptake (7.88 kg/ha) was obtained with the S₃₀P₈₀ dose.

Table 1. Effect of sulfur and phosphorus fertilizer application on nutrient uptake and yield of faba bean.

S-level (kg/ha)	Grain					Straw				
	P ₂ O ₅ level (kg/ha)					P ₂ O ₅ level (kg/ha)				
	0	40	80	Mean	CD at 5%	0	40	80	Mean	CD at 5%
Nitrogen (kg/ha)										
0	54.81	70.16	82.54	69.17	S, P = 8.46	24.41	18.33	20.76	21.16	S, P = NS
30	65.40	79.15	94.07	79.54	S $\times$ P = 14.66	11.34	18.74	18.82	16.30	S $\times$ P = NS
60	77.50	89.26	86.08	84.27		18.82	16.70	17.29	17.60	
Mean	65.90	79.52	87.56			18.19	17.92	18.96		
Phosphorus (kg/ha)										
0	3.48	5.37	7.21	5.35	S, P = 0.52	0.99	0.95	0.96	0.97	S, P = NS
30	4.56	6.71	7.88	6.38	S $\times$ P = 1.05	0.60	0.82	1.04	0.82	S $\times$ P = NS
60	5.65	7.53	7.21	6.79		1.00	0.69	0.95	0.88	
Mean	4.56	6.54	7.43			0.87	0.82	0.98		
Potassium (kg/ha)										
0	15.66	20.04	23.76	19.82	S, P = 1.53	18.83	14.62	16.44	16.63	S, P = NS
30	18.93	28.22	34.35	27.30	S $\times$ P = 3.07	9.66	16.74	17.32	14.57	S $\times$ P = NS
60	21.80	32.78	34.38	29.30		17.20	14.68	15.01	15.63	
Mean	18.79	27.01	30.96			15.23	15.35	16.26		
Calcium (kg/ha)										
0	8.55	11.63	14.42	11.53	S, P = 1.02	35.32	24.61	25.20	28.37	S, P = NS
30	11.32	12.64	14.59	12.85	S $\times$ P = NS	16.72	25.76	23.90	23.13	S $\times$ P = NS
60	13.04	14.84	13.78	13.88		27.61	20.83	19.57	22.67	
Mean	10.97	13.03	14.26			26.55	23.73	23.89		
Magnesium (kg/ha)										
0	1.16	2.33	3.60	2.36	S, P = NS	8.37	5.23	5.76	6.45	S, P = NS
30	3.21	3.16	3.79	3.39	S $\times$ P = NS	3.65	5.32	6.35	5.44	S $\times$ P = NS
60	2.53	2.54	4.18	3.42		6.02	4.76	5.41	5.39	
Mean	2.30	3.01	3.85			6.02	5.44	5.84		
Sulfur (kg/ha)										
0	2.17	3.06	4.87	3.36	S, P = 0.39	0.62	0.83	0.84	0.76	S, P = 0.08
30	2.89	5.13	6.48	4.83	S $\times$ P = 0.80	0.53	0.94	0.92	0.79	S $\times$ P = NS
60	3.31	5.98	6.36	5.21		0.75	0.79	0.85	0.80	
Mean	2.79	4.72	5.91			0.63	0.85	0.87		
Yield (t/ha)										
0	1.45	1.79	2.12	1.78	S, P = 0.19	1.74	1.18	1.20	1.21	S, P = NS
30	1.69	1.97	2.32	1.99	S $\times$ P = 0.38	0.76	1.17	1.15	1.03	S $\times$ P = NS
60	1.95	2.22	2.12	2.09		1.25	0.99	0.95	1.06	
Mean	1.69	1.99	2.18			1.08	1.11	1.10		

Potassium uptake

A proportionate increase in K uptake was associated with both S and P fertilizer application (Table 1). This may be because the level of available potassium in the experimental soil was sufficiently high so that K was absorbed luxuriously just to maintain electro-neutrality (cation:anion) in the plants. Similar findings are reported by Nayak and Dwivedi (1990).

Calcium uptake

The uptake of calcium increased significantly with successive application of S and P up to their highest dose (Table 1). The priming effect of applied fertilizer nutrient might be responsible for release of soil-Ca and its subsequent removal by plants (Dwivedi et al. 1983). The interaction of S $\times$ P was not significant.

Magnesium uptake

A statistically non-significant Mg-uptake increase by both grain and straw was obtained when fertilizer S and P were applied (Table 1). A similar finding is reported by Dwivedi et al. (1983).

Sulfur uptake

The uptake of S increased significantly with successive application of fertilizer S and P (Table 1). This could be due to the direct increase in available sulfur (Morok and Dev 1980; Nayak and Dwivedi 1990), as well as by the synergistic and priming effects of the phosphate ion for releasing inherent soil-S (Morok and Dev 1980). The interaction of S $\times$ P was significant in grain and highest uptake (6.48 kg/ha) was recorded with S₃₀P₈₀.

Yield

The successive application of fertilizer S and P alone as well as in combination, significantly increased grain yield of faba bean (Table 1). The experimental soil was low in available S and P,

and the deficiency was removed by the successive application of fertilizer; hence, higher yields were obtained (Morok and Dev 1980; Dwivedi et al. 1983; Nayak and Dwivedi 1990). The interaction of S $\times$ P was significant in grain and the highest grain yield (2.32 t/ha) was produced with 30 kg S/ha and 80 kg P₂O₅/ha. Thus, we conclude that there is a synergistic relationship between S and P fertilizer in combination.

References

- Bardsley, C.S. and J.D. Lancaster. 1960. Determination of reserve sulphur and soluble sulphate in soils. *Proceedings of the Soil Science Society of America* 24: 265.
- Chapman, H.D. and P.F. Pratt. 1961. Soil Water and Plant Analysis. University of California Agriculture Division.
- Dwivedi, A.K., S.B. Sinha, J.P. Mahajan and G.S. Rathore. 1983. Effect of different levels of phosphorus on the uptake of some nutrients by soybean (*Glycine max* (L.) Merrill) in vertisol. *JNEVV Research Journal* 17(1-2): 77-83.
- Dwivedi, A.K., S.B. Sinha and J.P. Mahajan. 1986. Concentration of major nutrients in soybean varieties as influenced by phosphorus fertilization in vertisol of M.P. *Proceedings of the National Academy of Sciences, India* 56(B) II: 175-179.
- Koenig, R.A. and C.R. Johnson. 1942. Colorimetric determination of phosphorus in biological materials. *Industrial and Engineering Chemistry. Analytical Edition* 14: 155-156.
- Morok, A.S. and G. Dev. 1980. Phosphorus sulphur relationship in berseem (*Trifolium alexandrinum*) as measured by yield and plant analysis. *Journal of Nuclear Agriculture and Biology* 9: 54-56.
- Nayak, G.S. and A.K. Dwivedi. 1990. Interaction of sulphur and phosphorus fertilizers on yield and nutrient composition of faba bean grown on black soils of Central India. *FABIS Newsletter* 27: 13-15.
- Panse, V.G. and V.S. Sukhatone. 1961. Statistical Methods for Agricultural Workers. 2nd Edn. ICAR New Delhi Pub.
- Piper, C.S. 1967. Soil and Plant Analysis. Asia Publishing House, Bombay and New Delhi.

Pattern of Protein Synthesis in Faba Bean as Influenced by Sulfur and Phosphorus Nutrition

G.S. Nayak and A.K. Dwivedi

Department of Soil Science & Agricultural Chemistry
J.N. Krishi Vishwa Vidyalaya
Jabalpur 482004, INDIA

Abstract

Faba bean (*Vicia faba* L.) is a protein-rich grain and a vegetable crop. A field experiment was conducted to evaluate the effect of sulfur and phosphorus fertilizer nutrition on protein content of faba bean grown on black soil. Increasing application of fertilizer had a significant synergistic influence on protein content. The highest seed protein content (25.59%) was obtained with a combination of 30 kg S/ha and 40 kg P_2O_5 /ha. The seed had a higher protein content than the straw.

Key words: *Vicia faba*; faba beans; sulphur fertilizers; phosphate fertilizers; protein synthesis; protein content; seed.

Introduction

Protein is one of the important constituents contributing to the quality of a legume crop – within limits, the higher the protein content, the better the crop quality. Although the metabolic pathways are genetically controlled, the rate, kind and amount of photosynthate assimilates are influenced by nutritional balance (Salem and El Massri 1988). The supply of sulfur and phosphorus is important because it affects the rhizobial fixation of nitrogen as well as subsequent synthesis of protein. In contrast, lack of sulfur retards the incorporation of ammonia into amino acids and thereby suppresses its metabolism at the amide stage only (Tisdale 1977). Hence, the present study was conducted to evaluate the effect of sulfur and phosphorus nutrition on protein content of faba bean.

Material and Methods

The study was carried out on a black soil (Vertisol) at the research station at J.N. Krishi Vishwa Vidyalaya, Jabalpur, India. The soil had pH 7.6 (1:2.5 soil water ratio), organic carbon 0.4%, and a nutrient status of 260, 12.5, 296 and 14.4 kg/ha as available N, P_2O_5 , K and S, respectively. The fertilizer treatments were arranged in a 3×3 factorial with three levels of

تأثير العناصر المغذية الكبريتية والفوسفورية على نمط تخليق البروتين في الفول

المخلص

يعتبر الفول (*Vicia faba* L.) محصولاً بقولياً حبيباً غنياً بالبروتين. وقد أجريت تجربة حقلية لتقييم تأثير السمادين الكبريتي والفوسفوري على المحتوى البروتيني للفول المزروع في تربة سوداء. وكان لزيادة التسميد أثر تآزري هام على محتوى البروتين. وقد تم الحصول على أعلى محتوى بروتيني للبذور (25.59%) عند استخدام توليفة مكونة من 30 كغ S/هـ و 40 كغ P_2O_5 /هـ وكان محتوى البروتين في البذور أعلى مما هو عليه في التبن.

sulfur (0, 30 and 60 kg S/ha as gypsum) and three levels of phosphorus (0, 40 and 80 kg P_2O_5 /ha as calcium phosphate). Nitrogen (20 kg N/ha as urea) and potassium (40 kg K_2O /ha as muriate of potash) were applied to all plots. A randomized complete block design with three replications was used. The faba bean (variety JV-2) was grown in 15 m² plots.

The faba bean was grown up to maturity and, at harvest, the grain and straw samples were analyzed for protein content (AOAC 1965).

Results and Discussion

Sulfur and phosphorus application had a pronounced influence on quality (protein content) of faba bean (Table 1) as a direct result of increased symbiotically-fixed nitrogen supply and consequent protein synthesis (Morok and Dev 1980). The relative protein content was higher in grain than in straw. This might be a result of transformation of nitrogenous compounds from the shoot leading to the formation of seed protein (Dwivedi et al. 1986). Hence it naturally leads to the depletion of protein in straw. Secondly, a lower protein content in straw could be the result of the reduced synthetic capacity as well as increased protein degradation (Dwivedi et al. 1987).

The interaction of S × P was significant and highest protein content (26.97%) in grain was deposited at the 60 kg S, 80 kg P_2O_5 /ha dose, while the highest straw protein content was obtained at 30 kg S, 40 kg P_2O_5 /ha. This implies a synergistic relationship of sulfur and phosphorus fertilizer for faba bean grown on a black soil.

Table 1. Effect of fertilizer sulfur and phosphorus levels on protein content (%) in faba bean.

Sulfur level (kg S/ha)	Phosphorus level (kg P ₂ O ₅ /ha)				CD at 5%
	0	40	80	Mean	
Grain					
0	20.63	22.21	22.80	21.88	S level = 0.93
30	22.50	25.69	26.39	24.83	P level = 0.93
60	22.61	25.39	26.97	25.00	S × P = 1.61
Mean	21.91	24.39	25.38		
Straw					
0	8.75	9.35	9.35	9.15	S level = 0.57
30	9.63	11.92	10.50	10.68	P level = 0.57
60	9.25	10.30	10.38	10.11	S × P = 0.98
Mean	7.17	10.69	10.08		

References

- AOAC. 1965. Official Method of Analysis of the Association of Official Agricultural Chemists. Washington, DC, USA.
- Dwivedi, A.K., S.B. Sinha and J.P. Mahajan. 1986. Concentration of major nutrients in soybean varieties as influenced by phosphorus fertilization in vertisol of M.P. *Proceedings of the National Academy of Sciences India* 56(B)II: 175–178.
- Dwivedi, A.K., S.B. Sinha and J.P. Mahajan. 1987. Effect of phosphorus application on yield and nitrogen uptake by soybean varieties in Typic Chromustert. *Journal of the Indian Chemical Society* 59: 166–168.
- Morok, A.S. and G. Dev. 1980. Phosphorus sulphur relationship in berseem (*Trifolium alexandrinum*) as measured by yield and plant analysis. *Journal of Nuclear Agriculture and Biology* 9: 54–56.
- Salem, S.A. and M.F. El Massri. 1988. Effect of *Rhizobium* inoculation and phosphorus fertilizer level on nodulation, seed yield and other agronomic characters of fababean (*Vicia faba* L.). *Faba Bean Abstracts* 8(3): 187.
- Tisdale, S.L. 1977. Sulphur in forage quality and ruminant nutrition. *Sulphur Institute Technical Bulletin* 22: 2–4.

Pests and Diseases

Optimizing Sowing Date of Faba Bean for Grain Yield and to Counter Leaf Miner *Liriomyza trifolii* (Burg) in New Halfa, Sudan

Tag Elsir Elamin Abdalla

Agricultural Research Corporation (ARC)

New Halfa Research Station

SUDAN

Abstract

Planting faba bean (*Vicia faba* L.) at New Halfa between 25 October and 30 November had no significant effect on leaf miner (*Liriomyza trifolii* (Burg)) infestation. Sowing faba bean from the last week of October to 10 November resulted in significantly higher yield compared with sowing from 20 November onwards.

Key words: *Vicia faba*; faba beans; sowing date; grain; yields; pest control; *Liriomyza trifolii*; Sudan.

Introduction

Faba bean (*Vicia faba* L.) is the most popular food legume in Sudan. The production in the traditional areas (Northern region) is not sufficient to satisfy the increasing demand for this commodity. Hence, widening the sphere of faba bean production in new areas seems to be logical. Therefore, studies are underway to investigate the factors which will facilitate profitable cultivation of the crop in these areas.

The objective of this experiment was to investigate the possibility of monitoring sowing date to produce economic grain yield without the use of insecticides for the control of leaf miner *Liriomyza trifolii* (Burg) in the New Halfa agricultural scheme.

Material and Methods

The experiment was conducted at New Halfa Research Station Farm. A complete randomized block design for five sowing dates with four replications was adopted. Sowing dates were 1, 10, 20 and 30 November 1993, plus the normal date of 25 October. Plot size was 6 × 8.5 m of which 4.8 × 7.5 m was harvested for yield. Seeds of faba bean cv Selaim were sown in

الموعد الأمثل لزراعة الفول للحصول على غلة حبية

ومكافحة ثاقبات الأوراق *Liriomyza*

trifolii (Burg) في حلفا الجديدة بالسودان

الملخص

لم يكن لزراعة الفول (*Vicia faba* L.) في حلفا الجديدة خلال الفترة بين 25 تشرين الأول/أكتوبر و30 تشرين الثاني/نوفمبر تأثير كبير على الإصابة بثاقبات الأوراق [*Liriomyza trifolii* (Burg)]، في حين أسفرت زراعته بين الأسبوع الأخير من تشرين الأول/أكتوبر و10 تشرين الثاني/نوفمبر عن غلة أعلى بكثير مقارنة بزراعته بدءاً من 20 تشرين الثاني/نوفمبر وما بعد.

holes (3 seeds/hole) at an intra-row spacing of 20 cm on ridges 60 cm wide; sowing was on both sides of the ridge. Urea at about 86 kg N/ha was applied. Irrigation was at seven-day intervals. Eight counts were taken throughout the season to determine the percentage of infested leaflets by counting all leaflets on 10 plants randomly selected per plot. All other cultural operations were standard practice.

Results and Discussion

The growing season was characterized by relatively long warm periods, during a short mild winter. The maximum temperature for the coolest month ranged from 33 to 37°C and the minimum from 14 to 18°C.

Incidence of Leaf Miner

There were no significant differences among sowing dates for infestation in each of the eight counts taken (e.g. range = 24.1–30.8% on 1 February 1994; $P > 0.05$). This may be due to the relatively high and stable temperatures occurring during the winter which favored pest attack soon after sowing; the insect populations then developed throughout the season.

Grain yield

There was a variation in number of pods per plant, but these variations failed to attain statistical significance (Table 1). Thousand-grain weight was significantly higher in the first date compared with all other treatments, followed by the second date. Other treatments recorded significantly less 1000-grain weight.

The highest yield was obtained from plants sown on 10 November (Table 1), which exceeded that of the standard by 8.25% (non-significant difference). Yield from 10 Nov sowing was 18.2% and 75.4% more than that from sowing on 20 and 30 Nov, respectively ($P < 0.05$).

Plants sown on 1 November produced yield statistically equal to the standard, but significantly higher than those sown

on 30 Nov by 63.76%. Plants sown 30 November produced significantly lower yields compared with all other treatments.

Acknowledgement

This work was financed by the ICARDA/Nile Valley Project on faba bean.

Table 1. Yields and components of faba bean as affected by sowing date, New Halfa, Sudan, 1993.

Sowing date	No. pods/plant	1000-grain wt (g)	Yield (kg)	
			per plot (36 m ²)	per Feddan
25 Oct (Standard)	23.2 a	331 ab	6.10 ab	712
1 Nov	23.3 a	347 a	6.16 ab	719
10 Nov	24.4 a	330 ab	6.60 a	770
20 Nov	19.8 a	310 bc	5.59 b	652
30 Nov	19.3 a	289 c	3.76 c	439
Effect	NS	Sig.	Sig.	
SE $\pm$	1.00	3.5	0.12	
CV(%)	20	4.9	9.5	

Means followed by the same letter are not significantly different at $P = 0.05$.

Vicia faba Seed Infestation and Losses Due to *Bruchus rufimanus* Boh. (Coleoptera: Bruchidae) in Morocco

A. Boughdad¹ and Ginette Laugé²

¹ Département de Zoologie Agricole, ENA, B.P. S/40, Meknès, MOROCCO

² Laboratoire de Reproduction-Développement de l'Insecte, Bât. 445, Université de Paris-Sud, 91405 Orsay Cedex, FRANCE

Abstract

Vicia faba L. seeds, sampled from 29 areas of Morocco, were used to assess the pest status of *Bruchus rufimanus* Boh. The apparent infestation rate varied from 4 to 62% according to the area and the field studied. Across the country, the average infestation rate of faba bean seeds by

إصابة بذور الفول بخنفساء الفول الكبيرة (فصيلة *Bruchus* بروكيدي ورتبة غمديات الأجنحة) *rufimanus* Boh. والخسائر الناجمة عنها في المغرب

المخلص

استخدمت عينات من بذور الفول مأخوذة من 29 منطقة في المغرب لتقدير حجم الإصابة بخنفساء الفول الكبيرة. وقد تباين معدل الإصابة الظاهر بين 4 إلى 62% وذلك تبعاً للمنطقة والحقل المدروس. وكان المعدل الوسطي لإصابة بذور الفول بتلك الآفة الحشرية في المغرب ككل، حوالي 33%. وفي حالة الإصابة الشديدة، بلغ عدد البالغات 3 لكل بذرة في 49% من حقلاً مدروساً، ووصل إلى 5 بالغات لكل بذرة في حالات قليلة، إلا أنه في 60% من البذور المفحوصة نمت بالغة واحدة فقط في كل بذرة. وبلغ متوسط الخسائر الفعلية حوالي 5% من وزن البذور الجافة، وقد ارتبطت

the bruchid was close to 33%. The infestation intensity was 3 adults per seed in 49% of the 152 fields studied, and reached 5 adults per seed in a few cases. However, in 60% of the seeds examined, only one adult developed per seed.

The real average losses were close to 5% of the seed dry weight. These losses were correlated with the infestation severities. The average weight loss due to one larva was 46.91 (± 8.15) mg; frass produced was 31.17 (± 5.50) mg.

Infestation severity reduced seed germination: with one adult bruchid per seed, the germination rate was 90.5%; with 5 adults per seed, only 55% of the seed germinated.

Key words: *Vicia faba*; faba beans; seed; *Bruchus rufimanus*; infestation; crop losses; germination; Morocco.

Introduction

Loss assessment studies in pulses have been focused mainly on multivoltine bruchid species (e.g. Caswell 1961, 1981; Booker 1967; Salkini et al. 1982; Singh and Ntare 1985; Dias and Yadav 1988; Nakhla 1988; Shazali 1990). However, exact estimations of losses caused by univoltine bruchid species are rare (Boughdad and Gillon 1989), although some sporadic indications on univoltine bruchid damage are reported by Kamel (1967), Bishara et al. (1967), Sadej and Zuranska (1986), and Ozar and Gen (1987). In Morocco, no study has been undertaken on the subject (Boughdad 1994).

To manage a monovoltine bruchid pest, it is necessary to estimate the economic impact of the pest in the farmer's context. This work aimed to determine the pest status of *B. rufimanus* in Morocco. We focused on assessing the rate of infestation, the real weight losses per Adams (1976, 1977), and the effect of bruchid infestation on seed germination.

Material and Methods

Survey

A survey was undertaken in 29 areas representative of 152 fields of faba bean in Morocco. From each field, about 3 kg of ripe, dry seed was collected. Information on factors affecting infestation rates were obtained from the farmers.

Observations

In the laboratory, each seed sample was placed in an aerated jar until the bruchids emerged. The emerged bruchids were counted and sexed daily. When all the bruchids had left the seeds, each sample was mixed; then 100 seeds were randomly collected and divided into infested and uninfested groups. The rate of apparent infestation corresponds to the proportion of infested seeds in all

these examined. For each infested seed, the number of bruchid emergence-holes was noted (i.e. severity = intensity). Next, the infested seeds were grouped into five categories according to the number of bruchid emergence-holes. The frequency of seed per severity was calculated.

For each sample, the 100 collected seeds were weighed individually with 0.01 g accuracy and placed into a drying oven at 110°C, until constant weight was obtained. Their dry weight was recorded. The mean dry weight was calculated per undamaged seed and for each severity class.

At the same time, the frass (=cocoon + exuvia + fractions not ingested but which fell into the larval gallery) was extracted from 100 seeds per severity category. The frass was dried and the dry weight was determined.

The real weight losses per severity group were evaluated for each sample according to the method B of Adams and Schulten (1978), but by adding the frass quantity corresponding to each seed.

The effect of bruchid infestation on seed germination was evaluated for each severity class in comparison with controls (uninfested seeds). For each category of severity or control, 100 seeds (with four replications) were sown in the field. The germinated seeds were counted daily. Twenty days after the sowing date, the ungerminated seeds were unearthed and their health condition noted.

The effect of bruchid infestation on seed germination was evaluated for each severity class in comparison with controls (uninfested seeds). For each category of severity or control, 100 seeds (with four replications) were sown in the field. The germinated seeds were counted daily. Twenty days after the sowing date, the ungerminated seeds were unearthed and their health condition noted.

The effect of bruchid infestation on seed germination was evaluated for each severity class in comparison with controls (uninfested seeds). For each category of severity or control, 100 seeds (with four replications) were sown in the field. The germinated seeds were counted daily. Twenty days after the sowing date, the ungerminated seeds were unearthed and their health condition noted.

Results

Rate of infestation

Bruchus rufimanus was found in all prospected areas. The infestation rates of *V. faba* seeds varied according to the areas and the fields sampled. The highest average rates varied from 38 to 51% (39 of 152 fields visited), the lowest rates varied from 17 to 30% (62 fields). The remaining fields (51), had infestation rates between 31 and 37%. The factors which could influence infestation rate, i.e. seed health and distance between fields and seed stores, were comparable in all the areas studied.

There was a positive correlation between the infestation rates and severity noted in each field ($r = 0.69$; $P < 0.05$; $n = 152$): the highest infestation rates and severities were recorded in small fields.

The distribution of field severity frequencies, i.e. the actual population density of bruchids in the field, showed that in about 49% of the studied fields, 3 larvae developed per seed. In 1.32% of the prospected fields, one larva was found per seed. In the remaining fields, 2, 4 or 5 larvae per seed concluded their development (Fig. 1). Conversely, in about 60% of the seeds, only one adult emerged from each seed (Fig. 2). The proportion of seeds in which 4 or 5 bruchids developed was less than 2%. From the remaining seeds, 2 or 3 adults emerged.

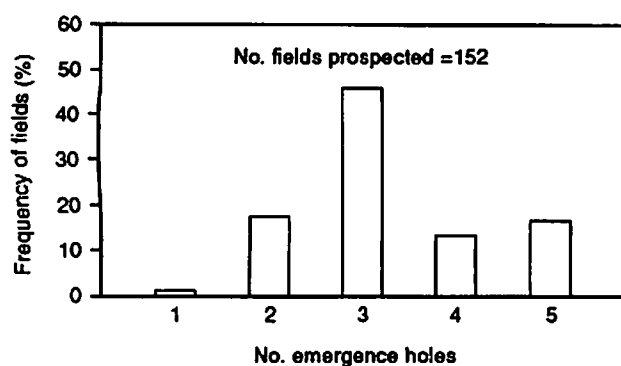


Fig. 1. Distribution of crop fields of *Vicia faba* in terms of maximum emergence hole numbers of *Bruchus rufimanus*

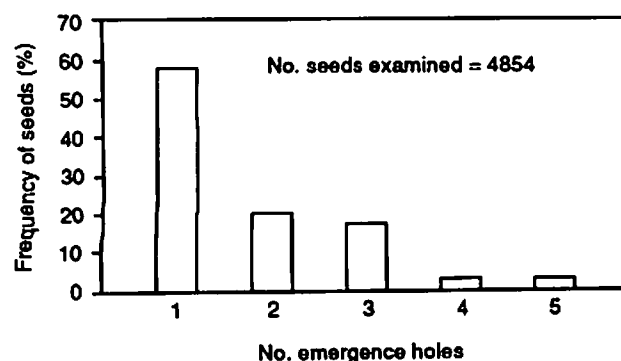


Fig. 2. Distribution of infested seeds of *Vicia faba* in terms of maximum emergence hole numbers of *Bruchus rufimanus*.

Weight losses

Regional losses

Weight loss on a regional basis varied from 2.8 to 6%. The highest losses, close to 5–6%, were noted in 7 of the 29 areas prospected, and concerned 28 of 152 fields; the lowest (2.8–3.8%) were found in 8 areas (31 fields). In the remaining areas (14, representative of 93 fields), the mean real weight losses were about 4% of the seed dry weight. No relationship was found between either the average weight losses and infestation rates ($r = -0.023$; $P > 0.05$; $n = 152$), or between infestation rates and regional production ($r = -0.09$; $P > 0.05$; $n = 29$). However, mean weight losses were negatively correlated with seed dry weights ($r = -0.89$; $P < 0.05$); the highest losses were obtained with the lightest weight seeds.

Losses according to severity

The mean of weight losses of seeds in which one or several bruchids concluded their development are presented in Table 1. There was great variation in the dry weight losses according to severity, from 1.46 to 21.83%. The variation was due mainly to differences in the seed weights: these were between 0.7 to 3.3 g per seed, according to their origin.

Table 1. *Vicia faba* seed dry weight losses (%) due to *Bruchus rufimanus*.

	No. emergence holes				
	1	2	3	4	5
No. seeds	2926	977	817	72	62
Losses (%)					
Average *	2.84	5.87	8.27	11.04	14.15
SD(±)	0.94	2.00	2.56	3.33	4.42
Min	1.46	2.91	5.54	7.39	9.35
Max	5.14	10.67	15.41	17.46	21.83

* All averages are significantly different (ANOVA followed by Sheffé test at 5% level, after data transformation into $\text{Arcsin } \sqrt{(\%)}$).

The mean amount lost for one larva was close to 46.91 (± 8.15) mg; this value was calculated by subtracting the dry weight of infested seeds from that of undamaged ones. It was approximately constant, even if the number of bruchids developed per seed was different. This quantity can also be estimated by the slope of the line giving the relationship between dry weight losses and number of emergence holes (Fig. 3); the correlation was positive. Then, knowing the number of bruchid emergence-holes in a seed sample, it is possible to calculate the real weight losses of *V. faba* seeds according to the severity by the following equation:

$$\text{Real average weight losses (\%)} = 2.88\% \times \text{number of bruchid emergence holes} + 0.32$$

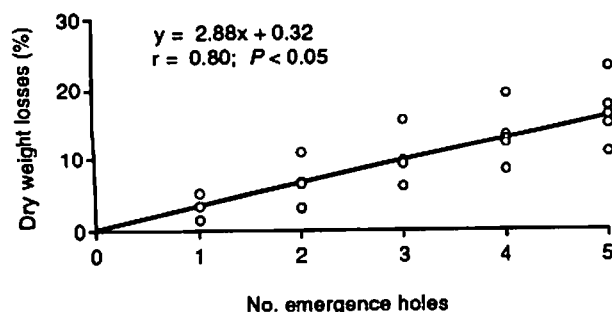


Fig. 3. Relationship between dry weight losses of *Vicia faba* seeds and emergence hole numbers of *Bruchus rufimanus*.

So, each larva developed in a seed caused a loss close to 2.88% of the seed dry weight. The average quantity of frass produced per larva was 31.7 (± 5.5) mg ($n = 500$).

Germination

The influence of bruchid infestation on faba bean seed germination became significant once two larvae developed in the seed (Fig. 4). The mean percentage of germination decreased from 90.5% (when one larva developed per seed) to 80.5% (when 2 larvae developed per seed). This percentage then decreased progressively as the number of larvae in a single seed increased. For 5 larvae per seed, the proportion of germinated seeds was only about 55% (Fig. 4). Therefore, each larva of *B. rufimanus* which accomplished its development in a *V. faba* seed reduced the germination by about 8% in comparison with the undamaged seeds. In addition, for those infested seeds which did germinate, germination took place 2 days later than that of uninjured seeds. Ungerminated seeds developed mycelium and fructification of fungi of the genera *Penicillium* and *Aspergillus*.

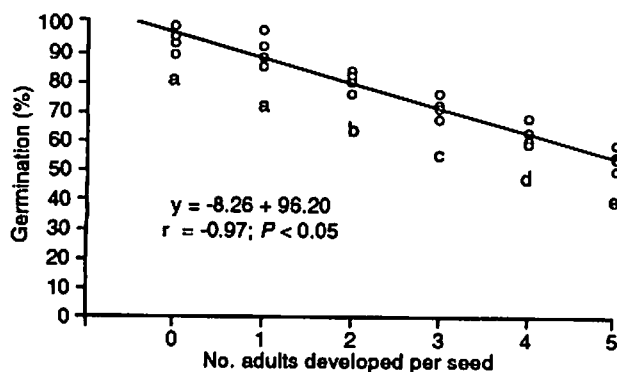


Fig. 4. Influence of *Bruchus rufimanus* on the germination of *Vicia faba* seeds.

Discussion

In this study, *B. rufimanus* was found in all areas prospected. The large dissemination of the bruchid seems to be facilitated by trade of infested seeds of *V. faba*, as has been shown by Hodges (1986) with other insects which develop in the seed. In fact, among the 152 farmers interviewed, only one disinfested his seeds before sowing. This observation is in agreement with that made by Bouhatous (1987), who noted that the majority of the farmers visited did not disinfect *V. faba* seeds against seed-borne injurious organisms.

In Morocco, the rates of apparent infestation of *V. faba* seeds by *B. rufimanus* varied from 4 to 62% depending on the area and fields prospected. As observed for the same bruchid in France on tick bean (Dupont and Huignard 1990), the differences in the infestation rates between areas and fields seemed to be determined by the importance of faba bean crops. The variation in infestation rates could also be due to the abundance of bruchid natural enemies, different in each area, as has been noted for other bruchid species (Alzouma 1987; Lammers and Van Huis 1989).

The infestation rates of *V. faba* by *B. rufimanus* in Morocco largely exceed the level tolerated for export trade and agro-industrial transformation, which is 2–3% of the seeds (Berne and Dardy 1987). Moreover, these infestation rates do not reflect the actual severities, since about 40% of *V. faba* seeds examined harbored 2–5 bruchids each.

On the national scale, the real average weight losses were close to 5% of seed dry weight with large differences between fields and seeds. In contrast to the findings of Shazali (1990), who did not find a relationship between weight losses of *V. faba* seeds due to *Bruchudius incarnatus* (Boh.) and seed weight, in our study the losses were correlated with seed weight. Like us, Sadej and Zuranska (1986) also observed that the weight losses of faba bean seeds due to *B. rufimanus* were more important in small seeds than in large ones. For seeds having similar dry weight, the differences between observed losses could be due to the larva's sex: the male (dry weight = 13.2 (± 2) mg; $n = 100$) is lighter than the female (dry weight = 15.2 (± 2.5) mg; $n = 100$) (Boughadad, unpubl.).

The real weight losses increased with the number of larvae developed within a single seed. The correlation was positive. Therefore, knowing the severity of infestation of *V. faba* seeds caused by *B. rufimanus*, it is possible to calculate the real losses according to the equation expressing the losses as a function of bruchid infestation severity. This result allows one to make a decision in the cases of litigious trades, by fixing the price of commodity in consideration of rebate. Adams and Schulten (1978), and Shazali (1990) give conversion coefficients of grain

losses expressed in percentage for severity of more than 3 larvae per seed. In actual conditions, 7 larvae can develop in a single seed (Boughdad, unpubl.) or even 9 (Middlekauff 1951). In our study, and in agreement with Geier et al. (1983), the losses increased progressively with pest abundance.

The severity of infestation gives a good picture of the bruchid population density actually realized in a seed bulk; this helps farmers decide about bruchid control and correct the sowing rates according to the severity of infestation. In fact, our work shows also the impact of bruchids on seed germination. The negative effect seems to be due to micro-organism contamination of infested seeds, as has been observed on wheat grain infested by other beetles (Sinha 1983).

In conclusion, the mean infestation rate of *V. faba* seeds caused by *B. rufimanus* in Morocco was close to 33% of the seeds examined. The bruchid infestation effected weight loss and germination reduction of *V. faba* seeds. The pest status of *B. rufimanus* justifies control measures. Bruchid management methods require integration of biological and ecological knowledge of the pest, obtained under farmers' conditions (Boughdad 1994).

Acknowledgement

This work was supported by DPVCTRF, PV-Rabat and E.N.A. Meknès.

References

- Adams, J.M. 1976. Weight loss caused by development *Sitophilus zeamais* (Motsch) in maize. *Journal of Stored Products Research* 12: 269–272.
- Adams, J.M. 1977. A review of the literature concerning losses in stored cereals and pulses, published since 1964. *Tropical Science* 19: 1–8.
- Adams, J.M. and G.G.M. Schulten. 1978. Losses caused by insects, mites and micro-organisms. Pages 83–89 in *Post-harvest Grain Loss Assessment Methods*. AACC.
- Alzouma, I. 1987. Reproduction et développement de *Bruchidius atrolineatus* aux dépens des cultures de *Vigna unguiculata* dans un agrosystème sahélien au Niger. Thèse de Doctorat d'Etat, Université de Tours.
- Berne, J.J. and J.M. Dardy. 1987. La bruche sur féverole: un ravageur bien difficile à maîtriser. *Phytoma-Défense des Cultures* 338: 30–32.
- Bishara, S.I., M.Y. Haggag and A.A. Riad. 1967. Field infestation of broad bean by bruchids in U.A.R. *Agricultural Research* 45: 33–39.
- Booker, R.H. 1967. Observation on three bruchids associated with cowpea in northern Nigeria. *Journal of Stored Products Research* 3: 1–15.
- Boughdad, A. 1994. Statut de nuisibilité et ecologie des populations de *Bruchus rufimanus* Boheman, 1833 sur *Vicia faba* L. au Maroc. Thèse d'Etat, Université de Paris-Sud.
- Boughdad, A. and Y. Gillon. 1989. Transformation du risque par la modernisation des méthodes de stockage. Pages 345–353 in *Le Risque en Agriculture* (M. Eldin and F. Millville, ed.). ORSTOM, Paris.
- Bouhatous, B. 1987. Broomrape parasitism situation and perspective. Pages 197–219 in *Légumineuses Alimentaires au Maroc*. INRA/ICARDA, Rabat.
- Caswell, G.H. 1961. The infestation of cowpea in the western region of Nigeria. *Tropical Science* 3: 145–158.
- Caswell, G.H. 1981. Damage to stored cowpea in the northern of Nigeria. *Samur Journal of Agricultural Research* 11: 11–19.
- Dias, C.A.R. and T.F. Yadav. 1988. Incidence of pulse beetles in different legumes seeds. *Indian Journal of Entomology* 50: 457–461.
- Dupont, P. and J. Huignard. 1990. Relationships between *Bruchus rufimanus* Boh. (Coleoptera: Bruchidae) and the phenology of its host plant *Vicia faba* L. Their importance in the spatial distribution of the insects. *Symposia Biologica Hungarica* 39: 255–263.
- Geier, P.W., L.R. Clark and D.T. Bries. 1983. Principles for the control of arthropod pests. 1. Elements and functions involved in pest control. *Protection Ecology* 5: 1–96.
- Hodges, R.S. 1986. The biology and control of *Prostephanus truncatus* (Horn) (Coleoptera: Bostrychidae). A destructive storage pest with an increasing range. *Journal of Stored Products Research* 22: 1–14.
- Kamel, A.H. 1967. A study of the possibility of eradication the broad bean weevil *Bruchus rufimanus* Boh. (Coleoptera: Bruchidae) by fumigation. *Journal of Stored Products Research* 3: 367–369.
- Lammers, P.A. and A. Van Huis. 1989. *Uscana lariophaga* egg parasitoid of the stored insect pests *Callosobruchus maculatus* and *Bruchidius atrolineatus*. Proceedings of the International Conference on Pest Management in Tropical Ecosystem 3: 1013–1022.
- Middlekauff, W.W. 1951. Field studies on the bionomics and control of the broad bean weevil. *Journal of Economic Entomology* 44: 240–243.
- Nakhla, J.M. 1988. Loss in seed weight of five different pulse caused by the cowpea weevil (*Callosobruchus maculatus* F.). *Agricultural Research Review (Cairo)* 66: 71–75.
- Ozar, A.I. and H. Gen. 1987. Study on the rate of infestation and damage by species of Bruchidae (Coleoptera), damaging stored food legumes in the Aegean region. Pages 341–350 in *Turkiyzt I. Entomoloji Kongresi Bildirleri*. Ege Universitesi Atatürk Kültür Merkezi.
- Sadej, W. and I. Zuranska. 1986. Observation on the harmfulness of the broad bean weevil, *Bruchus rufimanus*

Entomoligiczne 56: 447–452.

Salkini, A.B., D.F. Nygaar and T. Nordblom. 1982. Farmer and consumer perspectives on insects of faba bean: survey and results in Sudan. *FABIS Newsletter* 5: 25–28.

Shazali, M.E.H. 1990. Weight loss in faba bean caused by feeding larvae of *Bruchidius incarnatus* (Boh.). *FABIS Newsletter* 26: 30–32.

Singh, B.B. and B.N. Ntare. 1985. Development of improved varieties in Africa. Pages 105–116 in *Cowpea Research Production and Utilisation* (S.R. Singh and K.O. Rachice, ed.). IITA, Nigeria.

Sinha, R.N. 1983. Effects of stored-product beetle infestation on fat acidity, seed germination, and microflora of wheat. *Journal of Economic Entomology* 776: 813–817.

Effect of Maleic Hydrazide (MH) as a Growth Inhibitor for Controlling *Orobanche crenata* on Faba Bean

Khaled A. Khalaf, G.M. Metwely and T.A. El Shahawie

Botany Department, Agricultural Chemistry Unit
National Research Center, Dokki
Cairo, EGYPT

Abstract

In greenhouse trials, maleic hydrazide (MH) was examined as a growth inhibitor for controlling *Orobanche crenata* Forsk. parasitism on faba bean (*Vicia faba* L.) at different rates and dates of application. Foliar application of MH at low concentrations (5–50 ppm) 60 days after sowing (flowering stage) failed to eliminate *O. crenata* infestation on faba bean. However, spraying MH at higher concentrations (100–500 ppm) 60 and 90 days after sowing, i.e. during the flowering and initial pod stages, respectively, reduced *O. crenata* parasitism, mainly by reducing the number and length of *Orobanche* emerging spikes, which largely prevented them from producing seed capsules. Spraying MH at an earlier stage (60 days after sowing) was much more effective for controlling *O. crenata* than later spraying (90 days from sowing).

Biological studies revealed that MH concentrations of 1 to 500 ppm failed to induce the germination of *O. crenata* *in vitro*. Also, MH showed an inhibitory effect on the viability of *Orobanche* seeds *in vitro*, particularly at high concentrations.

It is evident that inhibiting the viability of *Orobanche* seeds already produced and/or depressing *Orobanche* shoot development must be considered as control strategies, either by using growth inhibitors or other substances, which might play a part in long-term integrated control of *Orobanche* species.

تأثير Maleic Hydrazide (MH) كمانع للنمو لمكافحة الهالوك في الفول

المخلص

تمت دراسة MH في تجارب دفيئات ككباح للنمو لمكافحة تطفل الهالوك *Orobanche crenata* Forsk. على الفول (*Vicia faba* L.) وذلك عند معدلات ومواعيد للرش مختلفة. وقد فشل رش الأوراق بتراكيز متدنية من MH (5-50 جزء بالمليون) بعد 60 يوماً من الزراعة (طور الإزهار)، في القضاء على الإصابة بالهالوك في الفول. غير أن رش MH بتراكيز أعلى (100-500 جزء بالمليون) بعد 60 و90 يوماً من الزراعة، أي خلال طوري الإزهار والقرن الأولي، على التوالي، خفض تطفل الهالوك بشكل رئيسي عن طريق تخفيض عدد وقوة سنابل الهالوك المنبثقة، مما أعاق إلى حد كبير قدرتها على إنتاج محافظ البذور. وكان رش MH في مرحلة أبكر (60 يوماً بعد الزراعة) فعالاً في مكافحة الهالوك أكثر بكثير من الرش فيما بعد (90 يوماً بعد الزراعة).

وقد بينت الدراسات البيولوجية أن تراكيز MH من 1 إلى 500 جزء بالمليون قد فشلت في تحفيز إنبات الهالوك مخبرياً. كما أظهر MH تأثيراً كاحاً على قابلية نمو بذور الهالوك مخبرياً ولاسيما عند التراكيز العالية.

وإنه لأمر جلي أن يتعين اعتبار كبح قابلية نمو بذور الهالوك المنتجة حديثاً أو إضعاف نمو فروع الهالوك أو كليهما، كاستراتيجيات للمكافحة، سواء باستخدام كباحات النمو، أو باستخدام مواد أخرى قد تشكل جزءاً من مكافحة متكاملة طويلة الأمد لأنواع الهالوك.

Key words: *Vicia faba*; faba beans; MH; growth inhibitors; *Orobanche*; foliar application; spraying; weed control.

Introduction

Over decades, the traditional, biological and chemical measures for controlling *Orobanche* spp. parasitism have failed. However, in recent years, a new approach has been considered, namely studying the efficiency of growth inhibitors for controlling *O. crenata* parasitism in *Vicia faba*, since most of the growth-promoter hormones, amino acids, vitamins, as well as strigol and its analogues, have shown some efficiency as germination factors for eliminating *Orobanche* spp. infestations (Chabrolin 1938; Kasasian 1973; Garas et al. 1974; Johnson et al. 1976; Zwanenburg et al. 1986).

This approach might allow new control measures. Such substances might modify either the anatomical or physiological features of the host and/or parasite (Hassan et al. 1989). Only a few studies have been conducted on the effect of growth inhibitors against *Orobanche* spp. parasitism. Edwards et al. (1973) report that ethylene had no stimulatory effect on the germination of *O. crenata*.

El-Masry et al. (1993) indicate that using Morphactin as a growth regulator at 50 and 100 ppm for controlling *O. crenata* on *V. faba* reduced the height, number of flowers and dry-matter accumulation in *Orobanche* shoots. However, Belyaeva et al. (1978) indicate that spraying the growth inhibitor maleic hydrazide (MH) at 7 kg/ha on well-established *Cuscuta campestris* Yuncker on sugar beet killed the veins and reduced the viability of any dodder seeds already produced. Mattson et al. (1947) suggest that MH inhibits plant growth by blocking dehydrogenase enzyme activity. Such enzymes exist in viable *Orobanche* seeds and are capable of reducing the tetrazolium chloride (TTC) compound to a red formazan compound (Aalders and Pieters 1985; Khalaf 1989).

Special attention has been given in this work on MH as a growth inhibitor on *O. crenata* infestations, rather than using it as a herbicide for controlling *Orobanche* spp. (Perez 1956; Evtushenko and Eletskii 1973), by studying the effect of MH on *O. crenata* development and the viability of its seeds in relation to faba bean.

Material and Methods

Greenhouse Trials

Foliar application of maleic hydrazide at low concentrations on the course of Orobanche crenata development 60 days after sowing

This experiment was carried out at the National Research Center, Egypt; it was sown on 10 November 1991. Eighteen pots (20 × 20 cm), were filled with clay soil and infected with

O. crenata seeds (0.1 g/pot) 5 cm below the soil surface. Faba bean seeds (cv. Giza 2) were sown (6 seeds/pot) 3 cm below the soil surface, and maintained under greenhouse conditions. Maleic hydrazide (MH, 1-2-dihydro-3,6-pyridazinedione, 30% a.i., BASF) was applied as foliar application at the concentrations of 0, 5, 10, 50 and 100 ppm 60 days after sowing (flowering stage). Three pots were used for each concentration, and the pots were watered as required. Three extra pots, free of *Orobanche* seeds, were used as the control. Faba bean roots for each treatment were examined for *Orobanche* infection 160 days after sowing (harvest stage). The number and fresh and dry weight (dried at 150°C for 24 h) of *Orobanche* tubercles attached to the faba bean were determined for each treatment. The number and mean length of *Orobanche* shoots were also recorded. The time taken for *Orobanche* shoots to emerge from the soil was observed. MH phytotoxicity at different concentrations was noted during host and parasite development.

Foliar application of maleic hydrazide at high concentrations on the course of Orobanche crenata development 60 and 90 days after sowing

This experiment was also conducted at the National Research Center, Egypt; it was sown on 15 November 1992. In this trial, MH was applied at different stages of growth, to verify whether *O. crenata* development was depressed and whether viability of *O. crenata* seeds already produced was effected, corresponding to the present biological results which indicated that MH is capable of inhibiting the viability of *O. crenata* seeds *in vitro* only at high concentrations (100 to 500 ppm, Fig. 1).

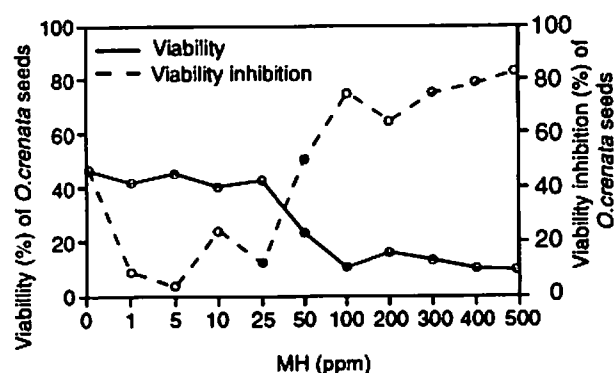


Fig. 1. Effect of maleic hydrazide at high concentrations on the number and length of *O. crenata* shoots at different dates of spraying.

Thirty-six pots were infected with *O. crenata* (0.1 g/pot) and sown with faba bean cv. Giza 2 as in the previous experiment. The pots were divided into two sets (18 pots/set) and

maintained under greenhouse conditions. Maleic hydrazide was applied at the concentrations 0, 100, 200, 300, 400 and 500 ppm. The two sets were sprayed with MH concentrations 60 and 90 days after sowing, i.e. at flowering and initial pod stages. Three pots were used for each concentration and 3 extra pots uninfected with *Orobanche* were used as controls. The data on *O. crenata* and host plant were collected as in the previous experiment. The effect of MH on the morphology of faba bean and *Orobanche* were observed.

All data obtained in both seasons were subjected to statistical analysis of variance for both seasons.

Biological Studies

Effect of maleic hydrazide on the viability and germination activity of Orobanche crenata in vitro

Orobanche crenata seeds were treated with sodium hypochloride (5%) for 5 minutes to remove the light and dark brown color of the seed coats, then the seeds were soaked in distilled water for 10 days at 17°C. Maleic hydrazide was tested at a wide range of concentrations (1 to 500 ppm, Fig. 1). Aliquot MH solutions (1 ml) were placed in petri dishes (6 cm diameter, Whatman No. 1), and three replicates were used for each treatment. The *Orobanche* seeds were then transferred to the petri dishes using a tip brush. The treatments were incubated at room temperature (20±2°C) for 10 days, and the stimulatory effect of MH on the germination activity (%) was obtained by determining the total number of seeds and number of those that had germinated, then the mean germination (%) was calculated.

Determination of the viability of *O. crenata* seeds (%) was carried out by removing the MH solutions from the petri dishes, using a dropper, followed by adding tetrazolium chloride solution (TTC, 1%) to each treatment (1 ml/petri dish). The treatments were incubated in the dark over night (14 h) at room temperature. The viability (%) of *Orobanche* seeds was assessed according to the formula of Khalaf (1989), using the red-stained seeds (formazan formed), discolored seeds, and the metabolic activity was calculated in relation to the total number of seeds. The activity of viability inhibition (-%) of MH on *Orobanche* seeds is expressed according to Itokawa et al. (1982) as follows:

Activity of viability inhibition =

$$100 - \frac{\text{Viability after treatment of the sample} \times 100}{\text{Viability after treatment of the control}}$$

Results and Discussion

Maleic hydrazide has been applied as a herbicide for controlling *Orobanche* spp. in various crops (Perez 1956; Kasasian 1973). However, in the present study we examined MH as a growth inhibitor during the course of *O. crenata* development on faba bean and studied the effect of MH on the viability of *Orobanche* seeds.

The influence of spraying MH at low concentrations (5 to 100 ppm) during the course of *O. crenata* development on faba bean 60 days after sowing (flowering stage) is shown in Table 1. Foliar application of MH as a growth inhibitor at all the tested concentrations on faba bean 60 days after sowing gave fair control of *Orobanche* development, particularly at 100 ppm. Applying MH at 100 ppm was much more effective in reducing *O. crenata* growth, compared with lower concentrations (5 to 50 ppm) and with the infected control. Maleic hydrazide at 100 ppm had a pronounced effect on the number and length of *O. crenata* spikes after their emergence from the soil (1.7 *Orobanche* spikes, mean 2.3 cm *Orobanche* shoots length/V. faba plant) compared with the infected control (10 *Orobanche* spikes, 13.4 cm *Orobanche* shoot length/V. faba plant). Moreover, MH at 100 ppm also significantly reduced the number of *Orobanche* tubercles compared with lower concentrations and the infected control (Table 1). Spraying MH at 50 ppm inhibited *Orobanche* shoot length to some extent, whereas the lower concentrations (5–25 ppm) failed to reduce *Orobanche* development (Table 1). Maleic hydrazide did not show any phytotoxicity on host plant growth, with the exception of 100 ppm, which gave some host plant phytotoxicity.

Response of spraying MH at high concentrations (100 to 500 ppm) on faba bean 60 and 90 days after sowing is presented in Table 2 and Figure 2. Applying MH at high concentrations (100 to 500 ppm) 60 days after sowing (flowering stage), i.e. during production of *Orobanche* tubercles on the host roots, significantly reduced *Orobanche* parasitism. Maleic hydrazide also significantly reduced the number and length of emerged *Orobanche* spikes. Applying MH at 400 and 500 ppm completely prevented development of *Orobanche* spikes, while spraying MH at lower concentrations (100 to 300 ppm) reduced the number and length of *Orobanche* spikes to some extent, compared with the infected control (Table 2). However, MH showed a significant phytotoxicity on the host plant, irrespective of rate of application, within two weeks after spraying. The phytotoxicity was characterized by "burning" and bending of the leaf edges and a reduction in the number of flowers of the host plant compared with healthy controls (Table 2).

Table 1. Effect of foliar application of maleic hydrazide at low concentrations on the growth and development of *Orobanche crenata* on faba bean 60 days after sowing.

MH (ppm)	No. <i>Orobanche</i> tubercles	Fresh wt <i>Orobanche</i> (g)	Dry wt <i>Orobanche</i> (g)	No. <i>Orobanche</i> shoots	Length <i>Orobanche</i> shoots (cm)	Phytotoxicity of MH on faba bean
Infected control	24.7	134.4	24.0	10.0	13.4	-
5	19.3	165.4	36.4	9.0	13.2	No effect
10	15.3	121.7	21.7	11.7	24.7	No effect
25	4.7	58.8	11.9	8.7	3.4	No effect
50	5.7	118.4	16.5	5.3	6.1	No effect
100	3.7	32.0	5.6	1.7	2.3	Slightly toxic
LSD _{0.05}	7.9	NS	10.6	NS	-	

Table 2. Effect of foliar application of maleic hydrazide at high concentrations on the growth and development of *Orobanche crenata* on faba bean 60 and 90 days after sowing.

MH (ppm)	No. <i>Orobanche</i> tubercles	Fresh wt <i>Orobanche</i> (g)	Dry wt <i>Orobanche</i> (g)	No. <i>Orobanche</i> shoots	Length <i>Orobanche</i> shoots (cm)	Phytotoxicity of MH on faba bean
Sprayed 60 days after sowing						
Infected control	5.3	23.2	5.3	2.0	9.5	
100	6.3	10.7	0.9	1.0	5.1	Slightly toxic
200	10.0	12.1	0.9	1.0	4.3	Toxic to some extent
300	4.7	8.1	0.9	1.3	3.8	Severely toxic
400	0.7	2.2	0.1	0	Nil	Severely toxic
500	3.3	7.2	0.6	0	Nil	Severely toxic
LSD _{0.05}	4.3	6.2	1.9	1.1	-	
Sprayed 90 days after sowing						
Infected control	9.3	36.8	6.5	5.0	18.4	
100	9.0	57.2	7.5	6.3	2.8	Slightly toxic
200	9.7	65.5	8.4	4.0	2.6	Slightly toxic
300	4.3	6.6	1.5	5.3	4.4	Severely toxic
400	6.0	12.5	4.9	6.5	2.0	Severely toxic
500	7.7	29.6	7.4	5.0	3.9	Severely toxic
LSD _{0.05}	NS	20.5	NS	NS	-	

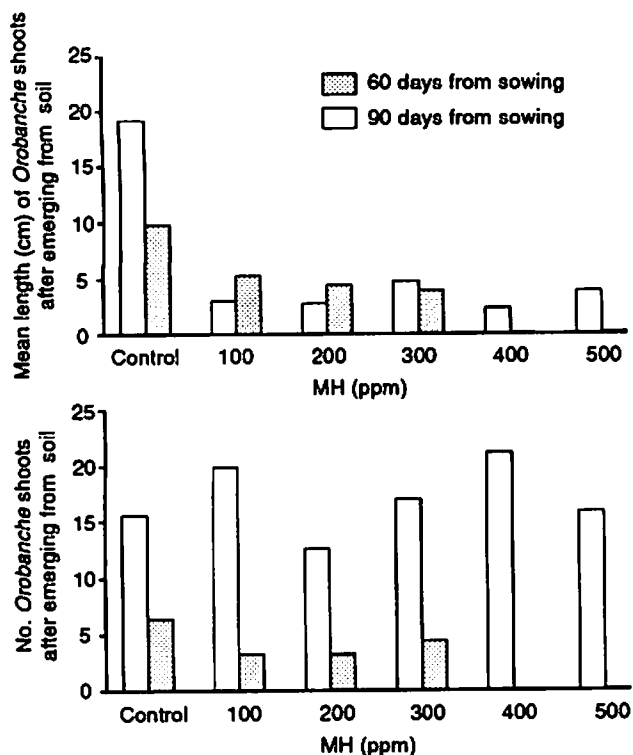


Fig. 2. Effect of maleic hydrazide at different concentrations on the viability of *Orobancha crenata* seed *in vitro*.

Maleic hydrazide was also tested at the same concentrations (100 to 500 ppm) on the development of an *O. crenata* infestation 90 days after sowing (initial pod stage), i.e. during emergence of *Orobancha* spikes from the soil surface. Maleic hydrazide controlled *Orobancha* by reducing the length of the spikes, rather than by reducing the number of emerged spikes or by reducing the number of tubercles (Table 2; Fig. 2). There were significant differences in the effect between applying MH 60 and 90 days after sowing at high concentrations on the number of *Orobancha* tubercles (Table 2). Spraying MH 90 days after sowing showed limited phytotoxicity on the host plant at 100 and 200 ppm, while higher concentrations (300 to 500 ppm) were extremely toxic to the host plants – similar to those plants sprayed with the same concentrations 60 days after sowing (flowering stage).

The present results indicate that foliar application of MH as a growth inhibitor at low concentrations (5 to 50 ppm) failed to control *Orobancha* parasitism on faba bean. However, spraying MH at high concentrations (100–500 ppm) 60 days after sowing was more effective in controlling *O. crenata* parasitism than later spraying (90 days). Control was characterized by reduced emergence of *Orobancha* spikes and prevention of

seed-capsule formation. The reduction in the number and length of *Orobancha* spikes may be explained by MH interference with the physiological processes of the parasite and/or host plant (Hassan et al. 1989). These results agree with those obtained by Prokundina (1972), who reports that spraying water melon with MH when *O. aegyptiaca* haustoria had formed and again 20 to 30 days later prevented the emergence of the parasite. El-Masry et al. (1993) found that spraying *V. faba* with Morphactin as a growth regulator at 50 and 100 ppm for controlling *O. crenata*, reduced the height, number of flowers and dry-matter accumulation in *Orobancha* shoots. Maleic hydrazide had no influence on the time taken for *Orobancha* spikes to emerge from the soil surface. However, it would be difficult to use MH for controlling an *O. crenata* infestation in faba bean, since most MH concentrations show significant phytotoxicity on the host plant.

This evidence might be supported by the fact that it is doubtful that MH can be used as a herbicide for controlling *O. crenata* in faba bean, although Kasasian (1973) claims that applying MH at 0.33–3 kg/ha gave fair control of *O. crenata* in faba bean, but the host-plant vigor was impaired. Mazaheri et al. (1991) found that a single post-emergence application of MH at low rate (0.7 kg a.i./ha) 40 days after tobacco transplanting controlled *O. aegyptiaca* by 63.8–85.9%; however, higher rate of MH application caused apical leaves to be narrow with pale green-yellowish color.

In-vitro biological studies revealed that MH entirely failed to trigger the germination of *O. crenata* seeds irrespective of rate of application (1 to 500 ppm). However, MH inhibited the viability of *Orobancha* seeds *in vitro*, but only at high concentrations.

The viability of *O. crenata* seeds pre-treated *in vitro* with MH for several days, followed by incubation with tetrazolium chloride (TTC) for 14 h, was remarkably reduced, particularly at higher concentrations (100 to 500 ppm), rather than at lower concentrations (1–25 ppm) (Table 2). Maleic hydrazide inhibited the viability of *O. crenata* seeds by 65.6–76.1% at high concentrations (100–500 ppm), whereas the moderate concentrations of MH at 50 ppm inhibited the viability of *O. crenata* by 51.9% (Fig. 1). The lower concentrations (1–25 ppm) of MH did not show any inhibitory effect on the viability of *O. crenata* seeds compared with the control (Fig. 2). *In vitro*, the viable *Orobancha* seeds pre-treated with MH at low concentrations, and incubated with TTC, gave a red stain, corresponding to the formation of red-formazan substance. However, the viable *Orobancha* seeds largely failed to form red-formazan substance at high MH concentrations (100–500 ppm). Formazan substance was located mostly in the viable *Orobancha* seeds and varied at different levels of concentrations.

This suggests that MH could be used as an inhibitor of *O. crenata* seed germination rather than being used as a stimulatory factor for germination of *O. crenata* seeds *in vitro*. Disappearance of the formazan substance in viable *Orobanch*e seeds treated with MH seems to indicate that MH is capable of inhibiting the viability of *O. crenata* seeds *in vitro* by inhibiting the activity of dehydrogenase enzymes, which exist in viable *Orobanch*e seeds and are responsible for forming red-formazan substance on reduction of tetrazolium chloride (Aalders and Pieters 1985; Khalaf 1989). These results are in agreement with those of Mattson et al. (1947) who report that MH inhibits the growth tissues by blocking the dehydrogenase enzyme activity, and such enzymes may be important in TTC reduction.

Perhaps this explains the results obtained by Belyaeva et al. (1978) who found that MH (7 kg/ha), when sprayed onto well-established *Cuscuta campestris* on sugar beet, reduced the viability of any dodder seeds already produced.

In the present investigation, the performance of MH on the viability of *Orobanch*e seeds proved to be unsuccessful, corresponding to the fact that MH mostly prevented *Orobanch*e shoots from emerging from the soil and/or forming spike capsules. On the other hand, it was not worth determining the viability of *Orobanch*e seeds already produced, since the effective MH concentrations were phytotoxic to the host plant, although such concentrations inhibited the viability of *Orobanch*e seeds *in vitro*.

Two conclusions may be reached from examining the response of MH as a growth inhibitor for controlling *O. crenata* parasitism on faba bean: first, MH is capable of preventing emergence of *Orobanch*e spikes and the production of seed capsules to a large extent, and second, MH inhibited the viability of *O. crenata* seeds *in vitro*. However, the phytotoxicity of MH on the host plant must be taken into consideration. Thus, further investigations are necessary for studying the response of growth inhibitors, particularly in inhibiting the viability of *Orobanch*e seeds and depressing *Orobanch*e development without causing any host-plant phytotoxicity.

References

- Aalders, A.J.G. and R. Pieters. 1985. *In vitro* testing with 2,3,5-triphenyl tetrazolium chloride (TTC) of *Orobanch*e *crenata* seed metabolism. *FABIS Newsletter* 13: 35-37.
- Belyaeva, A.V., A.P. Cherkasova, L.G. Shpanova and R.S. Alfimova. 1978. Maleic hydrazide against dodder (on sugar beet). *Sakharnaya Svekla* 23: 37-37.
- Chabrolin, C.H. 1938. La germination des graines de l'*Orobanch*e *speciosa*. *C.R. Acad. Sci-Paris*. 206: 1990-1992.
- Edwards, W.G., R.P. Hiron and A.I. Mallet. 1973. Some studies on the germination of *Orobanch*e *crenata* seed. Pages 147-158 in 4th Colleague International sur l'Ecologie et la Biologie des Mauvaises Herbes.
- El-Masry, R.R., A.A. Zakaria, R. El Ebrahim and L.O. Salah. 1993. Some aspects on the effect of morphactin on the host-parasite relationships between *Vicia faba* L. and *Orobanch*e *crenata* Forsk. Proceedings of the Third International Workshop on *Orobanch*e, 8-12 November, Amsterdam, The Netherlands (in press).
- Evtushenko, G.A. and A.I. Eletskii. 1973. Possible uses of maleic acid hydrazide on a tobacco crop. *Gidrazid Maleinovo Kisloty Regul. Rosta. Rsat.* 177-190.
- Garas, N.A., C.M. Karssen and J. Buisma. 1974. Effects of growth regulating substances and root exudates on the seed germination of *O. crenata*. *Zeitschrift für Pflanzenphysiologie* 71: 108-114.
- Hassan, H.M., N.F. Kheir, E.Z. Harb, L.A. Badr and A.M. Ghobashy. 1989. The effect of CCC and GA³ on growth, yield, sugars and anatomical structure of tomato parasitized by *Orobanch*e *ramosa*. In Proceedings of the International Workshop on *Orobanch*e Research, 19-22 August, Obermarchtal, Germany.
- Itokawa, H., Y. Oshida, A. Ikuta, H. Inatomi and T. Adachi. 1982. Phenolic plant growth inhibitors from the flowers of *Cucurbita pepo*. *Phytochemistry* 21: 1935-1937.
- Johnson, A.W., G. Roseberry and C. Parker. 1976. A novel approach to *Striga* and *Orobanch*e control using synthetic germination stimulants. *Weed Research* 16: 223-227.
- Kasasian, L. 1973. The chemical control of *Orobanch*e *crenata* in *V. faba* and the susceptibility of 53 cultivars of *V. faba* to *O. crenata*. Pages 224-230 in Symposium on Parasitic Weeds, Malta. European Weed Research Council, Wageningen, Netherlands.
- Khalaf, K.A. 1989. Determination of the viability of different *Orobanch*e *crenata* seed origins, in relation to their Metabolic Germination Activity. In Proceedings of the International Workshop on *Orobanch*e Research, 19-22 August, Obermarchtal, Germany.
- Mattson, A.M., C.O. Jensen and R.A. Dutcher. 1947. Triphenyl tetrazolium chloride (TTC) as a dye for vital tissues. *Science* 106: 294-295.
- Mazaheri, A., M. Vaziri and N. Moayed-Zadeh. 1991. Studies on the chemical control of broomrape (*Orobanch*e *aegyptiaca* Pers.) in tobacco (*Nicotiana tabacum* L.) fields. Pages 90-92 in Fifth International Symposium on Parasitic Weeds, Nairobi, Kenya, 24-30 June 1991.
- Perez, R. 1956. Procedure for exterminating *Orobanch*e *ramosa*. *Rev. Agric. Habana* 39: 78-84.
- Prokudina, V.F. 1972. The use of maleic hydrazide against broomrape on water melons. *Khimiya v Sel'skom Khozyaistve* 10: 66-67.
- Zwanenburg, B., G.L. Mhehe, G.K. Ilam, F.J. Dommerholt and M.A. Kishimba. 1986. The search for new germination stimulants of *Striga* spp. Biology and control of *Orobanch*e. Proceedings of a Workshop, Wageningen, The Netherlands, 13-17 January 1986.

News

Editors' notes

Publication delays

This double-issue of *FABIS Newsletter* (cover date 1995) is going to press in late 1996. We apologize for the delays in

production, which are partly due to lack of material. Please note that it will also be necessary for us to produce a double-issue for 1996 in order to bring the sequence back on schedule in 1997.

Forthcoming Events

1997

2nd International Conference on Soil Solarization and Integrated Management of Soilborne Diseases, Aleppo, Syria, 16–21 March 1997. Contact: Dr K. Makkouk, GP, ICARDA [E-mail k.makkouk@cgnet.com].

Workshop on the Origins of Agriculture and the Domestication of Crop Plants in the Near East, Aleppo, Syria, 10–14 May 1997. Contact: Dr J. Valkoun, GRU, ICARDA [E-mail j.valkoun@cgnet.com].

International Food Legume Research Conference III, Adelaide, Australia, 22–26 September 1997. Contact: Dr F.J. Muehlbauer, Chair: IFLRC-III, 303W Johnson Hall, Washington State University, Pullman, WA 99164-6434, USA [Tel. +1-509-335-9521; Fax +1-509-335-8674]; or, Prof. R.J. Summerfield, Program Chairman IFLRC-III, Department of Agriculture, University of Reading, Early Gate, Reading, Berkshire RG6 2AT, UK [Tel. +44-734-318482; Fax +44-734-352421; Telex 847813].

Recent faba bean publication

Handbook of tropical legume cultivation, by Kazumi Maeda. Association for International Cooperation of Agriculture & Forestry, 19, Ichibancho, Chiyoda-ku, Tokyo, Japan. March 1995, 109 pp.

This book provides an introduction to tropical grain legumes. The first part covers generalities, from taxonomy, distribution and ecology, through farming systems, nitrogen fixation, pests and diseases, to problems of food use of certain legumes (e.g. lathyrism and favism), and seed procurement. The main part of the book, however, is devoted to individual crops, which each receive 2–16 pages of text and tables – soybean (*Glycine*

max (L.) Merrill.), groundnut (*Arachis hypogaea* L.), chickpea (*Cicer arietinum* L.), pigeonpea (*Cajanus cajan* (L.) Millsp.), lentil (*Lens culinaris* L. [sic]), black gram (*Vigna mungo* (L.) Hepper) and green gram (*V. radiata* (L.) Wilczek), cowpea (*V. unguiculata* (L.) Walp. var. *unguiculata*), grass pea (*Lathyrus sativus* L.), sword bean (*Canavalia gladiata* (Jacq.) DC.) and jack bean (*Can. ensiformis* (L.) DC.), and velvet bean (*Mucuna pruriens* (L.) DC. var. *utilis* (Wall. ex Wight) Baker ex Burck, *M. deeringiana* (Bort) Merrill, and *M. aterrima* (Piper & Tracy) Merrill).

Agricultural Libraries Receiving ICARDA Publications

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

Algeria	Ghana	Philippines
Bahamas	Guatemala	Saint Lucia
Bahrain	Guyana	Saudi Arabia
Bangladesh	India	Senegal
Benin	Iran	Somalia
Belgium	Italy	Spain
Bhutan	Kenya	Sri Lanka
Botswana	Korea (Republic)	Sudan
Brazil	Lesotho	Swaziland
Canada	Malawi	Syria
Chile	Malaysia	Taiwan
China	Mali	Tanzania
Costa Rica	Mauritania	Thailand
Cyprus	Mexico	Tunisia
Djibouti	Myanmar	United Kingdom
Ecuador	Netherlands	United Arab Emirates
Ethiopia	Nepal	USA
Fiji	Nigeria	Yemen
Finland	Norway	Zambia
France	Papua New Guinea	Zimbabwe

Contributors' Style Guide

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

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

Manuscript

Contributions should be sent to FABIS/CODIS, ICARDA, P.O. Box 5466, Aleppo, Syria. The name, address, e-mail address (if available), and telex or fax number of the corresponding author should be included in the covering letter. One good-quality original of the text should be submitted, typed double-spaced on one side of the paper only. Alternatively, word-processed files in WordPerfect 5 or 6 or Microsoft Word 6.0 may be sent as e-mail attachment to: *G.Manners@cgnet.com* or *ICARDA@cgnet.com*. However, there is a size restriction of 128 kb on incoming e-mail to ICARDA – please discuss in advance if you have any doubts. Figures should be original drawings, good-quality laser prints, or black-and-white photographs of good quality. Photographs and figures should be suitable for reduction to a printed size of 8.5 or 17.4 cm wide. Photocopies are not acceptable for publication in *FABIS Newsletter*.

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

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

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

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

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

Journal article: Schubert, I. and R. Rieger. 1990. Alteration by centric fission of the diploid chromosome number in *Vicia faba* L. *Genetica* 81: 67–69.

Article in book: Bos, L. 1982. Virus diseases of faba beans. Pages 233–242 in *Faba Bean Improvement* (G. Hawtin and C. Webb, ed.). Martinus Nijhoff, The Hague.

Article in proceedings: Montoya, J.L. 1988. The production of seed of leguminous crops in Spain. Pages 136–142 in *Seed Production in and for Mediterranean Countries. Proceedings of the ICARDA/EC Workshop, 16–18 December 1988, Cairo, Egypt* (A.J.G. van Gastel and J.D. Hopkins, ed.). ICARDA, Aleppo, Syria.

Book: Agarwal, V.K. and J.B. Sinclair. 1987. *Principles of Seed Pathology*. CRC Press, Boca Raton, Florida, USA.

Thesis: El-Hosary, A.A. 1981. Genetic studies of some strains of field beans (*Vicia faba* L.). PhD Thesis. Menoufia University, Egypt.

ICARDA Publications and Services

ICARDA Publications

Request a list of all currently available publications from the Communication, Documentation and Information Services (CODIS).

LENS Newsletter

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

Rachis (Barley and Wheat Newsletter)

This publication is aimed at cereal researchers in the Near East and North Africa region and other Mediterranean-type environments. It publishes short scientific papers on the latest research results and news items. *Rachis* seeks to contribute to improved barley and wheat production in the region; to report results, achievements and new ideas; and to discuss research problems. For further information or to subscribe, write to: Rachis/CODIS.

Graduate Research Training Awards, Opportunities for Field Research at ICARDA

The Graduate Research Training Program (GRTP) 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 co-supervision of university and center scientists. For further information on terms of award, nomination procedure, selection criteria, appointment conditions, the university's responsibilities, and the student's responsibilities, write to: GRT Program, Training Coordination Unit.

Opportunities for Training and Post-Graduate Research at ICARDA

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

Library Services

The ICARDA library maintains bibliographic databases for the use of researchers at the center and elsewhere. FABIS and LENS databases contain 6500 and 2800 references, respectively, extracted from AGRIS since 1975 and AGRICOLA since 1970. Literature searches can be conducted by the library staff and results downloaded to diskette or hard copy. Photocopies of up to 5 articles per search can be provided to users, if available. Researchers can request a literature search by letter or telex to: The Manager, LIS.

To obtain further information on these services, please write to the program indicated and state that you saw the advertisement in *FABIS Newsletter*:

International Center for Agricultural Research in the Dry Areas
P.O. Box 5466, Aleppo, Syria

Tel. +963-21-213477, 225112, 235221
Fax +963-21-213490, 225105, 551860
Telex (492) 331208, 331263, 331206 ICARDA SY
E-mail ICARDA@cgnet.com