GRAIN LEGUMES

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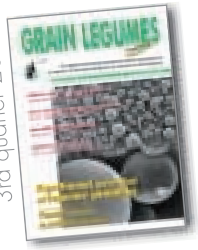

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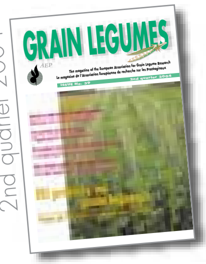

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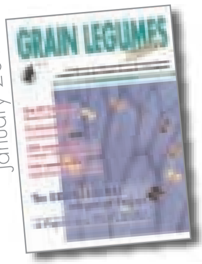

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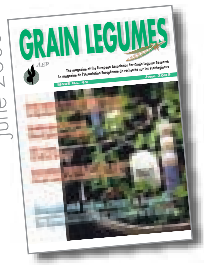

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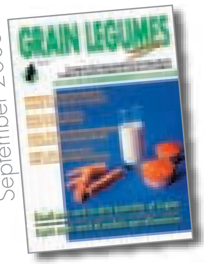

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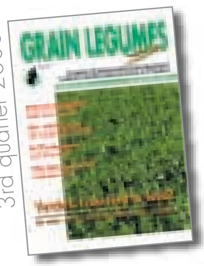

EDITORIAL

In 2007 legume-related research meetings will be plentiful and we hope that you will benefit from these opportunities for progress both in knowledge and collaboration.

Sadly, this positive trend in R&D activities at international level is occurring when there are economic difficulties in agriculture and poor recent harvests in several regions, as illustrated in our market column, taking Europe as an example. Hopefully, our legume network should be able to tackle the priority research and developmental issues so that there will be mutual benefits for research, agriculture and society.

In this magazine issue, we bring you a special report on the superb grain legume, faba bean. For centuries, China has been growing and consuming faba beans and these grains have been a part of traditional dishes in the Middle East region since Pharaonic times. This plant has high yield potential and is a valuable food resource, but it presents several challenges, such as its allogamy, its parasitic plants and its seed quality, for scientists and breeders to deal with.

Anne SCHNEIDER
Managing Editor

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Carte blanche to...

Fred Stoddard*
(in Finnish national costume)

A call for Nordic – Baltic legume research

Since you're reading this, you're already interested in legumes. So am I, since I have worked on them for 25 years in Britain and Australia. I moved to Finland in late 2005 and I have learned that less than 1% of crop land in the Nordic – Baltic region (Norway, Sweden, Denmark, Finland, Estonia, Latvia, Lithuania) is sown to grain legumes (FAOSTAT and EUROSTAT data). Furthermore, our legume areas have declined for 10 years while in the rest of Europe they have remained fairly stable. The GL-Pro project showed that 1 year of grain legumes every 4 to 6 years was applicable between the Baltic and the Mediterranean. Some Australian agronomists aim that one-sixth of crop land should be under legumes while Pulse Canada aims for a quarter. Our legume area should be going up but our community of legume researchers is small and scattered. Our regional pulse market is small so there is little support for breeding or crop management research, but the market cannot develop until there is a reliable supply of pulses adapted to short seasons at high latitudes. Growers of pigs, poultry and trout buy soyabean meal or fish meal rather than use locally grown grain legumes. Some of our colleagues and national funding agencies have also forgotten the other benefits that grain legumes deliver in addition to providing the pulse crop.

Nevertheless, the need for legumes to add sustainability in high-latitude agriculture has never been greater. There is potential for alternative uses of legumes in cropping systems and in feed and food products. Furthermore, concerted effort could improve adaptation to short seasons, perhaps based on using photoperiod response, so that the crops would reach maturity in a timely manner. ■

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First calls of FP7 launched

The Seventh Framework Programme for Research and Technological Development (FP7) is the EU's main instrument for funding research in Europe and it will run from 2007 to 2013.

The EC budget for the next seven years is €50.5 billion and the Euratom budget for the next five years is €2.7 billion. Overall, this represents a 41% increase from FP6 at 2004 prices and 63% at current prices. FP7 is also designed to respond to Europe's employment needs and competitiveness. FP7 supports research in selected priority areas – the aim being to make, or keep, the EU as a world leader in those sectors.

Knowledge Based Bio-Economy (KBBE)

FP7 is made up of four main blocks of activities plus a fifth specific programme on nuclear research (Insert 1).

Among the 10 themes of 'Cooperation', the aim of the FP7 theme 2 'Food, Agriculture and Biotechnology' is "Building a European Knowledge Based Bio-Economy, by bringing together science, industry and other stakeholders, to exploit new and emerging research opportunities that address social, environmental and economic challenges:

– the growing demand for safer, healthier, higher quality food and for sustainable use and production of renewable bio-resources;

– the increasing risk of epizootic and zoonotic diseases and food related disorders;

– threats to the sustainability and security of agricultural, aquaculture and fisheries production; and the increasing demand for high quality food, taking into account animal welfare and rural and coastal contexts and response to specific dietary needs of consumers."

In this theme 2 there are three activities:

1) Sustainable production and management of biological resources from land, forest and aquatic environments
2) Fork to farm: food (including seafood), health and well-being
3) Life sciences, biotechnology and biochemistry for sustainable non-food products and processes.

Insert 1

FP7: five specific programmes and the JRC

Cooperation – Collaborative research (€32,365 million)
- Health
- Food, Agriculture and Biotechnology
- Information and Communication Technologies
- Nanosciences, Nanotechnologies, Materials and new Production Technologies
- Energy
- Environment (including climate change)
- Transport (including Aeronautics)
- Socio-economic sciences and Humanities
- Security
- Space

Ideas – European Research Council (€7460 million)

People – Human Potential, Marie Curie actions (€4728 million)

Capacities – Research capacities (€4217 million)

Joint Research Centre – Actions in Euratom and Non-nuclear actions (€1751 million)

Nuclear research and training – Fusion energy (ITER) and Nuclear fission and radiation protection (€2751 million)

Who and how to participate?

In principle FP7 participants can be based anywhere but there are different categories of country which may have varying eligibility for different specific and work programmes:

- Member states – The EU-25;
- Associated countries – with science and technology cooperation agreements that involved contributing to the framework programme budget;
- Candidate countries – currently recognised as candidates for future accession;
- Third countries – the participation of organisations or individuals established in countries that are not Member States, candidates or associated countries should also be justified in terms of the enhanced contribution to the objectives of FP7.

The instruments used in FP7 are of three main categories: 'Collaborative Projects', 'Networks of Excellence' and 'Coordination and Support Actions'. The expected Commission contribution for a small to medium Collaborative Project is up to €3 million, the contribution for a large Collaborative Project or a Network of Excellence is between €3 million and €6 million, and the contribution for a Coordination and Support Action is up to €1 million.

The other proposed funding schemes are Individual projects (ERC in Ideas), Support for training and career development actions (for the implementation of Marie Curie actions), and Research for the benefit of specific groups (in particular SMEs).

Except for the first call which will use the single stage procedure, the answers to calls will be organised in two stages, the first stage requesting a proposal of no more than 20 pages, and for those selected, the second stage requiring coordinators to submit a full proposal.

When and which topics?

The first calls of the different specific programmes and themes were released on 22 December 2006 and answers are expected in the Spring (02 May 2007 for Theme 2: see Insert 2). Other

Insert 2

Food, Agriculture and Fisheries, and Biotechnology – General call 1

Identifier: FP7-KBBE-2007-1

Publication date: 22 December 2006

Budget: €192,090,000

Deadline: 02 May 2007 at 17:00 (Brussels local time)

OJ Reference: OJ C316 of 22 December 2006

Specific Programme: [Cooperation]

Theme: [Food, Agriculture and Fisheries, and Biotechnology]

Submission: Proposals for indirect RTD actions are invited to be submitted only as an electronic proposal via the web-based Electronic Proposal Submission System (EPSS). All proposals for indirect RTD actions must contain two parts: the administrative forms (Part A) and the content (Part B). Proposals for indirect RTD actions must be prepared and submitted online. Part B of proposals for indirect RTD actions can only be submitted in PDF format ('portable document format', compatible with Adobe Version 3 or higher with embedded fonts). Compressed ('zipped') files will be excluded.

Continued overleaf…

… continued from previous page

calls will be released in the Spring for an autumn deadline (Theme 2 call 2A will be released on 8 May 2007 with a deadline on 11 September 2007 for the first stage).

The first two calls of Food, Agriculture and Biotechnology (the current one and the one to be open in May) provide the community with a fairly precise description of the topic to be covered by each proposal with an indication of the title, the main objectives, the type of instrument and the expected size. In the future, the topics could be issued from the recommendations of consultative groups, including the EU Technology Platforms.

Since there was no call for expression of interest (as was the case at the beginning of FP6) and since the recommendations of stakeholders, gathered especially through the EU Technology Platforms (1) or similar platforms for concerted discussions (2), will have significance, it will become more and more important to be linked to a network of actors that can enable the discussion of context, requirements and actions that will lead to strong proposals submitted to the EU selection for research and development funding. ■

(1) Schneider A. (2006) EU Technology Platforms: to stimulate private investment in European research, Grain Legumes **45**, p.5.

(2) Schneider A. (2006) AEP is the EUROCROP partner responsible for grain legume crops, Grain Legumes **47**, p.7.

Source: AEP from European Commission and related information.

More at: http://cordis.europa.eu/fp7

Strategies for the use of grain legumes – a national conference in Poland

With the exception of the IVth AEP Conference in Cracow, 2001, grain legume conferences have not been organised regularly in Poland. However, since 1992 the Polish Lupin Association has organised a national lupin conference every three years. As peas and field beans are the most important grain legumes in Poland in addition to lupins the Board of the Polish Lupin Association decided to organise a conference covering all legume crops. Although they have similar characteristics and usage, their growing area has decreased in the past 15 years. The conference, organised jointly by the Institute of Plant Genetics PAS and the Agricultural Academy at Poznań, was held in Zakopane – a major town in the high mountains area of Poland, on 25–27 September and there were 82 participants including three guests from the Czech Republic (see photo).

There were six plenary lectures and four oral and poster sessions on:

1. Genetics, biotechnology and breeding (16 presentations),
2. Biochemistry and physiology (16 presentations),
3. Cropping systems (28 presentations),
4. Food and feed (9 presentations).

(Photo W. Święcicki, Institute of Plant Genetics, Poznań)

The presentation by Professor M. Naruszewicz (Department of Pharmacognosy and Molecular Basis of Phytotherapy of the Medical University in Warsaw) on the health effects of the chronic (long-term, 3-month) administration of white lupin seed protein to volunteers with moderate hypercholesterolaemia, who also smoked more than 20 cigarettes daily, met with particular interest. The subjects of the study drank 250 ml of so-called lupin milk (6.7 g protein per 100 ml) twice daily for 90 days. A significant reduction in systolic and diastolic pressure, total cholesterol and LDL as well as glucose and homocystein was found. Furthermore, lupin protein caused a reduction in the level of C-reactive protein (CRP) and urine excretion of F2-isoprostanes. These results indicate that lupin protein is able to reduce the metabolic effects of the risk of cardiovascular disorders caused by atherosclerosis.

The conference proceedings will be published in Polish in the journal *Advances of Agricultural Sciences, Problem Issues*, but summaries and table headings in English will be included.

Two members of the Polish Parliament participated in a final discussion, and this was very important for the future of grain legumes in Poland since GMO feed components will not be allowed after 2008. Soyabean cake (about 1,800,000 t/year) originating from GM cultivars is the main component of compound feed at present in Poland, but it could be replaced by a rapeseed cake (the growing area of winter rape is expected to double for energy raw material) and also by grain legumes. The current use of grain legumes in Poland is limited: only 1% of the arable area and about 200,000 t of seed used in feed. ■

Source: Wojciech Święcicki, Institute of Plant Genetics, PAS, Poznań (wswi@igr.poznan.pl) and Jerzy Szukala, Agricultural Academy, Poznań (jszukala@au.poznan.pl)

March 22–24, 2007
Satellite workshop on abiotic stress
Tunis, Tunisia
Email: was.legumes@ecopark.rnrt.tn
Web: http://www.ecopark.rnrt.tn/waslegumes

March 24–28, 2007
2007 Model Legume Congress
Tunis, Tunisia
Email: mohamedelarbi.aouani@inrst.rnrt.tn;thierry.huguet@ensat.fr
Web: http://www.ecopark.rnrt.tn/mlc2007

April 23–25, 2007
First GL-TTP Workshop
Paris, France
Email: gl-ttp@prolea.com
Web: http://www.grainlegumes.com/default.asp?id_biblio=454

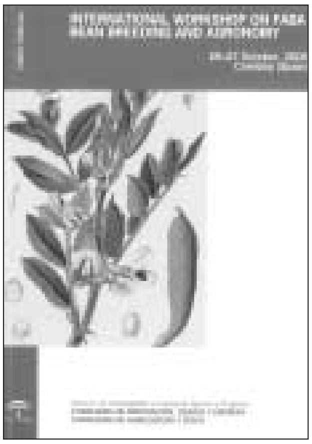
June 24–28, 2007
9th International Pollination Symposium
Iowa State University, Ames, USA
Email: plantbee@iastate.edu

September 12–14, 2007
RoS in plants 2007: a SFFR Plant Oxygen Group meeting on reactive oxygen and nitrogen species
Ghent, Belgium
Email: pog2007@psb.ugent.be
Web: http://www.pog2007.be

November 7–9, 2007
Third International Aphanomyces Workshop on Legumes
Rennes, France
Email: Asma.Allee@rennes.inra.fr
Web: http://www.grainlegumes.com/default.asp?id_biblio=453

November 12–16, 2007
Lisbon-2007
Dissemination Conference of GLIP and other legume-related activities
6th European Conference on Grain Legumes
Lisbon, Portugal
Email: aep@prolea.com

September 14–18, 2008
12th International Lupin Conference
Freemantle, Western Australia
Email: conference @lupins.org
Web: http://www.lupins.org



International workshop on faba bean breeding and agronomy

Córdoba, October 2006
Junta de Andalucia (Ed.)
2006, English
170 x 240 mm, 222 pages
ISBN 84-8474-195-8

This proceedings contains 77 articles based on talks presented at the International Workshop on Faba Bean Breeding and Agronomy, which took place in Córdoba (Spain) on 25–27 October, 2006. This workshop was a forum for assessing the 'state of the art' on faba bean production, for identifying research issues, for establishing research priorities and for promoting collaborative research among international scientists and industry. It centred around six sessions: 'Seed quality', 'Agronomy and breeding', 'Resistance breeding, Biotic and abiotic stresses', 'The potential of biotechnologies for genetic improvement' 'Genetic resources' and 'GL-TTP, Grain-Legume Technology Transfer Platform'.

Price: *€18 (outside Europe €20)*
Order: *Online at www.grainlegumes.com AEP publishing online>Subscriptions and ordering.*

RESEARCH

PhD thesis

Control of broomrape and rust in faba bean

Control de jopo y roya en habas

by Maria del Mar Rojas*

The purpose of this thesis was to identify and characterise sources of resistance to *Uromyces viciae-fabae* and *Orobanche crenata* in *Vicia faba* and to monitor virulence in pathogen populations. Resistance to broomrape and rust was searched in a collection of 500 accessions of *V. faba* under field conditions. Resistance of the most promising accessions was further characterised in pot and *in vitro* experiments.

Hypersensitive and incomplete resistance not based on hypersensitivity (Partial Resistance) were identified against rust. Components of resistance were characterised macro- and microscopically. Hypersensitive resistance was found to be due to cellular lignification whereas Partial Resistance was due to reinforcement of hot cell walls by callose deposition. Systemic acquired resistance was induced by exogenous application of benzothiadiazole (BTH) and salicylic acid (SA) causing a reduction in infection frequency in non treated leaves, which implies the systemic translocation of the induction signal.

Using a new method for testing rust resistance in detached leaves of faba bean, twenty-seven isolates of *Uromyces viciae-fabae* from various regions of Spain and Portugal were grouped in fifteen races.

Varying levels of incomplete resistance against *O. crenata* were identified with different mechanisms of resistance being operative: 1) low induction of germination; 2) host tissue darkening at the infection site due to accumulation of unidentified material secreted at the host–parasite interface and 3) reduced establishment of tubercles. Differences in aggressiveness were identified among *O. crenata* populations. In an attempt to design an integrated control package, several strategies of control were combined: delayed sowing dates, resistant lines and chemical control. When genetic resistance is not available, a delay in sowing of a few weeks is a compromise whereby a decrease in crop biomass is compensated for by the reduction in the infection. ■

*PhD thesis June 2006, Genetics Department, University of Córdoba, Spain. (b32marom@uco.es)

Bioactivity of legume components

Bio-fonctionalités des composants de légumineuses

by Marina CARBONARO*

Legumes are recognised to contain not only nutrients but also functional compounds, that may provide a health benefit beyond basic nutrition. However, research needs to be focused on bioavailability of micronutrients and bioefficacy of non-nutrient compounds to increase the potential of legumes as functional foods and confirm their role in health promotion and disease prevention.

About legume benefits

Besides being an excellent source of protein, legumes are rich in minerals and trace elements (magnesium, potassium, calcium, iron, zinc, copper and manganese). As beans are good sources of magnesium and potassium, they may decrease the risk of cardiovascular disease by helping to lower blood pressure. Legumes contain several B-vitamins. They have low levels of total and saturated fats and are cholesterol-free.

Beans, especially *Phaseolus* spp. L., are a major source of soluble fibre (Table 1), and it is this fibre fraction that helps to lower cholesterol levels and may reduce the risk of heart disease. In addition, soluble fibre helps to regulate blood glucose levels. As they have a low glycaemic index (a measure of the rise in blood glucose after a food is consumed), legumes are useful in the diets of diabetics.

Some evidence also indicates a protective effect of legume fibre on the risk of development of colon cancer.

Beans contain a number of non-nutrient physiologically active compounds (phytochemicals), including simple phenolics, especially flavonoids (phytoestrogens and catechins), polyphenols (tannins), phytates, saponins, alkaloids and sterols. Many of these compounds have been reported to be able to reduce the growth of different types of cancer cells and to lower cholesterol levels.

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Table 1. Content in major bioactive compounds of dry legumes (% dry weight basis).

Legume species	Phytic acid	Polyphenols*	Tannins**	α-Galactosides	Dietary fibre		
					Total	Soluble	Insoluble
Common bean							
white varieties	1.0	0.3	nd	3.1	18.5	2.3	16.2
brown varieties	1.1	1.0	0.5	3.0	18.4	2.3	16.1
Faba bean	1.0	0.8	0.5	2.9	21.1	1.6	19.5
Lentil	0.6	0.8	0.1	3.5	14.7	1.2	13.5
Chickpea	0.5	0.5	nd	3.8	14.0	1.2	12.8
Pea	0.9	0.2	0.1	5.9	12.0	1.1	10.9
Soyabean	1.0	0.4	0.1	4.0	11.9	0.9	11.0

*Tannic acid equivalents; **catechin equivalents; nd = not determined.

Several research findings have shed light on the real risk of adverse health effects from the so-called 'antinutritional factors' present in the seed: such risk has been limited mainly to the high content of heat-stable (non-protein) compounds (such as tannins and phytic acid), and to the well-known hazard of specific compounds for susceptible subjects (i.e. vicine and convicine for people affected by favism).

Plant breeding methods have the potential to change legume seed composition so that specific antinutritional factors are reduced. However, the use of processing procedures, such as thermal treatments, fermentation, germination and soaking, that are effective in reducing antinutrient levels remains an important strategy.

Trace element bioavailability

Legumes are good sources of trace elements, especially iron, zinc, copper and manganese. It has been recognised that some trace elements, especially iron, zinc and copper have a role in health besides their established nutritional function: maintaining gastrointestinal mucosal integrity and improving immune response to infections are two such examples.

Trace elements of plant origin, however, are often poorly available. In legume seeds, iron is present in the non-heme form, which is far more sensitive to enhancers and inhibitors of diet origin than heme iron. Amino acids (mostly cysteine), ascorbic acid, citric acid, and fructose enhance iron absorption, whereas phytate, polyphenols, oxalate and even calcium are inhibitors (7). Similarly, amino acids such as histidine and cysteine are promoters of zinc absorption; only phytate has been demonstrated to be a strong inhibitor of zinc bioavailability, but other known inhibitors are oxalate, fibre, EDTA, and polyphenols (especially tannins). The latter are inhibitors of copper absorption, too.

Trace element bioavailability can be improved by processing, such as germination and fermentation, that increase the activity of endogenous phytases and polyphenol-degrading enzymes. More research is needed to establish the effect of cooking on trace element bioavailability, taking into account that indirect effects on mineral bioavailability may result from modifications in protein solubility and digestibility (1, 3).

The planning of strategies for improving bioavailability will benefit from increasing knowledge of the chemical form of trace elements in plant foods and their speciation during processing and gastrointestinal digestion.

The prebiotic effect

Because humans lack the enzymes capable of digesting the raffinose-like sugars in beans, bacterial fermentation in the colon may cause intestinal discomfort. On the other hand, non-digestible α-galactosides (like raffinose) have recently been hypothesised to have prebiotic properties, similar to those ascribed to inulin and other fructooligosaccharides of cereals. A prebiotic is a non-digestible food ingredient that affects the host beneficially by selectively stimulating the growth of helpful commensal bacteria in the colon.

Some oligosaccharides have functional effects, such as improvement of glucose control and modulation of the metabolism of lipids, that are similar to those of soluble dietary fibre. Moreover, possible enhancing effects of non-digestible carbohydrate on mineral (calcium, magnesium, iron) absorption has been reported (8).

Prebiotic properties of non-digestible oligosaccharides contained in legume seeds (raffinose, stachyose, verbascose) need to be assessed in further studies.

How bioactive are phenolics?

Phenolic compounds, including their major subcategory, flavonoids, have been studied extensively in legumes. Both highly polymerised polyphenols, that is tannins (M_r 500-5,000), and low molecular weight phenolics (phenolic acids, flavonoids) have been found to be present (0.01-4.0 g/100 g of dry weight). Low molecular weight phenolics of legumes are predominantly of flavonoid origin, although the concentration varies widely among the different legume species.

Oligomeric proanthocyanidins (2-10 catechin units), compounds with a wide range of pharmacological activity, including protection against collagen destruction, antimicrobial and ulcer activity, have been found recently in significant amounts in the testa of lentil seeds (*Lens culinaris* L.) and in broad beans (*Vicia faba* L.) (0.16 g/100 g).

Bioavailability assessment is of key importance to the bioactivity claimed for most of the legume phenolics (6). Gallic acid and catechin are well-absorbed and the soy isoflavones (phytoestrogens), genistein and daidzein, appear to be sufficiently bioavailable to humans to act *in vivo*. However, contrasting data on their potential in preventing hormone-dependent cancers (for example, breast and prostate) have been provided.

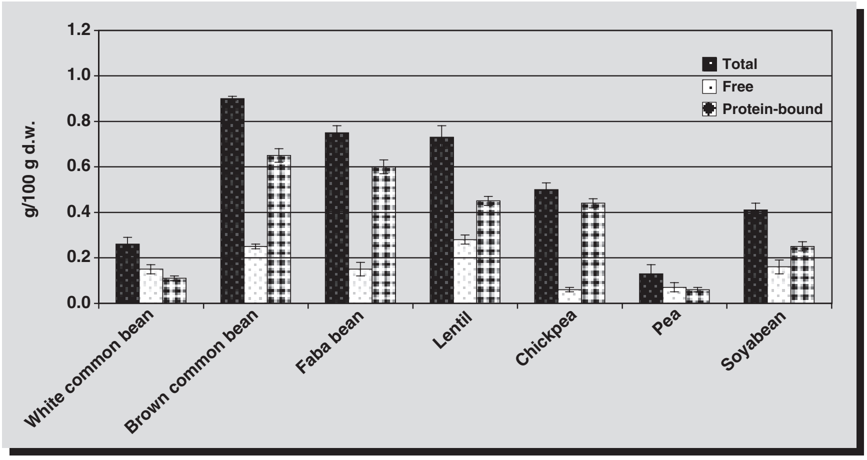

Figure 1. Total, free and protein-bound polyphenols in different legume species (M. Carbonaro, unpublished results).

Not enough data have been collected hitherto on the absorption and bioefficacy of the other flavonoids from legumes. The degree of polymerisation, galloylation and glycosylation also affects the antioxidant properties of catechins and proanthocyanidins. Their absorption through the gut barrier is probably limited to the molecules with a low degree of polymerisation and to metabolites (partially unknown) formed by the colonic microflora. Moreover, most polyphenols have a high affinity for proteins. Interaction with proteins has been reported to impair bioavailability of phenolics (catechin, tannic acid) in the small intestine (2). A significant number of legume phenolics have been found to be bound to proteins in the seed (Figure 1).

It appears that further studies of the bioavailability of phenolic non-nutrient compounds of legumes and the related influencing factors are still required. The possibility of systemic effects or local effects in the gut also needs to be ascertained.

Legume proteins are bioactive

Legume seed proteins, notably those from soyabean, have been demonstrated to exert cholesterol-reducing properties, thus representing powerful bioactive components (4). Moreover, bioactive peptides from soy digestion have been found to exert activity on the immune system and on the gastrointestinal tract.

Recently, lupin proteins have also been shown to present similar properties to those of soyabean in relation to cholesterolaemia, thus representing an alternative to soy proteins in Western Europe. Evidence of the possible use of a protein from lupin (conglutin γ) in the control of glycaemia has also been presented (5).

Phaseolus vulgaris L. contains a proteinaceous inhibitor of alpha-amylase, named phaseolamin, which was first discovered in 1975, and has attracted much interest in recent years because of its ability to slow down starch digestion.

Recent research findings have highlighted an increasing number of health benefits from legumes and considerable other research is being performed on legume bioactivities.

Although legumes are certainly rich in compounds that may potentially protect from the risk of cancers and from cardiovascular disease, the results of epidemiological studies do not yet provide any conclusive conclusion regarding these points. However, there is already sufficient scientific evidence to recommend increasing consumption of legumes from different species rich in bioactive compounds to improve health and well-being. ■

(1) Carbonaro, M. *et al.* (1997). J. Agric. Food Chem. **45**, 3387–3394.

(2) Carbonaro, M. *et al.* (2001). Eur. J. Nutr. **40**, 84–90.

(3) Carbonaro, M. *et al.* (2005). J. Sci. Food Agric. **85**, 65–72.

(4) Food and Drug Administration (FDA) (1999). Final rule. Federal Register 64, 57699–57733.

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Faba beans

La féverole

(All photos: A. Mauffret, UNIP, Paris, France)

Field of faba beans (main picture), pods and seeds (in insert).
Champ de féveroles (photo principale), gousses et graines (en médaillon).

Faba beans (*Vicia faba* var. *minor, equina* or *major*) are both an excellent source of protein and a valuable break crop, and they are produced mainly in China, Australia, UK and France. Faba beans are the second most important grain legume after peas in the EU. Between 2000 and 2005 the area of faba beans grown in the EU increased by 64% to 445,000 ha, primarily in France, Spain and the UK – which still produces more than half the EU production. The demand for faba beans is for human consumption, especially in the Middle East and the Maghreb, and for animal feed in Europe.

To increase and stabilise the supply of good quality faba beans, improved varieties need to be developed and problems occurring during cultivation and storage need to be controlled. In the first two articles of this special report we look at some of the recent recommendations for weed management and bruchid control in faba beans. Then we outline the market opportunities for exporting quality seed for human consumption, very relevant for the coming campaign. The second part of this special report reviews the progress in genetic enhancement being made in different disciplines: the status of germplasm collections and ongoing breeding programmes, improvement of seed quality with low contents of tannins and vicine–convicine, work on improved frost and drought tolerance and towards better resistance to the main diseases of faba bean using valuable identified markers. ■

*La féverole (*Vicia faba*) est à la fois une excellente source de protéine et une tête de rotation intéressante pour les systèmes agraires. La fève (*Vicia faba *var.* major*) et la féverole (*V. faba *var.* minor *and* equina*) sont surtout produites en Chine, Australie, Angleterre et France. Il s'agit du second protéagineux dans l'Union Européenne en terme de surfaces avec 445,000 ha en 2005 suite à une augmentation de 64% entre 2000 et 2005 surtout en France, en Espagne et au Royaume Uni, ce dernier produisant plus de la moitié de la production communautaire.*

Les débouchés sont l'alimentation humaine au Moyen Orient et au Maghreb, et l'alimentation animale en Europe.

Les améliorations pour augmenter et stabiliser l'offre en féverole de qualité passent par des variétés améliorées et la maîtrise des problèmes rencontrés au cours de la culture et du stockage. Les deux premiers articles de ce dossier résument les recommandations en terme de contrôle des adventices et de la lutte contre les bruches chez la féverole. Puis sont soulignées les opportunités de marchés pour l'export en consommation humaine, très intéressantes pour la campagne à venir. La deuxième partie du dossier fait un tour d'horizon sur les avancées en amélioration génétique dans les différents domaines: état des collections de ressources génétiques et programmes de sélection en cours, amélioration de la qualité avec des graines à faibles teneurs en tannins et vicine–convivine, recherches pour améliorer la résistance à la sécheresse et au gel, résistances aux maladies et aux parasites avec identification de marqueurs pertinents. ■

Weed control in faba beans (*Vicia faba*)

Contrôler les mauvaises herbes dans les féveroles (Nicia faba)

by Delphine BOUTTET* and Catherine VACHER*

The interest of French farmers in field beans, especially spring beans, has led to a need to widen the choice of herbicides and range of tank mixes to use on the crop. Currently, only pre-emergence herbicides are registered. These give good control of a wide range of annual broad-leaved weeds until the crop is large enough to suppress any further weeds that emerge. However, an additional post-emergence treatment may sometimes be necessary, especially for winter beans which are still weak and very susceptible to the rapid germination of spring weeds such as *Polygonum* spp. and *Galium aparine.* In spring crops, the effectiveness of residual herbicides is reduced when the weather is dry after application, and so a remedial application may be required.

For post-emergence weed control, herbicides such as bentazone, currently used on peas, are not selective for field beans. Therefore, mechanical weed control seems to be an interesting alternative solution.

Post-emergence broad-leaved weed control needs care

Results from field trials carried out by Arvalis and its partners in recent years show that contact-acting foliar applied herbicides such as bentazone or pendimethalin are risky and cannot therefore be recommended. It is difficult to predict if herbicide applications will cause visible effects on the crop and/or a decrease in yield (Table 1).

To avoid weed control problems in field beans it is important:

- To maintain fields of beans with a low density of weeds;
- To choose pre-emergence herbicides or tank mixes on the basis of the weed spectrum anticipated;
- Not to reduce the application rate;
- To ensure that at the time of sowing the climatic conditions are likely to be suitable for herbicides to be applied in the days between sowing and crop emergence.

On the other hand, the control of grass weeds is easy; a large range of post-emergence graminicides gives good control of species including blackgrass, ryegrass and wild-oats. On farms with resistant strains of grass weeds, good results can be obtained with residual herbicides such as propyzamide or carbetamide.

With a late harvest following a wet season, the persistence of leaf and succulent stem in field beans can make harvesting difficult even though the pods may be ripe, and there is frequently a build-up of weeds such as *Chenopodium album* and *Solanum nigrum*. Desiccation with diquat is possible to make the harvest easier.

Table 1. Chemical weed control strategy of winter beans: visual injury and yield.

		Trial in Bourges (centre of France)		Trial in Condom (south of France)	
	Active ingredient (Herbicide rate/ha)	Injury (mean of 3 plots)	Yield (t/ha) (mean of 4 plots)	Injury (mean of 3 plots)	Yield (t/ha) (mean of 3 plots)
Pre-emergence	Aclonifen (3 l/ha)	0	2.1 b	0	5.87 a
Pre-emergence then post-emergence at the end of winter	Aclonifen (3 l/ha) then bentazone* (1 kg/ha)	0	2.31 a	2.8	5.47 ab
	Aclonifen (3 l/ha) then pendimethalin* (2 l/ha)	0	2.22 ab	0.3	5.36 b
	Aclonifen (3 l /ha) then aclonifen + pendimethalin* (0.5 l+1 l)	0	2.19 ab	1.8	5.21 b
	Aclonifen (3 l/ha) then bentazone* + pendimethalin* (0.6 kg + 1 l/ha)	0	2.26 ab	0.8	5.66 ab
	E T R		0.908		1.9
	LSD (0.05)		0.043 S		0.006 S

Source: FNAMS and ARVALIS – Institut du végétal (2005).
*Not registered. Scale for visual injury: 0: no visual injury to 10: crop completely destroyed and: 3 critical limit.

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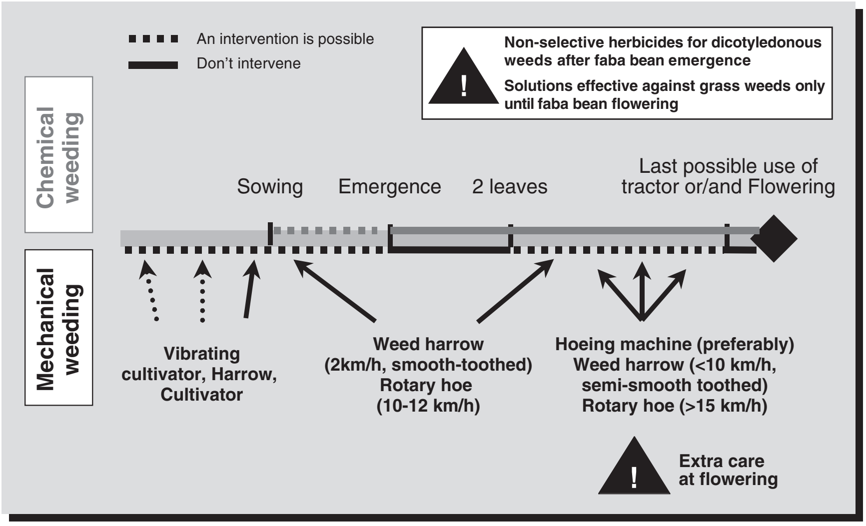

Figure 1. Field beans (*Vicia faba*): periods of chemical and mechanical weeding.

Mixed weeding works well for field beans

Field beans are favoured in organic agriculture because they are suited to mechanical weeding (Figure 1). Based on the techniques used in organic agriculture, it appears possible to combine a pre-emergence chemical treatment with one or two post–emergence mechanical weedings, especially hoeing. However, this requires sowing in drills and a between-row spacing of at least 30 cm. Initial trials of mixed weeding (selective pre-emergence herbicide applied over the whole surface followed by inter-row mechanical weeding) in partnership with others organisations are encouraging, and this is a promising strategy for post-emergence weed control. ■

Controlling bruchids in the field and in silos

Maîtriser les bruches de féveroles aux champs et dans les silos

by Véronique BIARNÈS* and Alexandre HÉMET**

Controlling bruchids is important if faba beans are to meet the visual requirements for seed quality and satisfy the human consumption market. Egypt is one of the most important faba bean-consuming countries that demands quality criteria more severe than those of the animal feed market, including a rate of bruchid-damaged and/or spotted seeds lower than 2%.

Field control at the right time

Bruchids are prevalent in the fields throughout the faba bean flowering period because they feed on the flower pollen of this crop. They can be injurious when the females lay their eggs on the first pods. The sensitive stage begins when the faba bean plant bears young pods at the first reproductive node and ends at the end of the flowering period when bruchids go away (1, 2, 3).

Chemical treatments may be applied to control adult bruchids if the conditions are suitable: the sensitive stage (young pods) has been reached and the maximum temperatures are above 20 °C, since high temperatures favour bruchid activity (6).

According to what is known about bruchid biology, Arvalis - Institut du végétal and UNIP have developed decision support software to activate treatment on relevant dates (4, 5) (Figure 1). The sensitive stages (young pods on the lowest part of the plant and the end of flowering) can be predicted from meteorological data provided for a 5-day period by METEO France for a given sown variety, at a given sowing date, and in a given production area. The predicted meteorological data integrated in the decision support tool indicate whether the climate is favourable for bruchid activity

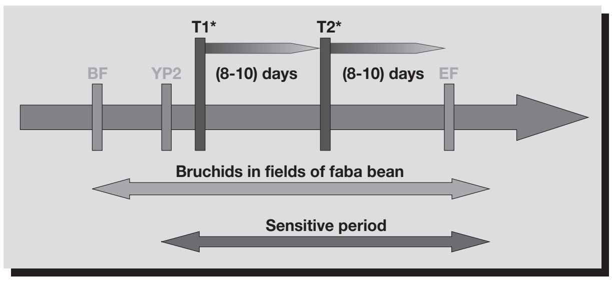

Figure 1: Basis of the decision making tool for controlling bruchids in faba beans.
T1: First insecticide treatment; T2: Second insecticide treatment.
*T1 or T2 are made only if maximum temperatures are above 20 °C during two consecutive days. It is necessary to wait 10 days after a treatment before making a second one because of the presence of product residues.
BF: Beginning of flowering YP2: Young pods of 2 cm long EF: End of flowering

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and whether or not it is necessary to activate chemical treatment. Then, the treatment advice is sent to cooperatives who relay the relevant information to faba bean producers.

The decision support tool[1] was used in 2006 by different farmers' cooperatives in the North of France. A survey indicates that good results were obtained when treatments were applied at the dates indicated by the tool. Seeds damaged by bruchids were under 2% and were sold in the food export market to Egypt.

The choice of chemical control product is important for good results. Products made with endosulphan, efficient but strong, will be forbidden from the 31 May 2007. However, in field and laboratory experiments in 2006, Arvalis - Institut du végétal, UNIP and FNAMS, have identified a new product which gives satisfactory results and which is compatible with directives on bees.

Control in silos to prevent the next bruchid generation

The fumigation of silos with aluminium phosphide (phosphine) is the only method which ensures that no living insects are present in the harvested seeds. It can reduce bruchid populations at the next harvest very significantly if used at a production area scale and applied early enough. This method does not affect the rate of seeds damaged by bruchids but kills all the adult insects and larvae present in seeds.

There are no residues with fumigation and it is relatively cheap. The product used is dangerous and must be manipulated by a specialist company and suitably-qualified staff. Silos must be airtight, and when security standards are respected there is no danger with this technique.

Therefore it is strongly recommended to complement the control of faba bean bruchids in fields with control in storage silos to reduce the pressure of bruchids over the growing season and harvest period. ■

(Photo A. Biddle, PGRO, UK)

Adult bruchid beetle infestation.

(1) Dupont, P. and Huignard, J. (1986). Recherches réalisées sur les conditions de contamination de la féverole par la bruche *Bruchus rufimanus* (coléoptère : bruchidae) en 1986. Compte-rendu Institut de biocenotique expérimentale des agrosystèmes – Université de Tours, 25 pp.

(2) Dupont, P. *et al.* (1988). Les conditions de contamination de la féverole (*Vicia faba* L.) par la bruche (*Bruchus rufimanus* Boh). Leur importance dans l'élaboration des méthodes de protection de la féverole. Compte-rendu Institut de biocenotique expérimentale des agrosystèmes – Université de Tours, 33 pp.

(3) Dupont, P. (1990). Contribution à l'étude des populations de la bruche de la féverole, *Bruchus rufimanus.* Analyse des relations spatio-temporelles entre la bruche et sa plante hôte. Thèse Université François Rabelais de Tours.

(4) Garrabos, P. (2006). Lutte raisonnée contre la bruche de la féverole. Mémoire de fin d'études Master de l'Université Paris-Sud XI Orsay, 25 pp.

(5) Bouttet D. *et al.* (2007) (in press). Féveroles : contre la bruche, intervenir au bon moment. Perspectives Agricoles n° **330**, 7–9.

(6) Laborde, S. *et al.* (1990). Les bruches dans les cultures de pois et de féverole : résultats 1988. Perspectives Agricoles n° **147**, 27–34.

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International workshop on faba bean breeding and agronomy, October 2006

It has been a long time since faba bean experts had the opportunity to get together and so the recent International workshop on faba bean breeding and agronomy organised on 25–27 October, 2006 at IFAPA, Córdoba (Spain) provided just such an opportunity: 60 participants came from all over the world.

Talks and posters for the different sessions (Seed quality, Agronomy and breeding, Resistance breeding: biotic and abiotic stresses, Biotechnologies for genetic improvement, Genetic resources, Technology transfer) allowed delegates to learn more about the on-going research on faba beans, as well as to exchange ideas and strengthen international collaboration in a friendly atmosphere and with Spanish hospitality.

Several topics are summarised in this special report and the Proceedings (see page 7) are also available from AEP (aep@prolea.com or http://ww.grainlegumes.com)

Further information: Ana María Torres (anam.torres.romero@juntadeandalucia.es)

IAWL 2007
Third International Aphanomyces Workshop on Legumes
7–9 November 2007, Rennes, FRANCE

First announcement and call for expression of interest

Following the 1st and 2nd International Aphanomyces Workshops held in 2002 in Rennes (France) and in 2003 in Prosser (WA, USA), the objective of this 3rd workshop is to report recent advances in the science of Aphanomyces in legumes and to compare what is known about the disease in different legumes species.

The workshop will be a forum aiming to facilitate exchanges between participants in order to i) create a favourable environment for information exchanges concerned with methodology and strategy, ii) develop or promote integrative collaborative networks that combine different skills and iii) identify research issues and establish research priorities for integrated disease control strategies.

This event is being planned just before the Conference of GLIP (EU GRAIN LEGUMES Integrated Project) and other legume-related activities to be held in Lisbon (Portugal) from Monday 12 to Friday 16 November 2007.

Please submit your contribution or expression of interest as soon as possible to Asma.Allee@rennes.inra.fr

Further information at http://www.grainlegumes.com/default.asp?id_biblio=453

SPECIAL REPORT
FABA BEANS

An insufficient supply of faba beans for human consumption in 2006/07

Une offre insuffisante en féverole qualité alimentation humaine

by Jean-Paul LACAMPAGNE*

World faba bean production has two outlets: feed, primarily in Europe, and human consumption, particularly in the Middle-East, the Maghreb, South America and Asia. For 2006/07 Egypt, the major importing country, is facing a shortfall in its supply because production has decreased in the main exporting countries (France, Australia and the UK).

After China, Egypt is the second largest faba bean consumer in the world and, since 2000, has imported an average of 300,000 t per year for human consumption (Figure 1), Imports have followed an upward trend for 10 years, but production fluctuates between 300,000 and 400,000 t (Figure 2). In Egypt faba beans are consumed in various traditional food recipes: 'foul' (either cooked whole seeds or hulled seeds which are mashed with a mixture of olive oil and spices) and 'falafel' (rissoles of mashed cooked faba bean seeds mixed with chickpea flour and fried with oil). In the current season, Egypt must face a lack of available supplies.

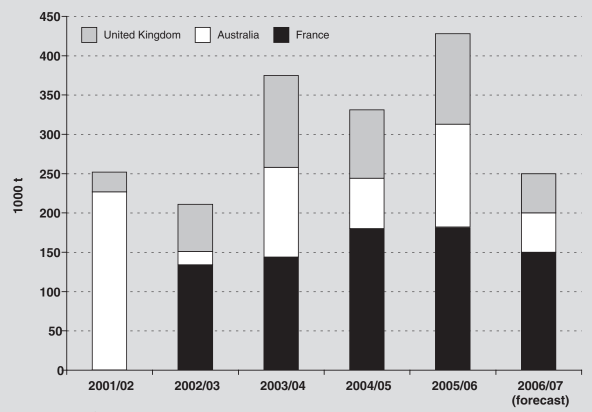
France has been Egypt's main supplier since 2002/03 with 182,000 t supplied in 2005/06. However, in 2006 overall French production fell to 320,000 t compared with 400,000 t in 2005 because of a decrease in the area cultivated to 78,000 ha compared with 102,000 ha in 2005. This decrease came after a continuous increase in area between 2000 and 2005.

Australian exports greatly reduced

In Australia, the faba bean harvest has been very irregular with low production in one out of two years over a five-year period, and the 2006 harvest decreased by severe drought and not exceeding 100,000 t from 153,000 ha compared with 329,000 t in 2005. Like France, Egypt is by far the main destination for Australian faba beans which are also exported in smaller tonnages to a multitude of other countries in the Middle-East and Asia. Australian exports to Egypt will not exceed 50,000 t in 2006/07 compared with 131,000 t in 2005/06. This is well below the 225,000 t exported to Egypt in 2001/02, but since then Australia has partly lost its share of the Egyptian market because of French competition.

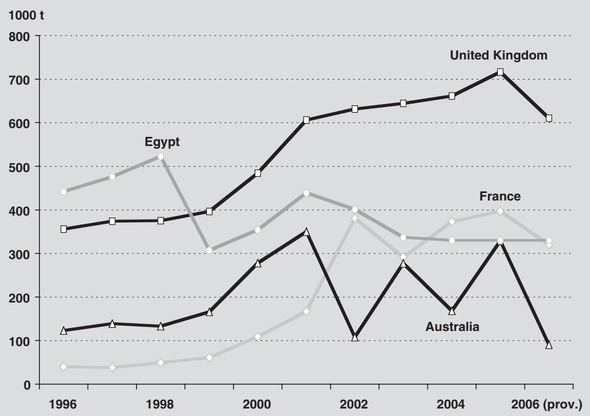
For 2006/07 the United Kingdom has only very low exporting potential (50,000 t maximum) for the human consumption outlet, because the harvest (about 600,000 t from 185,000 ha) has been of poor quality seed (caused by rain at the time of harvest and unusual bruchid damage). In contrast to France and Australia, UK exports to other EU countries (on average about 100,000 t per year to Italy and about 50,000 t or more to Spain) represent volumes more important than those to Egypt.

China is by far the world's most important broad bean/faba bean-producing country (2 Mt in 2004 according to FAO)



Sources: UNIP from French and English Customs, and ABARE.

Figure 1. Main imports of faba bean in Egypt.



Sources: UNIP from Eurostat, Abare and FAO (no availble data for Egypt for 2005 and 2006).

Figure 2. Production of faba bean in Egypt and in the main exporting countries.

*UNIP, Paris, France (j.lacampagne@prolea.com)

and was an important exporter until the 1990s (particularly to Egypt until 1996). Since then, it has consumed almost all its own production.

Elsewhere, in other countries of the EU, the production of faba bean is marginal and is intended for local consumption. In 2005 Italy produced 87,000 t on 49,000 ha, in 2006 Spain produced 49,000 t on 37,000 ha and Germany produced 46,000 t on 15,000 ha.

Strong rise in prices

In contrast to 2005/06 when prices fell because of abundant supplies in the main exporting countries, the prices of high quality faba beans for human consumption have risen sky high since the beginning of the 2006/07 season. This is mainly due to the lack of supplies but also to the overall increase in raw material prices (cereals, pea and others). At the beginning of December 2006 the prices on the French market reached €200/t in Rouen for the 2006 harvest. Rouen is the principal port of shipping, located in Normandy in north-west France, which is the main zone of production of French faba beans (Figure 3).

The Egyptians have already started to purchase the 2007 French faba bean harvest at high price levels (€180/t Rouen at the beginning of December). Indeed, they need to accumulate stocks at the beginning of 2007/08 because Ramadan, when large quantities of faba beans are consumed, begins on 13 September 2007, 11 days earlier than in 2006. French faba beans are preferred to English faba beans because they are harvested earlier, and the new Australian harvest will not arrive on the market until the end of 2007. ■

Figure 3. Prices of french faba beans.

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World production of faba beans

World production of faba beans (*Vicia faba*) is about 4 Mt (Figure 1). China is undoubtedly the world's major producer of faba beans but most of the production (about 1.8 Mt) is for home consumption. Australia, the countries of North and East Africa, and the EU are also producing faba beans. Australia, the United Kingdom and France are the main exporters of faba beans, primarily to the Middle East (Egypt) whose inhabitants are traditional consumers.

In Europe, faba beans are a traditional dry seed field crop and they have been used for decades both for food in the south of Europe and for cattle or pigeon feed in other EU countries. Faba beans are grown in almost all countries, except in the northern part of Europe where they mature too late. In the UK, Italy and Spain, most faba beans are sown in autumn, unlike France and Germany where they are sown in spring.

Faba bean has always been the second most cultivated grain legume in the EU after pea (28% of grain legume areas over the past 20 years) but in contrast to other grain legume species, its area has expanded in recent years (Figure 2). Between 2000 and 2005 the increase was about 175,000 ha (+64%). Faba bean areas (445,000 ha in 2005) are increasing primarily in France, Spain, and also in the UK, which still produces more than half of the European production.

In 2005, the production level of 1,379 Mt exceeded for the first time a level equivalent to half the European production of pea, which still remains the most important grain legume produced in the EU.

Source: AEP. http://www.grainlegumes.com

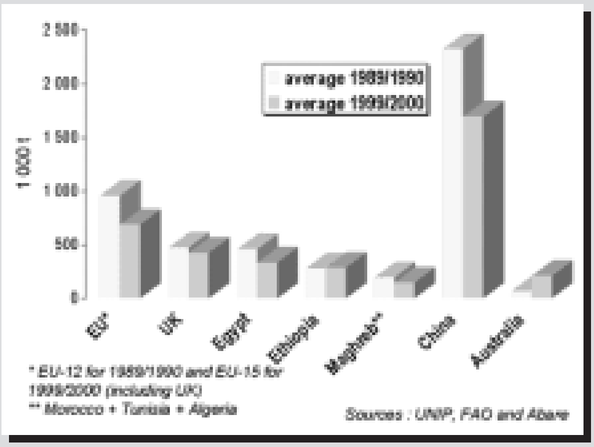

Figure 1. The main faba bean producing countries.

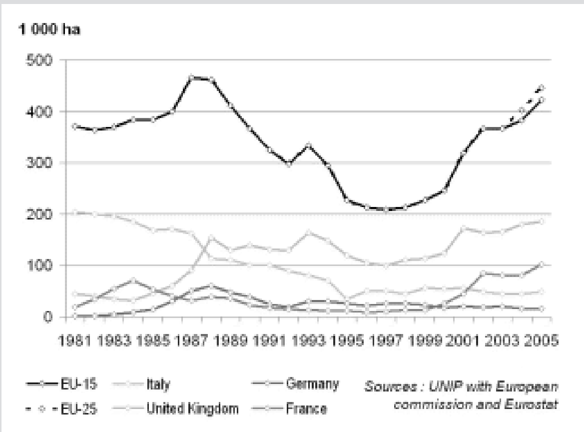

Figure 2. EU trends in areas of faba beans.

Low vicine–convicine and zero tannin 'FEVITA' faba beans

Fevita, des féveroles sans tannins et à basse teneur en vicine–convicine

by Paolo Arese*, Gérard Duc**, Michel Lessire***, Pascal Marget**

Seeds of faba bean (*Vicia faba*) have been shown to be good sources of protein for animal or human nutrition. However tannins, vicine and convicine are components of faba bean seed that according to consumers may sometimes reduce their nutritional value.

Positive effects of reducing tannin, vicine, convicine on poultry performance

There is good agreement in the literature showing that tannins which are polyphenolics contained in the seed coat (5–10 g/kg seed DM (3)) reduce protein digestibility in pigs and poultry (5). Two recessive genes *zt1* and *zt2* that simultaneously determine a white flower character and a zero tannin content in the seed have been identified and used by breeders.

Vicine and convicine are glucopyranosides contained in the cotyledons of fresh and mature seeds of faba beans. In conventional cultivars, the vicine + convicine (V+C) content ranges from 6 to 14 g/kg. The gene *vc*- which divides the content of V+C by 10 to 20 has been discovered (3). It has been demonstrated that performances of adult cockerels and broiler chickens are improved by the use of double-low genotypes (low tannin - low V+C)(4, 6, 8).

In the EUFABA project (2004–2006) three trials were conducted in order to quantify the impact of vicine (V) and convicine (C) on the performance of laying hens. In the first trial, dehulled seeds of a conventional cultivar (Marcel) were compared with dehulled seeds of a low vicine–convicine cultivar (Divine). Dehulling aimed at removing the tannin effects. Fababean was introduced in the diet at a rate of 20% and different proportions of Marcel/Divine in mixtures (pure, 1/3-2/3, 2/3-1/3) were tested. The egg weight responded significantly to the diets and was negatively correlated with the content of V+C. In a second trial, two isogenic zero-tanin faba beans, with or without the *vc*- gene were compared. Incorporated at a rate of 25% in the diet, the low V+C genotype resulted in a significant increase in egg weight. In the third trial, the same genotypes were used as in the 2nd experiment and a kinetic study demonstrated that the depressive effect of V+C on egg weight was significant as soon as one week after giving the diets containing vicine-convicine rich fababean seeds. The red blood cells of these animals are currently under analysis to evaluate whether they show a reaction similar to that found in the favism-suceptible humans.

Favism in G6PD-deficient human subjects

Favism is an acute hemolysis caused by the ingestion of faba beans, but it occurs only in glucose-6-phosphate dehydrogenase (G6PD)-deficient human individuals ((1) and (2) for reviews). Hemolysis means that red blood cells (RBC) are destroyed within a few hours after faba bean ingestion. A small portion of destroyed RBC breaks down (lysis) in the blood, but by far the largest proportion of disappearing RBC is removed by specialised cells called macrophages. Favism may cause rapid destruction of up to 80% of circulating RBC and is potentially fatal. Usually favism is benign and does not require blood transfusion. There is no cure for favism, except prompt RBC transfusion. Similar hemolytic crisis is also caused by oxidants (oxidant drugs, such as primaquine, sulfonamides; oxidant chemicals ingested by mistake). Vitamin C is dangerous only if consummed in large quantities (>10–20 grams). There are many G6PD variants with low activity. The Mediterranean and the Canton (frequent in China) variants have very low activity (1–3% of normal activity) and are more at risk of favism. The African variant A- (20% of normal activity) is not associated with favism. The association of faba bean consumption and G6PD deficiency is frequent in the Mediterranean area, the Middle East (Turkey, Iran and Iraq) and the Far East (Taiwan and southern China). In Italy, favism is restricted to Sardinia and Sicily. Severe favism mostly affects male children between 2 and 5 years of age (67–75% of the cases of severe favism), as G6PD deficiency is X-linked and homozygous females are rare. On average, less than 20% of G6PD-deficient individuals experience favism in their life, in spite of frequent faba bean consumption. Favism is usually due to raw fresh seeds (>96% of all cases), or to fresh seeds incompletely cooked (brief boiling or frying). Frozen fresh faba beans are as dangerous as fresh beans. Toxicity is due to the presence in faba beans of two powerful redox

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pyrimidine derivatives (divicine, D; and isouramil, I), present in their inactive beta-glucosidic form (vicine, V and convicine, C). D/I are therefore generally considered to be the main causative agents of favism in G6PD-deficient subjects. Activation of V/C to D/I is performed by the enzyme beta-glucosidase which is absent in humans but is present in fresh faba beans. This enzyme is inactivated by cooking or seed drying. The toxic faba bean compounds are absorbed rapidly and react with RBC by oxidizing glutathione (GSH). GSH is a very important intracellular reductant that keeps in the reduced form a large number of thiol groups localised in enzymes and other proteins. When GSH is lowered, RBCs are altered in several functions: they become rigid, certain critical membrane proteins are aggregated (for example band 3), important enzymes are inactivated. As a consequence, RBC are transformed into senescent RBC and are recognised as non-self cells by the macrophages and rapidly removed. In normal RBC, oxidised GSH is rapidly regenerated by a metabolic cycle of which G6PD is an essential component. In G6PD-deficient RBC, regeneration of GSH is extremely slow. Therefore, D and I from ingested faba bean cause an almost irreversible oxidation of GSH and, as a consequence, a number of changes that finally provoke rapid and massive removal of large numbers of RBC by macrophages. As it is a well-accepted fact that D and I, obligatory components of all faba bean lines now commercially available, are the causal agents of favism, it is evident that faba bean strains with low or almost absent D and I content will not elicit favism. Preliminary experiments on a G6PD-normal volunteer have shown that ingestion of 500 g of commercially available faba bean elicited a 30–40% drop in the GSH level within three hours from ingestion. The GSH level was regenerated quickly. Following approval by the Ethical Committee, experiments are planned to test in parallel the effect of faba bean with normal or low D/I on RBC GSH levels and other biochemical parameters. Most likely, low D/I faba beans will elicit no changes in GSH and other RBC parameters and will not provoke hemolysis. The next steps will be to perform the same experiments with low D/I faba bean lines and G6PD-deficient volunteers. These last experiments are likely to provide the proof that low D/I faba bean lines are perfectly safe for consumption even by severely G6PD-deficient subjects.

'FEVITA' types offer a common quality for different uses

Data from poultry trials suggest that a reduction of tannin and vicine–convicine have additive beneficial effects which encourage breeders to select for a double low trait. The trade name FEVITA ® has been given to this type of quality which is the result of the combination of the *vc-* gene with the *zt1* or *zt2* gene[1]. This objective of breeding for FEVITA genotypes, should also provide added value to the faba bean crop in food markets with regard to the favism concern. Breeders will be helped in this direction by new molecular markers that were developed in the EUFABA project by Guttierez *et al.* (8). Together with this breeding objective, special care has to be given to traits of seed colour and seed shape, especially important in food markets. ■

Acknowledgements: The European Union for financial support within the framework of the EUFABA project 'Faba bean breeding for sustainable agriculture' QLRT-2001-02307 (FP5 - SCP).

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[1]The trade name FEVITA has been registered by UNIP in several countries (France, United Kingdom, Spain, Italy, Australia, Egypt and Canada).

FEVITA ® – a quality trade name for faba beans

The trade name **FEVITA** ® has been given to improved quality faba beans whose seeds have both reduced contents of tannins and vicine–convicine. This trade name FEVITA has been registered by UNIP in several countries. DISCO, the first FEVITA cultivar, was registered in France in 2003 and several current breeding programmes include the FEVITA quality criteria in their screening since there is genetic variability and markers are being developed.

The FEVITA seed quality is due to the simultaneaous presence of two genes, the *vc-* gene which reduces the contents of vicine and convicine and the *zt-* gene (*zt1* or *zt2*) which reduces the tannin content.

This FEVITA type of quality results in improved nutritional value compared with conventional faba beans when introduced in diets for monogastrics such as poultry. The economic value[1] of FEVITA types compared with conventional faba bean varieties can be 5% higher, especially in poultry formulas[2]. This value is also higher than for peas, due to FEVITA composition and nutritional values. It has also been demonstrated that faba beans are a good substitute for soyabeans in some broiler formulas.

Since the vicine–convicine content can cause favism (a haemolytic crisis) in some humans, their very low levels in FEVITA types may reduce or prevent this risk.

The quality improvement of FEVITA types will provide added value to the faba bean crop in different markets, especially with a well organised integrated chain to separate the different types of faba beans produced worldwide.

[1]Economic value in France is 'the interested price' which means the price/value of the raw material starting to be incorporated in the animal feed formula.

[2]From 2% to 8% increase in price/value for simulated finishing feed formula for chicken broilers reared up to 56 days (in a given price context in France) with Fevita faba beans compared with conventional faba beans.

More information at www.grainlegumes.com

Genetic resources of faba bean worldwide[1]

Ressources génétiques de la fève-féverole au niveau mondial

by Mohammed SADIKI*, Gérard DUC** and Bonnie J. FURMAN***

Faba bean is a major feed and food legume. In developed countries breeders are aiming to increase the stability and quality of seed yield for animal feed, but in many developing countries increasing production potential is still the main objective. Improved varieties have been released from direct selection within local populations, but genetic resources are increasingly exploited as sources of characters in crosses.

As one of the earliest domesticated crops, natural and human selection have resulted in local populations and ecotypes well adapted to the environmental conditions of a huge range of latitudes and altitudes and expressing enormous genetic diversity. Native to the Near East, faba bean is widely distributed in the Mediterranean, the Nile Valley, Ethiopia, Central Asia, and northern Europe as well as in South America, especially the Andean region and North America, especially Canada.

To avoid genetic erosion and provide breeders and scientists with potentially useful genes, this rich diversity must be conserved *ex situ* in genebanks and *in situ* in original habitats.

There are several collections of genetic resources of faba beans in the world (Table 1) and the largest one is housed at the International Center for Agricultural Research in the Dry Areas (ICARDA) in Aleppo, Syria. This institution has a global mandate for faba bean improvement. The ICARDA collection is maintained in two types. Original germplasm accessions are maintained as heterogeneous composite bulks as the ICARDA International Legume Bean (ILB) collection. This collection contains approximately 6000 accessions from 69 countries. A Faba Bean Pure Line (BPL) collection has been derived from the ILB collection by the creation of single plant progeny rows and subsequent reselection. This collection contains approximately 3000 accessions. Most of these germplasm accessions have been characterised for various morphological and agronomic traits.

Through its regular activity and also a recent survey, the ECP/GR (European Cooperative Programme for Plant Genetic Resources) Grain Legumes Working Group has identified in Europe at least 17,000 accessions contained in 25 collections (Table1), major ones resulting from national efforts in France, Germany, Italy, Poland, Spain and Russia.

To date, germplasm with resistance to chocolate spot, ascochyta blight, rust, stem nematode, bean leaf roll virus (BLRV), bean yellow mosaic virus (BYMV) and *Orobanche crenata* has been developed. There is also genetic variability for seed size and seed composition (protein content, tannins, vicine, convicine). Some faba bean cultivars are reported to exhibit tolerance to high pH, insects, low pH, slope, and viruses, but variability is still scarce for some important agronomic traits.

Collections of the wild species are very limited compared with collections of natural diversity. In addition, several obstacles still hinder the utilisation by breeders of wild relatives of faba beans for possible sources of interesting traits. These are barriers to hybridisation between species, insufficient data on characters of interest, and the problem of undesirable characters being transferred to the cultivated species following crosses.

Recent work has been carried out to create a composite collection of faba bean in collaboration between ICARDA, INRA, Dijon, and IAS in Córdoba, Spain. From these three collections, we have identified a composite germplasm set of 1000 accessions. This composite set will be characterised, utilising molecular markers

Table 1. ***Vicia faba ex situ*** **collections worldwide.**

Country	Institute	Number of accessions
WORLD		
Syria	ICARDA, Aleppo	9000
China	CAAS, Beijing	4200
Australia	DPI, Victoria, Australia	2445
Morocco	INRA, Rabat	1715
Ethiopia	PGRC, Addis Ababa	1118
USA	USDA, Pullman, Washington	575
Canada	PGRC, Canada	231
India	Unknown	–
Iran	Unknown	–
Pakistan	Unknown	–
Afghanistan	Unknown	–
Iraq	Unknown	–
EUROPE		
Austria	Gene Bank, OeirasBFL, Vienne	110
Bulgaria	IIPGR, Plovdiv	75
Cyprus	ARI, Cyprus	100
Czech Republic	Agritec, Sumperk	330
Czech republic	RICP, Prague	46
France	INRA, Dijon	2232
Germany	Gene bank, Braunschweig, Gatersleben	> 2000
UK	NIAB, Cambridge	180
UK	JIC, Norwich	270
Greece	Gene bank, Tessaloniki	150
Hungary	Institute for Agrobotany, Tapioszelle	341
Israel	Gene bank, Dagan	343
Italy	Gene bank, Bari	2279
Netherlands	DLO, Wageningen	726
Poland	PBAI, Radzikow	856
Poland	IPG-PAS Poznan	1258
Portugal	Gene bank, Oeiras	66
Russia	VIR, St Petersburg	1881
Spain	INIA, Madrid	1236
Spain	Germplasm, Zaragoza	43
Spain	INIA, Cordoba	1856
Sweden	Nordi Gene Bank, Alnarp	40
Tchekia	AGRITEC, Sumperk	341
Turkey	ETAE, Izmir	347
Ukraine	YIPB, Kharkov	114
EUROPE TOTAL	25 collections	> 17,000

Source: ECP/GR

More information from the Grain Legumes Working Group of the ECP/GR (European Cooperative Programme for Plant Genetic Resources at http://www.ecpgr.cgiar.org/Workgroups/grain_legumes/ grain_legumes.htm

Survey on conservation, management and regeneration of grain legume genetic resources: http://www.ecpgr.cgiar.org/Workgroups/grain_legumes/GLsurvey_ResultsAnalysis.pdf

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to determine its genetic structure, as part of the CGIAR's Generation Challenge Programme. This should help in the structuring of collections and the development of a core set to help breeding.

Combining *in situ* and *ex situ* conservation

On-farm conservation of faba bean diversity is an approach to maintain genetic diversity in the ecosystems where it has been generated. This raises issues of genetic diversity assessment in relation to geographic distribution and to farmers' perception of diversity. On-farm enhancement of local varieties and landraces through participatory breeding has yielded encouraging results. Ways of adding value to local farmers' varieties have been developed for faba bean as for other crops as a means of supporting farmers in managing their varieties. Linking this *in situ* conservation to *ex situ* conservation will provide important opportunities for regional and international cooperation in the future. ■

[1]This article is based on papers published in the proceedings, International workshop on faba bean breeding and agronomy (Córdoba, 25–27 October 2006), 185–187 (Ed. Junta de Andalucia), see page 7.

Faba bean breeding programmes

Les programmes de création variétale de fève-féverole

by Anne SCHNEIDER* and Frédéric MUEL**

Despite a difficult agricultural economic climate, faba bean breeding programmes remain active in the major producing regions, especially in China, Australia and Europe, but also in the North African countries, in Mexico, Bolivia and in the international centre ICARDA. In China, 30% of faba bean production is used as a green vegetable. The major use of the remaining production is dry seed, mainly for feed but also for food purposes (Middle East imports). Canada has recently initiated a breeding programme for faba bean to develop its production for the extension and diversification of its grain legume production areas.

In Europe, several small breeding programmes are ongoing (Figure 1[1]) and about five new varieties are registered each year. At present, the yield potential for faba bean cultivars in Europe is 9–10 t/ha. Yield potential is no longer a limiting factor as it used to be in the 1970s. Currently, breeders are aiming to improve yield stability and seed quality. The genotypes adapted to specific environments, when grown with appropriate technical management, have impressive yield potential. This highlights the key role of cropping management to realise the full genetic potential.

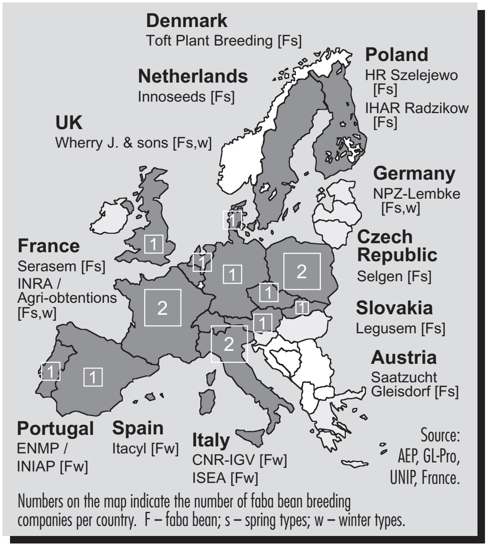

Figure 1. Faba bean breeding programmes in the EU.

Regional priorities and breeding goals

A survey among EU breeders made in EUFABA[2] has allowed European regional priorities for faba beans to be defined according to physiological and agronomic constraints on the crop and according to the types of uses of the crop. This has provided ideotypes to be targeted by breeders.

In addition to reducing susceptibility to factors affecting yield stability in a given region, objectives include extending the crop into new areas and making the crop product suitable for new uses or more valuable in existing markets.

Recent efforts in Europe have been on autumn-sown faba bean. For each targeted region, a specific combination of criteria including early maturity, disease resistance, freezing resistance, early flowering and a short cycle should be considered.

Maintaining or enhancing seed quality continues to be an important objective, either for visual criteria (avoiding discoloration, holes or spots caused by insect or diseases) or nutritional and healthy criteria (such as Fevita type). Other criteria such as pollination, suitability for organic farming, seed size and lodging are also considered.

Stronger together

To accelerate the progress being made, new strategies are being developed to combine the efforts of the individual breeding programmes. The EUFABA project has enabled a first step to be made to involve breeders' co-operation that extends to public research. Current discussions within GL-TTP[3] aim to widen the scope of collaboration to the international level, involving joint approaches among breeders and scientists to tackle specific issues and exploit further advanced techniques when relevant. ■

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[1]AEP, GL-Pro http://www.grainlegumes.com/gl-pro
[2]EUFABA http://www.ias.csic.es/eufaba
[3]http://www.grainlegumes.com/gl-ttp

SPECIAL REPORT
FABA BEANS

Faba bean breeding for drought and frost tolerance

Amélioration variétale de la féverole pour la tolérance à la sècheresse et au gel

by Fred STODDARD*, Wolfgang LINK**, Mustapha ARBAOUI** and Habib KHAN***

Crop breeding for resistance to abiotic or environmental stresses is vital, but difficult, because in field conditions the stress may be too mild to be selective or it may be too severe and kill all the plants. Modified field conditions have therefore been developed – rain-out shelters for drought stress, for example. These, however, have limitations of size and expense, as well as the fact that the crop has to grow through the entire growing season for the response to be measured as alteration in yield. We therefore aim to develop rapid, predictive, low-cost tests that can be used to screen large numbers of genotypes. Some tests can be used on young plants in pots in controlled environments. From this information we can develop physiological tests, that potentially can be done on hundreds of plants per day. Eventually, we may be able to develop a DNA-based marker for a key, stress-responding gene.

Environmental stress responses are often classified as escape, avoidance and tolerance. Recovery is a further key aspect. An example of the 'escape' mechanism is early maturity, before the onset of adverse weather. 'Avoidance' denotes better use of the environment, such as deep roots that exploit soil water more effectively in times of transient drought. 'Tolerance' indicates a physiological alteration in the plant, such as cell solute composition, that enables it to survive the stress.

Work package 3 of EUFABA has aimed to provide a physiological understanding of, and selection methods for, drought and frost responses in faba beans.

Frost tolerant genotypes are identified

Frost tolerance was assessed in multi-location field trials and in a growth chamber. The germplasm included the 'Göttingen Winter Bean Population' and progeny of two crosses involving Côte d'Or, an old French population that has outstanding frost tolerance. These crosses were with Scirocco, a spring bean cultivar, and BPL4628, a winter-hardy Chinese line from the ICARDA collection.

In the field trials, 12 cultivars plus 12 exotic lines were grown in 12 environments (up to five locations in four years). Over-wintering ability was scored from 1 (total winter kill) to 9 (no evidence of damage). European winter cultivars gave the five highest average scores (Table 1). The highest-scoring 'exotic', with a score of 4.32, was selection 3028/02 from Scirocco x Côte d'Or/1. The results showed high heritability for over-wintering score, indicating that selection on this basis in a segregating population should be highly effective. The good performance of the Göttingen Winter Bean Population, which has been selected and tested for winter hardiness for several generations, confirms this.

Table 1. Over-wintering score and yield of the five best lines from the 24 cultivars and breeding lines evaluated in 12 European environments from 2002 to 2006.

Genotype	Over-wintering score (higher is better)	Yield (kg/plot)
Hiverna/2	5.82	1.12
Hiverna	5.59	1.23
Bulldog/1	5.37	1.12
Karl	5.27	1.14
Göttingen winter bean population	5.26	1.40
LSD (5%)	1.45	0.35
Heritability	0.88	0.83
Environments	12	9

This set of 24 accessions, along with 101 recombinant inbred lines from Côte d'Or x BPL4628 and some other materials, were treated in frost chambers and evaluated for cell membrane fatty acid composition, with or without a hardening period before the freezing test. The plants were grown at 18 °C days/15 °C nights and then those to be hardened were subjected to 10 °C days/3 °C nights. Further hardening in the frost chamber was at 2.5 °C days/0 °C nights for a week and finally the frost test itself was performed, with a week of nights of increasingly low night temperatures (Figure 1). Symptoms of injury were scored after 11 hours of thawing at 5 °C (3). Leaves were dried at 50 °C, ground to a powder, and the lipids were extracted and analysed by gas chromatography.

The three best accessions for frost tolerance were Karl, Göttingen Winter Bean Population and selection 95 of Côte d'Or x BPL4628. The Spearman rank correlation between the average over-wintering score and frost tolerance measured in the chamber was significant ($r = 0.41$, $P < 0.05$). The relatively low value of this correlation is attributable to the complexity of the over-wintering response which expresses much more than frost tolerance. Screening in controlled environments is an efficient way to identify highly frost-tolerant genotypes without the confounding effects of other environmental interactions.

Fatty acid composition showed some very interesting results. Contents of several fatty acids all showed significant genotype x treatment interactions and we will here focus on polyunsaturated fatty acids C18:2

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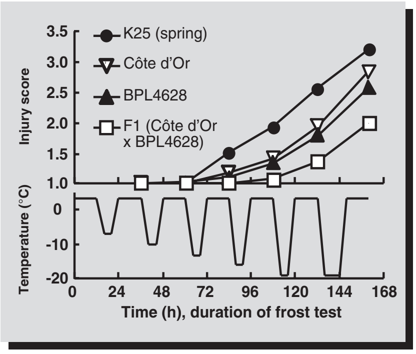

Figure 1. Frost tests of faba beans: temperature profile and response curves of a typical spring bean (K25), two winter beans (Côte d'Or and BPL 4628) and their superior F1 hybrid.

(linoleic acid) and C18:3 (linolenic acid) because of their established association with frost tolerance in other species (2). Hardening increased the proportion of linolenic acid to a varying extent: least in spring beans, to a moderate amount in less tolerant winter beans, and to the greatest amount in the most frost-tolerant winter beans. The correlation of linolenic acid increase with frost tolerance was significant (r = 0.48, P < 0.01). Highly unsaturated fatty acids contribute to preserving membrane fluidity, which is important in resisting frost damage and dehydration.

Drought tolerance can be predicted

Field trials at Göttingen previously identified ILB 938/2, a selection from an ICARDA line, as showing minimal yield losses in drought (4). Further field trials during the course of EUFABA showed that the French cultivar Mélodie along with Merkur/2, Lobo, and a selection from Merkur x Enantia were relatively little affected by drought and yielded much more than ILB938/2.

Thirty inbred lines were selected for pot experiments. Sets of 6–8 lines were grown for 4–6 weeks and then some plants were maintained at field capacity (20% water content in soil) while others were subjected to increasing drought stress at 2% loss of soil water content per day. Twelve traits were evaluated on both stressed and non-stressed plants (Table 2). Leaf temperature, carbon isotope discrimination, stomatal conductance and relative water content all reflect whether stomata are open, allowing continued transpiration, cooling and rejection of ^{13}C. Drought tolerance by way of water conservation involves early stomatal closure, so the ^{13}C can no longer be discriminated against. Carbon isotope discrimination is widely considered to be an excellent predictor of drought resistance and is the benchmark for comparison (1), but is expensive. Of the other methods for measuring stomatal characteristics, that were all highly correlated with each other, leaf temperature provided an ideal combination of speed of measurement, non-destructive sampling, low cost and a high correlation with carbon isotope discrimination (r = –0.74, P < 0.01) in well watered plants. A non-contact infrared thermometer costs about €200. Standard errors of stomatal characteristics were lower in adequately watered than in droughted plants, and discrimination of sensitive and tolerant lines was maintained, so these measurements should be taken under non-stress conditions. Thus we suggest that leaf temperature of non-stressed plants could be used as a general screen for drought tolerance, to be followed by carbon isotope discrimination testing of the most interesting accessions. ILB 938/2 and Mélodie had good stomatal characteristics to tolerate drought.

(Photo F. Stoddard, University of Helsinki, Finland)

The susceptible (wilted) faba bean line 332/2/91/015/1 and the tolerant (still standing) line Giza-3.

Table 2. Physiological parameters measured in drought experiments and their value in determining drought response.

Trait	Time	Cost	Variability	Level of information
Plant height	Low	Low	Medium	Low
Shoot dry matter	Low	Low	Medium	Medium
Water use	High	Medium (labour)	Medium	Medium
Transpiration efficiency	Low	Low	Medium	Medium
Relative water content	High	Low	Medium	Medium
Specific leaf weight	Low	Low	Low	Medium
Osmotic potential	Medium	Medium (capital)	Medium	High
Stomatal conductance	High	Medium (capital)	High	High
Leaf temperature	Low	Low	Low	High
Carbon isotope discrimination	Medium	High	Low	Very high
Root length	High	Low	Low	High
Root dry matter	High	Medium (labour)	Medium	Medium

Drought avoidance can be contributed by deep rooting and effective use of the rooting volume. The tap roots of ILB 938/2, L-7 and also Apollo/1 (a drought sensitive line with high stomatal conductance) were 15–30% longer than the tap roots of the other lines, including Mélodie, while the root mass of Enantia was 25% greater than that of any other line. While use of root characteristics is too labour-intensive for a breeding screen, it is valuable for identifying suitable parents for crossing.

To conclude, we have identified new genetic sources of drought and frost tolerance and demonstrated some of their modes of action. We have also confirmed the applicability of infrared thermometry, as used in other species, for rapid prediction of drought tolerance in faba beans. ■

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SPECIAL REPORT
FABA BEANS

Resistance to diseases in faba bean

Résistance aux maladies chez la fève-féverole

by Diego RUBIALES* and Ana Maria TORRES**

The faba bean (*Vicia faba*) is one of the oldest crops grown by man and is used as a source of protein in human diets, as a fodder or forage crop for animals, and for available nitrogen in the biosphere. Its critical role in crop rotation, reducing energy costs, improving soil physical conditions and decreasing the incidence of diseases and weed populations has long been recognised. In spite of its potential, there has been a steady reduction in the cultivated area of faba bean in many countries over the last century, especially in Asia and the Mediterranean region. Except for the recent spectacular increases in production reported in Canada and Australia, the general trend has been towards a slight decrease of the cultivated area with no appreciable changes in yield and production. Instability of yields as well as the lack of adapted cultivars resistant to the major diseases are considered to be the major constraints for the crop. Faba beans are adversely affected by a number of diseases, which vary in incidence and severity from one region to another. Among them, the most relevant are chocolate spot, broomrape, rust, Ascochyta blight and foot rots. Varying levels of incomplete resistance have been reported in breeding material and germplasm collections but the release of improved varieties is limited and still cannot satisfy all types of agroclimatic conditions present in faba bean growing areas.

Progress towards broomrape resistance

Crenate broomrape (*Orobanche crenata*) is a root parasite that produces devastating effects on many crop legumes and represents a limiting factor for faba bean production in the Mediterranean region. In addition to *O. crenata, O. aegyptiaca* is of importance in the Eastern Mediterranean countries, and *O. foetida* in Tunisia. These parasitic weeds are difficult to control because they are closely associated with the host root and remain underground for most of their life cycle. Different control measures have been proposed such as hand weeding, chemical control using glyphosate, late sowing, crop rotation with a low frequency of susceptible crops, but none of these have shown satisfactory results.

Because the efficacy of available control methods is minimal, breeding for broomrape resistance remains the most promising strategy. Breeding for broomrape resistance in faba bean is a difficult task, but significant successes have been achieved (3). Some accessions with moderate to low levels of resistance and/or tolerance had been reported, such as VF172, cv. Express, BPL2210 or Locale di Castellano), but the first significant finding of resistance was the identification of the family F402 derived from a 3-year cycle of individual plant selection in an F7 from the cross Rebaya 40 x F216. Several accessions have been developed, either by individual plant selection from the open pollinated varieties and germplasm accessions or through segregating populations of targeted crosses. Giza 402, Giza 429, Giza 674, Giza 843 (with resistance derived from F402) have been released in Egypt. Baraca has been released in Spain with resistance derived from VF1071 – itself a selection from Giza 402. Three QTLs for *O. crenata* resistance have been identified (2), explaining more than 70% of the phenotypic variance. Nevertheless, the saturation of the map is still inadequate to allow the required precision for a good marker/QTL. With improved genetic maps and the validation of the QTLs detected so far across environments and locations, greater accuracy in the selection of markers to assist breeding can be expected.

Sources of resistance to Ascochyta blight

Ascochyta blight (*Ascochyta fabae*) infects all above-ground plant parts including seeds, and the damage includes reduction in the photosynthetic area, lodging following stem girdling, pod and seed abortion, and seed infection. Disease control through crop rotation, clean seeds, and chemical treatment has not been completely effective and the development of resistant cultivars is widely recognised as the most efficient method of control. Very few resistance sources to *A. fabae* were available by the 1970s, but since then several sources have been identified and used in breeding programmes, although none resulted in complete resistance (6). Reduced infection can also be due to morphological plant features, such as straw length, that facilitate disease escape. The resistance to *A. fabae* in line 29H has been shown to be polygenic and governed by several QTLs. In addition to this, there is evidence in favour of an independent genetic control of the resistance in stems and leaves. Several QTLs have also been identified in other lines (7).

'Partial' and 'incomplete' resistance responses for rust

Rust (*Uromyces viciae-fabae*) is a disease with worldwide distribution that can cause up to 70% yield loss in early infections. Several sources of resistance to *U. viciae-fabae* have been reported in the last decades (5). Most of them displayed a slow-rusting resistance characterised by the presence of a susceptible infection type and a slower development of the disease, which translates into a reduced rate of epidemic development. This type of resistance is considered durable, stable, and frequently race-nonspecific.

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Macroscopic components of this partial resistance are characterised by reduction in both lesion size and infection frequency, a longer latency period and absence of necrosis (4). Preliminary data suggests that the most appropriate approach to study this type of resistance is through a quantitative analysis. At present, suitable mapping populations are being developed in order to identify resistance genes. A second type of response to faba bean rust was recently described as an incomplete resistance with characteristic low-infection types associated with late acting necrosis (hypersensitivity) of the host tissue, that is easily detected with specific pathotypes or races of the pathogen, and is controlled by genes with major effects (4). Bulk Segregant Analysis (BSA) has been used to identify markers linked to a gene determining hypersensitive resistance (1). Growing different hybrids carrying the different resistance genes or pyramiding such genes through MAS would greatly accelerate the breeding progress. This strategy may extend the life cycle of each gene providing a more durable resistance.

Resistance to chocolate spot

Chocolate spot can be caused both by *Botrytis fabae* and *B. cinerea* – *B. fabae* being more aggressive in the field. Losses are determined by the transition from non-aggressive to aggressive forms of the disease during flowering and early pod set. Although chemical control may provide partial protection, it is costly. Different levels of resistance have been identified and a genetic analysis of resistance is underway to identify the QTLs responsible for resistance to this pathogen.

M. trucatula is an essential tool

Medicago truncatula is providing essential tools for multiple aspects of legume genetics and genomics. The extensive conservation of gene order implies that genetic and genomic tools developed in *M. truncatula* can be readily applied to faba bean. A large set of EST markers from *M. truncatula* is being created and used to establish a worldwide framework for comparative genomic studies in legumes. EST markers derived from genes related to cell defence mechanisms in the model species might be used to map QTLs controlling disease resistance in faba bean. Identifying candidate genes for specific QTLs would ultimately provide the diagnostic tools to screen large amounts of germplasm for individuals carrying alleles of interest. The challenge is to identify DNA polymorphisms within candidate genes that might distinguish alleles and then associate alleles with differences among phenotypes. This can now be accomplished through SNP (Single Nucleotide Polymorphism) discovery and association studies between SNPs and phenotypes. Finally, the function of many genes isolated from crop plants can be understood better via study of their *M. truncatula* homologues and, for example, knowledge gained from *M. truncatula* on the defence mechanisms against pathogens, can be used to develop disease-resistant plants in faba bean. ■

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Insert

EUFABA – Faba bean breeding for sustainable agriculture

Thirteen partners from nine countries carried out a joint project, EUFABA, co-funded by the EU (QLK5-CT-2002-02307) from February 2003 to 30 November 2006. The objective was to combine the application of marker-assisted selection and conventional breeding methods to develop enhanced faba bean genotypes with characteristics of importance to sustainable agriculture across Europe. Farmers need plant genotypes resistant to biotic and abiotic stresses, and humans or animals need plant genotypes free of antinutritional factors (ANFs).

Screening methods for diseases and analyses of key traits for abiotic stress resistance

Following the analysis of the constraints for faba bean agronomic performance, resistance, adaptability and nutritional value in the different European regions, some desired phenotypes were defined as suitable for each area. Based on joint protocols, a series of spring and winter faba bean field evaluation trials were established at various sites in participating countries.

Studies of biotic constraints focussed on the development of reliable screening methods (in the field and growth chambers) against ascochyta, botrytis, broomrape and fusarium wilt, and studies on the stability of the resistance already identified. Sources of resistance have been identified under field conditions screening a collection of 400 faba bean accessions and lines. Resistance mechanisms are being characterised at the cellular and physiological level. A set of cultivars has been established to study stability of resistance in multilocation experiments during 2004, 2005 and 2006.

Frost resistance is studied in multi-location field trials and in the frost chamber, and a promising auxiliary trait the fatty acid composition of green tissue of very young, hardened and unhardened plants, was studied. Drought resistance is also studied in multi-location field trials, including the use of rain-out shelters and promising auxiliary traits studied included stomatal resistance, leaf temperature and carbon isotope discrimination.

Vicine and convicine toxicity

The toxicity of vicine and convicine and their active aglycones were quantified in animal models (laying hens). The redox sensitivity of laying hens given faba bean diets containing very high V–C or very low V–C was studied by measuring the hemolysis of their red blood cells.

QTLs and markers for breeding

DNA marker analyses were performed for (i) resistance to biotic stresses by identifying QTLs for diseases resistance; (ii) nutritional factors by identifying markers linked to low tannins and low vicine–convicine content that might facilitate selection efficiency; (iii) genetic variability in pathogens/parasite populations.

Molecular markers tightly linked to the genes/QTLs identified are being used to accelerate the selection of desirable genotypes. A backcross programme with the lines carrying favourable alleles has been established to transfer genes and QTLs from a donor line to recipient lines. Attempts were made to detect associations between markers tightly linked to the genes/QTLs identified and new material carrying the desired trait-phenotype without the use of mapping populations. A set of inbred lines fitting the ideotypes has been selected to check for SCARs developed in the project, focusing on the analysis of monogenic traits (Uvf1, zt1, zt2 and zvc).

Source: http://www.ias.csic.es/Eufaba

News of the 2006 grain legume harvest in Europe

Des nouvelles de la récolte 2006 des protéagineux en Europe

by Members of the GL-Pro network in AEP*

France: increase in yields of peas and faba beans

The French national average estimated yield of pea is about 4.4 t/ha (200 kg/ha more than in 2005). Areas have decreased by 24%, and are being assessed at 236,000 ha.

High regional differences have been observed. In the North-West area – the French departments Picardie, Normandie and Nord-Pas-de-Calais, yields were high and sometimes higher than the average for the five past years. In contrast, yields were low in the central part of France (Centre, Bourgogne, Champagne, Ardennes), sometimes lower than in the previous year.

These differences are due to climatic conditions, and are highly correlated with the rainfall between the 15 May and the 1 July. The North-West area experienced heavy rainfall and yields were high whereas the Centre of France experienced a severe drought with a water deficit during the sensitive period of seed filling for both spring and winter types of peas, even in heavy soils. As a result yields were poor.

High temperatures in mid-June made the damage worse, with abortion of seeds. However, with irrigation to correct the water deficit, yields were reasonably good (5.5 to 6.0 t/ha).

In the South-West, sowings early in the season, whether for winter types of peas sown in November or spring pea sown in December or January, enabled the hot periods to be avoided, thus reducing the impact of climate.

Winter peas and spring peas gave similar yields because the low temperatures throughout the winter delayed vegetative development and left the winter peas suffering from water deficit and high temperatures in June.

Similar trends were observed for faba beans. The average yield increased to 4.2 t/ha which was 300 kg/ha more than in 2005 and there were high yields in the North-West area compared with poor yields in the Centre of France. In addition, winter faba beans were severely damaged by drought and high temperatures in the South-West, in the West and in the Centre of France, resulting in poor yields.

Table 1. French harvest: crop area, yield and production in 2006 compared with 2005 and 2004.

FRANCE	2004	2005	2006	Trend 2006/2005
Peas	354,000 ha	311,000 ha	235,700 ha	–24%
	4.73 t/ha	4.18 t/ha	4.42 t/ha	+5.7%
	1,675,000 t	1,300,000 t	1,040,000 t	–20%
	22.6 % protein[1]	24.7 % protein	23.8 % protein	
Faba beans	81,000 ha	102,000 ha	78,000 ha	–24%
	4.6 t/ha	3.89 t/ha	4.17 t/ha	+7.1%
	373,000 t	397,000 t	325,000 t	–18%
	28.2% protein	28.8 % protein	29.1 % protein	
Lupins	9,500 ha	7,400 ha	7,000 ha	–5.4%
	2.5 t/ha	2.4 t/ha	2.4 t/ha	0
	26,000 t	18,000 t	17,500 t	–2.7%

[1]Protein percentage of dry matter.

Spain: a better year than 2005

In 2006, the grain legume area diminished sharply by 29%, to a total of 403,500ha (Table 2.). This decrease was due to the decoupling policy of the CAP reform. Lentil, chickpea, vetch and bitter vetch areas decreased by 54% compared with 9% for pea, 31% for faba beans and 32% for lupins. These protein legume crops have benefited from a specific payment of €55.57/ha.

In 2005, an extremely dry season, Spanish legume production was very low. In 2006 yields were higher than in 2005, but production was still lower than that

Table 2. Spanish harvest: crop area, yield and production in 2006 compared with 2005 and 2004.

SPAIN	2004	2005	2006 (provisional)	Trend 2006/2005
Peas	135,700 ha	146,500 ha	159,900 ha	(+9%)
	1.44 t/ha	0.9 t/ha	1.3 t/ha	(+44%)
	195,200 t	124,200 t	206,900 t	(+67%)
Faba beans	48,200 ha	53,100 ha	36,500 ha	(–31%)
	1.24 t/ha	0.5 t/ha	1.4 t/ha	(+180%)
	59,900 t	25,200 t	48,800 t	(+94%)
Lupins	15,800 ha	13,900 ha	9,400 ha	(–32 %)
	0 65 t/ha	0.45 t/ha	0.73 t/ha	(+62%)
	10,300 t	6,300 t	6,900 t	(+9%)
Total	573,900 ha	570,100 ha	403,500 ha	(–29%)
	588,700 t	263,900 ha	425,500 t	(+61.2%)

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Table 3. German harvest: crop area, yield and production in 2006 compared with 2005 and 2004.

GERMANY	2004	2005	2006	Trend 2006/2005
Peas	121,500 ha	110,000 ha	93,000 ha	–15.5%
	3.82 t/ha	3.14 t/ha	3.12 t/ha	–0.6%
	464,000 t	346,000 t	289,000 t	–16.5%
Faba beans	15,500 ha	16,000 ha	15,000 ha	–6.3%
	4.13 t/ha	3.80 t/ha	3.09 t/ha	–18.7%
	64,000 t	60,000 t	46,000 t	–23.3%
Sweet lupins[1]	35,800 ha	38,600 ha	33,100 ha	–14.2%
	2.0 t/ha	1.42 t/ha	0.71 t/ha	–50.0%
	72,000 t	55,000 t	23,500 t	–57.2%

[1]Sweet lupin yield and production data from COPA/COGECA. Source: Statistisches Bundesamt, ZMP.

usually expected. Annual rainfall was lower than the historical mean rainfall and, in May 2006, temperatures were higher and flowering was very poor.

In 2006, areas of faba beans and lupins decreased significantly, but the pea area increased by 9% and the production also increased compared with 2005 which was an extremely dry season.

In 2006 estimated average yields of the three species were higher than for 2005, and higher than for 2004 in the case of faba beans and lupins.

Germany: drought and sclerotinia

In Germany the area of grain legumes, especially peas, decreased again in 2006. In eastern parts of Germany and in the south the sowing dates were delayed until March because of snow.

The average yield of peas was about 0.1 t/ha lower than the average of the last 17 years. In some regions of the eastern part of Germany there were problems with drought from May to July. In the federal state of Sachsen-Anhalt there were serious problems with *Contarinia pisi*. *Sclerotinia sclerotiorum* also seemed to be more prominent than in other years, occurring in the late stages of growth. Harvesting problems varied a great deal according to the region and the rainfall. The late harvesting dates in August in particular suffered yield losses caused by lodging.

The average yield of faba beans was about 0.4 t/ha lower than the average of the last 17 years. The main reason was the summer drought causing loss of pods, and in some regions also *Sclerotinia sclerotiorum*.

Denmark: reduced areas

The area of field peas dropped once again. In 2006 the area of field peas for combining was only 8,000 ha in Denmark. The sowing conditions were not optimal due to wet weather in many parts of the country.

The disease attacks were primarily weak. Attacks from aphids were severe in some fields.

The not optimal establishment combined with a very hot and dry period during flowering led to very disappointing yields. The average was only about 3.22 t/ha.

UK: unlucky for spring sown pulses, but a good trading season

Peas suffered less from the July drought than beans, but using variety trials data, there is a loss of about 0.6 t/ha in 2006 compared with the most recent five year mean. Early maturity partially protected the crop, plus the relative drought tolerance of species. With spring faba beans, the equivalent value would be a loss of 1 t/ha reflecting the drought sensitivity of the crop. Winter faba beans, with their strong plants deeper rooting and early flowering still suffered and yields were 0.8 t/ha below normal.

Feed faba beans initially lagged behind the increase in value seen in feed wheat, but as the winter progressed, bean values exceeded those of feed wheat. The high level of bruchid infestation initially suggested that exports to Egypt would be reduced, but problems with the Australian bean crop restored interest in UK beans.

Crop values for UK pulses increased through the trading season and with the benefits of new varieties, historic yields could be reached again with some more cooperation from nature! ■

Insert

Some new registered grain legume varieties in Europe

Following the 2005 and 2006 registration trials, 13 new varieties have been registered in France in autumn 2006 (1), providing the growers with some improved agronomic characters:

- seven spring peas with yellow grains (with improved standing ability): Alixor, Antares, Gregor, Maggia, Marignan, Odéon, Safranos
- two winter peas with yellow grains (with increased yield potential and standing ability): Astrid and Enduro
- two spring faba beans with white flowers (no tannin) (with increased yield potential): Tamara and X (name to be approved)
- two spring faba beans with coloured flowers (with one with low vicin-convicine content): Betty and Lambada.

In the UK, the NIAB/PGRO Recommended Lists (RL) were agreed by the Pulse Trials Advisory Committee in November 2006 (2).

New to the RL with a provisional recommendation are the white-seeded peas Mascara and Ragtime, the large blue peas, Prophet and Paris, and the marrowfat pea, Genki. Mascara and Ragtime outyielded the control (% of control mean yield of 5.16 t/ha) with scores of 111 and 104, respectively, while the fully recommended variety Bilbo scored 104. Prophet and Paris scored 106 and 103, respectively, compared with 99 and 95 for the recommended large blues Venture and Nitouche, while Genki scored 93 and was the highest yielding marrowfat. All these varieties have good standing ability at harvest and good resistance to downy mildew.

A winter faba bean, Arthur, is new to the RL with a provisional recommendation. It had a yield score of 105 (% of control mean yield of 4.25 t/ha) compared with 102 for the fully recommended Wizard. It has a black hilum, slightly longer straw and not as good standing ability as Wizard. Fuego, Ben and Syncro were the fully recommended spring bean varieties.

In Germany (3) one new spring faba bean, Tattoo, was listed in autumn 2006. Tattoo is a white flowering variety with low tannin content, but also lower protein content. Two new varieties of spring peas, Maringa and Gregor, were also listed in 2006. Both varieties have good standing ability, but they are not as good as the best varieties for this trait. Gregor has a high protein content and also a good protein yield. Both pea varieties have yellow seeds. There are no official trials for winter types of faba beans and field peas in Germany because the breeders have no varieties that exhibit good winterhardiness under German conditions.

In Denmark (4) there was only one new variety of field peas added to the Danish national list in 2006 and the name has not been registered yet. The breeder's reference is A3.1

(1) Source: Arvalis-Institut-du-Végétal/UNIP. (unip@prolea.com); more information at: http://www.grainlegumes.com/gl-pro

(2) Source: Stephen Belcher, Pea & bean Progress, Winter 2006, 8–9. (info@pgro.org)

(3) Source: Wolfgang Sauermann, Landwirtschaftskammer Schleswig-Holstein, Germany. (wsauermann@lksh.de)

(4) Source: Jon Birger Pederson, Danish Agricultural Advisory Centre. (lfplanteavl@lrdk)

Nitrogen fixation: applications to poverty alleviation

Fifteenth International Congress on Nitrogen Fixation in South Africa

Poverty is a severe problem in Africa, Asia, South America and even in pockets of the developed world. Addressing poverty alleviation via the expanded use of biological nitrogen fixation (BNF) in agriculture was the theme of the Fifteenth International Congress on Nitrogen Fixation, held jointly with the Twelfth International Conference of the African Association for Biological Nitrogen Fixation, in Cape Town on 21–26 January 2007. Because N-fixation research is multidisciplinary, exploiting its benefits for agriculture and environmental protection has continued to attract research by diverse groups of scientists, including chemists, biochemists, plant physiologists, evolutionary biologists, ecologists, agricultural scientists, extension agents, and inoculant producers. There were 192 delegates representing 41 countries present at this conference.

Crop yields depend on many factors, but a primary consideration is the availability of a fixed-N (mineral or organic) source. This was the concern of delegates, particularly its availability through biological processes. BNF is Nature's way of making the enormous reservoir of atmospheric N_2 directly usable by the biosphere. Then, through associations with N-fixing microorganisms, plants (and consequently, animals) can derive a significant proportion of their fixed-N requirement for growth from BNF. These interactions clearly illustrate why BNF is a key metabolic process for food production and the maintenance of life on Earth.

The Congress theme, the application of BNF to sustainable agriculture, poverty alleviation, and environmental concerns, was well covered. Highlights included how to benefit from the introduction of N-fixing legumes into local small holdings, from appropriate use of soil and water, from the use of indigenous soil microbes to provide N and P, and from good agricultural practices generally. However, to maintain high yields, sustainable agriculture requires appropriate agricultural practices and plant cultivars that respond to environmental constraints. In addition to classical plant-breeding technology, modern-day engineering of high-performance crops and symbiotic associations can now access and use the incredible insight acquired through plant and bacterial genomics. Both topics were well represented, and refined gene-sequence maps of some simpler legumes have led to exciting genomic work in other legumes.

The basic sciences that underpin these more applied aspects were also well represented. One highlight was the discovery that, in the most agriculturally important associations of legume crops (for example, soyabeans, peas, and feed legumes, like lucerne and clover) with *Rhizobium* bacteria, alternative modes of communication exist between the plant and bacteria. This may help us understand how some bacterial species associate with only one legume, whereas others associate with many plants; it also opens up possibilities of developing new symbioses and enhancing current symbioses to increase crop yields. Other highlights included the discovery of a whole new class of plant micro-symbionts, the beta-proteobacteria – which makes us wonder how many other symbiotic systems await discovery! All this plus a cyanobacterium that anticipates sunrise each morning, a nitrogenase that works at 92 °C, how complex prosthetic groups in proteins are synthesised, and tricks to detect recruited accessory genes from the core genes in an organism!!

Also included were presentations on the fundamental biochemistry and genetics of N fixation, plant breeding, plant and microbial molecular biology, legume–*Rhizobium* genetics, genomics, gene expression, evolution of symbioses, nodulation physiology, stress responses, bioremediation, and forestry. Taken together, the excellent technical presentations and the lively discussions associated with the oral and poster sessions, are clear indicators of the success of the Congress. ■

Source: Bill Newton, Department of Biochemistry, Virginia Tech, Blacksburg, USA (wenewton@vt.edu) and Elizabeth Danckwerts (aecon.e@mweb.co.za).

Outlook for exports of pulse crops from Canada

In 2006-07 Canadian exports of dry peas are forecast to decrease sharply compared with 2005–06 due to lower production and supply. The average price, over all types, grades and markets is forecast to increase because of the lower world and Canadian supply.

Lentil exports are due to increase because of higher production of red lentils and strong demand. The average price over all types and grades is expected to increase because of lower world and Canadian supply.

Exports of dry beans are forecast to increase due to higher production and supply. The average price over all classes and grades is forecast to increase because the higher Canadian supply is more than offset by lower United States supply.

Exports of chickpeas are forecast to increase because of higher production and supply. The average price over all types and grades is forecast to increase due to lower world supply. ■

Source: Agriculture and Agri-Food Canada (February 2007). Canada: Pulse and special crops outlook. (www.agr.gc.ca/mad-dam/

Area harvested, yield and production of pulses 2004–2007.

CANADA	2004–05	2005–06	2006–07[1]	Trend
Pea	1,345,000 ha	1,319,000 ha	1,378,000 ha	+4%
	2.48 t/ha	2.35 t/ha	2.04 t/ha	
	3,338,000 t	3,100,000 t	2,806,000 t	–9%
Lentils	750,000 ha	862,000 ha	555,000 ha	–36%
	1.28 t/ha	1.48 t/ha	1.25 t/ha	
	962,000 t	1,278,000 t	693,000 t	–46%
Dry beans	126,000 ha	175,000 ha	174,000 ha	–0.6%
	1.75 t/ha	1.85 t/ha	2.09 t/ha	
	220,000 t	324,000 t	363,000 t	+12%
Chickpeas	39,000 ha	73,000 ha	144,000 ha	+97%
	1.31 t/ha	1.42 t/ha	1.26 t/ha	
	51,000 t	104,000 t	182,000 t	+75%

[1]Forecast

GRAIN LEGUMES

The magazine of the European Association for Grain Legume Research

Le magazine de l'Association Européenne de Recherche sur les Protéagineux

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COVER PHOTO:
White faba bean flower.
(Photo B. Carrouée, UNIP, Paris, France)

PHOTO DE COUVERTURE :
Fleurs blanches de féverole.
(Photo B. Carrouée, UNIP, Paris, France)

FIRST GL-TTP WORKSHOP

Targeting Science to Real Needs

23–25 April, 2007

Hotel Mercure Paris Bercy, Paris, France

Organised by GL-TTP[1] (Grain Legumes Technology Transfer Platform), sponsored by GLIP and reflecting on the needs of grain legume breeders, the workshop will focus on the exploitation of genetic resources, and on the concrete use and integration of molecular technologies in breeding. The main themes addressed in this first workshop will be genetic diversity, disease resistance, abiotic stress tolerance and seed quality.

The workshop will consist of highly interactive sessions, where the specific needs and interests of grain legume breeders will be addressed through concrete examples of research application, training sessions, and direct transfer of genetic material. Most importantly, proposals will be brainstormed throughout the workshop to set up Research & Development and technology transfer projects in partnership between research scientists and plant breeders.

Delegates will be primarily the GL-TTP members, mostly grain legume breeders and research scientists, but the workshop will be open to non-GL-TTP members interested in learning more about GL-TTP activities, or simply interested in hearing the speakers and joining in the discussions.

More information at http://www.grainlegumes.com/default.asp?id_biblio=454

[1]GL-TTP is a not-for-profit organisation that bridges the gap between research and industry to increase the production and quality of grain legumes worldwide. GL-TTP was initiated in 2005 by the EU Grain Legumes Integrated Project (GLIP) to ensure the exploitation of the project outputs by the grain legume industry.

GRAIN LEGUMES
Sponsorship list

AEP
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Association Européenne de recherche sur les Protéagineux

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The AEP is an associative network of persons with interests in grain legume research (peas, faba beans, lupins, chickpeas, lentils, dry beans, etc.) to favour the exchange of information and multidisciplinary collaborations (Conferences, publications, workshops, joint projects). It aims both to strengthen the research works and to enhance the application of research into the integrated chain of grain legumes.

UNIP
French Interprofessional Organisation of Protein Crops
Union Nationale Interprofessionnelle des plantes riches en Protéines

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The UNIP is the representative organisation of all the French professional branches of the economic integrated chain of grain legumes. It provides information about pulse production, utilisation, and the market and it coordinates research works related to grain legumes in France, especially peas, faba beans and lupins for animal feeding.

Processors and Growers Research Organisation

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The PGRO provides technical support for producers and users of all types of peas and beans. Advice is based on data from trials sited from Scotland to the South West of England and passed to growers and processors through technical bulletins and articles in the farming press.

APPO
Belgian Association for Oilseeds and Protein Crops
Association pour la promotion des protéagineux et des oléagineux

Faculté universitaire des sciences agronomiques
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The APPO is the representative organisation of Belgian growers of oilseeds and protein crops, especially rapeseed, peas and faba beans. The main tasks are experimentation, giving advice to producers, providing technical and economic information through meetings and mailings and encouraging non-food uses of vegetable oil.

Technical Institute for Cereals and Forage
Arvalis – Institut du végétal

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Run and financed by French farmers, Arvalis-Institut du végétal carries out and disseminates applied research on the production, storage and utilisation of cereals, grain legumes, potatoes, and forage.

UFOP
Union zu Förderung von Oel- und Proteinpflanzen

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UFOP is the representative organisation for German producers of oil and protein crops. It encourages professional communication, supports the dissemination of technical information on these crops and also supports research programmes to improve their production and use.

CRA-W
Animal Production and Nutrition Department

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A broad research topic of the Animal Production and Nutrition Department deals with the utilisation of lupin and pea seeds in animal feeding (ruminant, monogastric and poultry) in terms of nutritional value, environmental benefits, protein utilisation and economic aspects. The research is also concerned with the development of legume silages, seed treatments prior to feeding and seed processing for non-food uses.

Pulse Canada

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Pulse Canada is a national industry association. This organisation represents provincial pulse grower groups from Alberta, Saskatchewan, Manitoba, Ontario and the pulse trade from across Canada who are members of the Canadian Special Crops Association. Pulse crops include peas, lentils, beans and chickpeas.

To be added to this sponsorship list, do not hesitate to contact the AEP Office.