GRAIN LEGUMES

AEP

The magazine of the European Association for Grain Legume Research
Le magazine de l'Association Européenne de recherche sur les Protéagineux

ISSUE No. 50 February 2008

Exploiting wild accessessions of common beans
Exploiter les populations sauvages de haricot

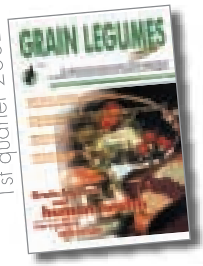
Dynamics of the EU grain legume sector
Dynamiques de la filière européenne

Genetic diversity in Moroccan faba beans
La diversité génétique dans les fèves marocaines

Give peas a chance – economic and environmental analysis in GLIP
Donnez aux pois leur chance ! Analyse économique et environnementale dans GLIP

GRAIN LEGUMES
Back issues

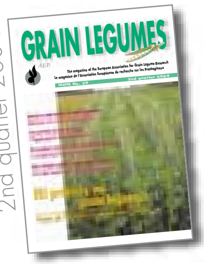
No.34
Highlights from the 4th AEP Conference
4th quarter 2001


No.35
Grain legumes and human health
1 st quarter 2002


No.36
Environmental benefits of grain legumes
2nd quarter 2002


No.37
Genetic resources of grain legumes
3rd quarter 2002

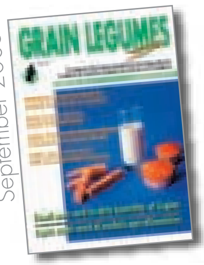

No.38
Use of synteny for genetic progress
4th quarter 2002


No.39
EU projects on grain legumes
2nd quarter 2004


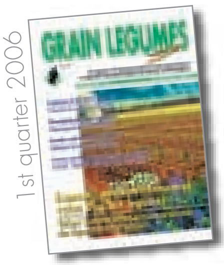
No.40
Highlights from Dijon 2004 (AEP-5 and ICLGG-2)
3rd quarter 2004


No.41
The GRAIN LEGUMES Integrated Project
January 2005


No.42
Drought and saline stress in legumes
June 2005


No.43
Food uses and health benefits of lupins
September 2005


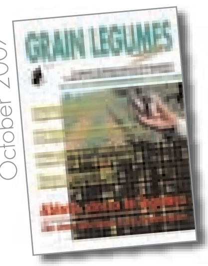
No.44
Seed protein in grain legumes
4th quarter 2005


No.45
Economic and environmental value of grain legumes
1 st quarter 2006


No.46
Integrated activities in the EU Grain Legumes Integrated Project
2nd quarter 2006


No.47
Vetches from Feed to Food?
3rd quarter 2006


No.48
Faba beans
January 2007


No.49
Abiotic stress in legumes
October 2007


EDITORIAL

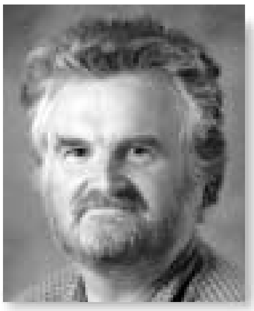
Since its creation the purpose of our Grain legumes magazine has been to enhance exchanges of information and collaboration among people interested in grain legumes in science and agriculture. We sincerely hope that this will be able to continue in the future: that is why we are looking for a volunteer or sponsor to help the Editorial Board to continue with this publishing effort. Sadly, the current economic situation for the Editor is not stable enough to allow satisfactory publication schedules, and so we are obliged to put the publication of Grain legumes magazine on hold again for a while (as was necessary once earlier in 2003). Meanwhile, we invite you to keep in contact through the AEP network and the web editing activities of the grainlegumes.com portal.

We thank you, the reader and subscriber, for your interest in Grain legumes and for your contributions and support. Any ideas or offers of help to support the publication of Grain Legumes magazine would be greatly appreciated!

Anne SCHNEIDER
Managing Editor

CONTENTS

Carte blanche to...



T. H. Noel Ellis

Legumes research: feedback from Lisbon and future prospects

The Sixth European Grain Legumes Conference 'Integrating legume biology for sustainable agriculture' held in Lisbon from the 12th to the 16th November was a significant success bringing together researchers from across the world to discuss much recent activity powered by advances in genetics and genomics. The conference was abuzz with discussion of traits, candidate genes and mutants.

At the time of the previous Conference in Dijon, our research community was anticipating developments that are now realised, and there is a palpable sense of relief that legumes have entered the 'post-genomics' era. Extensive sequence data is now available from several legume genomes, and it is becoming easier to collect sequence information and marker data in general. The investment in a reference genome sequence and the generation of systematic populations of mutants has provided the backbone on which to develop other platforms that can convert trait data into addressable problems in genetics and genomics.

However, this is not the time to pause for breath or relish these achievements: the need for legumes in agriculture is becoming more acute rather than less. It is clear that the agricultural contribution to greenhouse gas production is substantially connected with processes where the inclusion of legumes can mitigate damage, yet in Europe the area of legume production is declining. We therefore have a heightened social responsibility to ensue that the public investment in legume biology is seen to impact agriculture for the public good.

To quote Sydney Brenner, on the topic of 'translational research': "Those involved in basic research think it's applied, and those who support applied research think it's too early and too risky." and he coupled this with the idea that 'translational research' is "the research that nobody wants to support". In legume science we have had the benefit of substantial research support aligning research in model systems and crop species. Our challenge is to take the risk and apply what has been generated and learnt. ■

New delegates for AEP mandate 2007–2010

Following the AEP General Assembly held in Lisbon on 13 November 2007, Diego Rubiales has been endorsed in the role of AEP President at the meeting on 20 February of the new Executive Committee.

More at www.grainlegumes.com/aep_network

Executive Committee

Diego Rubiales (CSIC, Córdoba, Spain) *President*

Alvaro Ramos Monreal (Junta de Castilla y León, Spain) *Past President*

Judith Burstin (INRA, Bretenières, France) *1st Vice President*

T. H. Noel Ellis (John Innes Centre, Norwich UK) *2nd Vice President*

Christophe Salon (INRA, Dijon, France) *Treasurer*

Olivier De Gasquet (UNIP, Paris) *UNIP delegate* and *Executive Secretary*

Anne Schneider (AEP, Paris) *Executive Secretary Delegate*

Scientific Committee

Section 1: Genetics

Gérard Duc (INRA, Bretenières, France)

Helge Kuester (Bielefeld University–CeBiTec, Germany)

Aleksandar Mikić (Institute of Field and Vegetable Crops, Novi Sad, Serbia)

Carlota Vaz Patto (Instituto de Tecnologia Química e Biológica–ITQB, Portugal)

Section 2: Plant and crop physiology (including symbiosis) and systems

Eric Justes (INRA Toulouse, France)

Fred Stoddard (University of Helsinki, Finland)

Section 3: Plant health

Sara Fondevilla (University of Córdoba, Spain)

Section 4: Biochemistry of plant components

Keld Ejdrup Andersen (Biochemistry and Natural Product Chemistry, Department of Natural Sciences, University of Copenhagen, Denmark)

Hans Weber (IPK, Gatersleben, Germany)

Section 5: Nutrition, feed and food

Marina Carbonaro (Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione–INRAN, Rome, Italy)

Claire Domoney (John Innes Centre, Norwich, UK)

Section 6: Market and agro-industry (including novel uses)

Tanja Moellmann (FAL–Federal Agricultural Research Centre, Braunschweig, Germany)

Olaf Sass (Norddeutsche Pflanzenzucht H.G. Lembke K.G.–NPZ, Holtsee, Germany)

Section 7: Agroecology (crop systems and environment)

Henrik Hauggaard-Nielsen (Risø National Laboratory, Roskilde, Denmark)

Thomas Nemecek (Agroscope Reckenholz-Tänikon Research Station–ART, Zurich, Switzerland)

Grain legumes: what is at stake for the EU? – A report from the COPA–COGECA debate

Facing the declining cultivation of grain legumes in Europe, COPA-COGECA[1] organised a workshop-debate on this sector, bringing together 80 delegates, representing stakeholders and decision makers, in Brussels on 26 March 2008[2]. The aim was to analyse the situation and consider the need and means of action.

Contacted by the organisers, AEP proposed to supply the debate with background information based on recent European scientific and technical or socio-economic analyses (such as those issued from Eurocrop, GL-Pro and GLIP). This was summarised as follows in three presentations for the first part of the debate:

– the outlets do not limit the grain legumes sector: grain legumes are under-used in the compound feed industry, even with current raw material competitiveness, especially in Spain and Germany (GLIP findings[3]); there are also new markets (confirmed by the company Roquette in the second part of the meeting).

– legume crops have a positive impact on the environment, in particular a lower fossil energy consumption and lower GHG emissions (scientific research in agro-ecology and case studies in different European farming regions in GL-Pro);

– since 2000, the ceiling and recent decrease in EU grain legume production are explained partly by the changes in agricultural policies and also by climatic accidents in the spring in recent years; with current uncertainty, however, the relatively low attractiveness of grain legumes reflected by decreasing production trends must be considered in the light of the recently reinforced political strategies that support other arable crops (Eurocrop analysis[4]).

The second part of the debate enabled the different stakeholders to take the floor. The DG for agriculture of the European Commission reminded delegates of the history of this sector and of the related EU policies. He also explained that its proposals resulting from the CAP health check up will be published on 20 May: the general objective is the decoupling of aid to farmers but the discussion is open if convincing arguments are provided for specific cases.

In the round table, the UK, Germany, France and Spain released messages which were remarkably unanimous across countries and the sectors of activities (producers and inter-professional bodies, industry and the plant breeders). FEFAC (the European Federation of Compound Feed Manufactures) reminded the audience of its need for sources of protein but remain neutral towards the different raw materials on the market. All the other actors highlighted the urgent need for a political incentive to boost the grain legumes sector to ensure supplies sufficient to meet the market demand and the EU agricultural challenges for sustainability. COPA-COGECA proposed an increase in the coupled aid for these crops and also the need to consider how a price can be put on the environmental benefits of grain legumes for farmers and industrialists. ■

Source: Anne Schneider (a.schneider-aep@prolea.com)

[1]Committee of Professional Agricultural Organisations in the EU and General Confederation of Agricultural Co-operatives in the EU.

[2]More at: http://www.copa-cogeca.eu/Main.aspx?page=CCEvents&lang=en and http://www.grainlegumes.com/events/debate_at_copa_cogeca_26_march_2008.

[3]See page 12–14.

[4]See page 25–27.

XVI Plant and Animal Genome Conference (January 12–16, 2008)

This annual conference, hosted by the Town & Country Convention Center, San Diego, California (USA) and visited by some 2500 participants, was, is, and will be a must for plant and animal genomics researchers. Its various workshops alone span from Abiotic Stress over Bioinformatics, Comparative Genomics, Evolution and Genome Size, Functional Genomics, Genomics-Assisted Breeding, Host-Microbe Interactions, Insect Genomics, International Triticeae Mapping Initiative, Legumes, Mutation Screening, Organellar Genetics, Plant Cytogenetics, QTL cloning, Root Genomics, Small RNAs, Transposable Elements to Weedy and Invasive Plant Genomics, to name very few. Computer demonstrations soared, and industry presence was strong with some 24 booths. Additionally, a series of plenary lectures excellently addressed general genomics issues, for example. *Small RNA networks in plants* (David Baulcombe, JIC, Norwich, UK), *Advances in proteomics* (Gilbert Omenn, University of Michigan, USA), *Back through the genetic bottleneck: rice domestication and wild alleles for rice improvement* (Susan McCouch, Cornell University, USA), *Ontologies for biologists* (Michael Ashburner, EMBL, Cambridge, UK), *Energy genomics* (Eddy Rubin, DOE, Joint Genome Institute, USA), and *Systems genetic approaches for finding complex disease genes in mice and men* (Steve Horvath, UCLA, USA), to give a superficial impression. Numerous posters were displayed, and the participant literally had the bitter choice of either listening to this, or viewing that, or simply meeting colleagues.

This spartanic overview already suggests a complex diversity of topics, so that it is impossible to portray each one in desirable depth. Here some major tendencies (and highlights as well) are introduced in pathological brevity.

Second generation DNA sequencing technologies

An impressive development infiltrated nearly every topic: the advent of high-throughput second generation DNA sequencing technologies, advanced by Roche-454 Life Science (GS20 and GS-FLX Sequencers), Illumina (Solexa platform), and Applied Biosystems (SOLiD platform). Although Sanger sequencing will be in further use, these new technologies will doubtless catalyse genome research tremendously, partly by the sheer number of sequence reads (Sanger: 384, GS-FLX: 400,000; Solexa:40,000,000; ABSOLiD: 120,000,000) and megabases spanned Sanger: 70kb; GS-FLX: 100 Mb; Solexa: 1000 Mb; ABSOLiD: 3000 Mb), partly by the decaying costs for each run. *De novo* sequencing of whole genomes and the massive re-sequencing of parts or whole genomes now are in reach for practically all institutions. The new era of sequencing is reflected by the number of genomes sequenced (bacteria: 587; archaea: 50; eukaryotes: 82), and under sequencing (prokaryotes: 1760; archaea: 92; eukaryotes: 905). And interest is growing to include these platforms in genome-wide transcriptome research as well. For example, the combination of SuperSAGE with 454 pyrosequencing has enhanced the use of the former open architecture technology worldwide.

Small non-coding RNA

Another hot area of present research is small non-coding RNA, including a multitude of relatively small RNAs, that are not translated into proteins (are 'non-coding'), but influence or regulate multiple cellular functions. To this group of RNAs belong cell cycle RNAs, *cisRs*, microRNAs, non-coding RNAs, short hairpin RNAs, short interfering RNAs, small RNAs, small endogenous RNAs, small interfering RNAs, small non-messenger RNAs, small nucleolar RNAs (snoRNAs), small regulatory RNAs, small temporal RNAs, spatial development RNAs, stress response RNAs, and tiny RNAs, to name some. All these RNAs are encoded by the non-genic regions of a genome, which are more widely transcribed than previously imagined. In an excellent introductory plenary lecture, David Baulcombe illustrated the network of small RNAs in plants, particularly *Arabidopsis thaliana*. Since the functions of only very few of these small non-coding RNAs are known, and the interaction(s) among them, and between them and target genes are obscure, and the regulation of their transcription is simply unknown, the future research area of small non-coding RNAs can be predicted with certainty.

Legumes

The legumes are generally well represented in the Genome Conference. Three workshops, Cool Season Legumes, Legumes, and Soyabean Genomics are dedicated to various legume research topics, with a marked imbalance favouring the non-crop *Medicago truncatula*. However, the massive data from this plant, including a BAC-based physical map and a yet partial genome sequence, reviewed by Nevin Young, is (1) an extremely rich source of sequence information for synteny mapping and comparative genomics, also for the other legumes such as bean, cowpea, chickpea, lentil, pea and soyabean, and (2) infiltrates all other genomics approaches, as witnessed by many posters and presentations outside the above workshops. The European Union also appreciates the growing importance of legumes for food, feed, industrial use, and nitrogen fixation, and for the first time contributed a special seminar on the achievements made in the completed Grain Legumes Integrated Project (GLIP) joining more than 60 groups Europe-wide.

A short review unfortunately but inevitably has to ignore many other highlights of the XVI Plant and Animal Genome Conference, and the reader is therefore advised to contact the web site http://www.intl-pag.org/ for a broader view on all aspects of a successful meeting for molecular biologists working with plant and animal systems. ■

Source: Guenter Kahl, Biocenter, University of Frankfurt am Main, Germany (kahl@em.uni-frankfurt.de) and GenXPro Ltd, Frankfurt am Main, Germany (kahl@genxpro.de)

Towards an improvement of the protein quality of common bean

Progrès dans l'amélioration de la qualité des protéines du haricot

by Carlos A. MONTOYA*, Jean-Paul LALLÈS**, and Pascal LETERME*

Phaseolin is the main storage protein of common beans (*Phaseolus vulgaris*). It accounts for 40–50% of the total protein and is characterised by a low content of sulphur amino acids and tryptophan and a high resistance to hydrolysis in unheated form. However, cooking markedly improves susceptibility to hydrolysis (1). Many genetic variants have been reported, presenting from two to six subunits, with molecular weights ranging from 41 to 55 kDa (Figure 1).

Plant breeders hope that such diversity will also be reflected in the nutritional value of phaseolin and that this could lead to the selection of beans with improved nutritional value. This would be possible if phaseolins present diversity: a) in amino acid profile, namely the content of sulphur amino acids; b) in susceptibility to proteolysis (digestibility) and/or c) in nutritional value.

Therefore, 43 purified phaseolins were evaluated. These came from wild and cultivated beans collected from Argentina to Mexico and kept at CIAT (Cali, Colombia).

No diversity in amino acid profile

Despite differences in the number and molecular weight of subunits, no differences in amino acid profile were found in the phaseolin collection. Since phaseolin represents only 40–50% of the total protein content of the bean and since the other proteins contain higher amounts of sulphur amino acids, it is unlikely that the nutritional value of beans could be improved by modifying the amino acid profile of phaseolin alone (2).

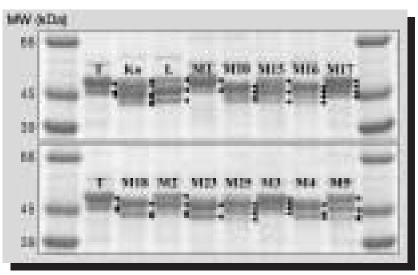


Figure 1. Electrophoretic pattern of different phaseolins in SDS-PAGE gels. MW: Standard molecular weight.

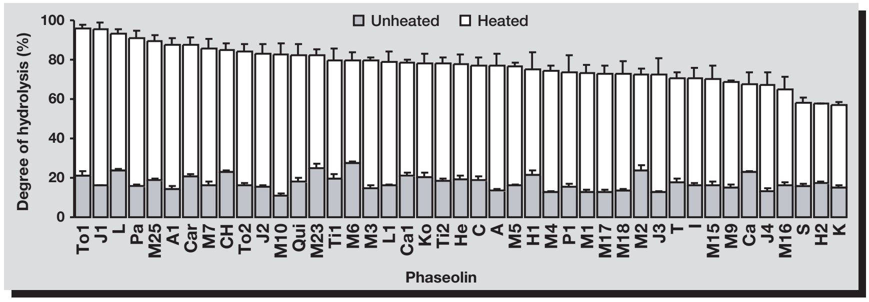


Figure 2. Degree of hydrolysis of different phaseolins in unheated and heated form after 360 min of *in vitro* hydrolysis (120 min pepsin + 240 min pancreatin). Values are means for three measurements per phaseolin.

High variability in proteolytic susceptibility

Purified phaseolins were hydrolysed *in vitro* with pepsin and pancreatic proteases in order to mimic the proteolysis sequence occurring along the gastrointestinal tract. Important differences in susceptibility to proteolysis were observed among unheated phaseolins: the degree of hydrolysis ranged from 11 to 27% (Figure 2). The overall high resistance of unheated phaseolins was ascribed to the general compact structure of these proteins.

Thermal treatment dramatically improved phaseolin hydrolysis *in vitro* (from 57 to 96%). Surprisingly, the improvement appeared to be independent from susceptibility to proteolysis in the unheated state. Heat treatment influences structural changes and favours enzymatic hydrolysis.

The S and T phaseolins, which are present in more than 90% of the beans cultivated in South America, were among the ten phaseolins with the lowest proteolytic susceptibility.

Phaseolins differ in nutritional value

The combination of the amino acid profile together with the results of protein hydrolysis *in vitro* allows for the estimation of the nutritional value of the phaseolin types. According to our calculations, the phaseolins with the highest degree of hydrolysis (e.g. To1 and J1 in Figure 2) released 38% more of sulphur amino acids, than phaseolins with the lowest degrees, including some present in cultivated beans (S). Moreover, only phaseolin with the highest degree of hydrolysis cover all the requirements for lysine, threonine, valine and leucine amino acids.

Towards beans with a higher protein digestibility

In conclusion, this study showed for the first time a wide variation in susceptibility to proteolysis among different phaseolin types. The phaseolin types found in cultivated varieties (S and T) had among the lowest degree of hydrolysis. The inclusion of highly digestible phaseolin types in breeding programmes could thus have very positive consequences on the nutritional value of beans. ■

*Prairie Swine Centre, Saskatoon, Canada. (pascal.leterme@usask.ca)

**INRA, Saint-Gilles, France.

(1) Montoya, C. A. *et al.* (2006). Br. J. Nutr. **95**, 116–123.

(2) Montoya, C. A. *et al.* (2008). Food Chem. **106**, 1225–1233.

Exploiting wild accessions to improve common beans (*Phaseolus vulgaris*)

Exploiter les populations sauvages pour améliorer le haricot (Phaseolus vulgaris)

by Matthew W. Blair*, Gloria Iriarte, Stephen Beebe

Cultivated common bean was domesticated from wild *Phaseolus vulgaris,* a viny plant with indeterminate growth from the mid-altitude Neo-tropics/ Subtropics that has a wide distribution range from northern Argentina to northern Mexico (6). Domestications of cultivated common beans from diverging populations of wild common beans is known to have occurred in two distinct centres of origin in South America and Central America, giving rise to the Andean and Mesoamerican gene pools, respectively (3). The existence of these two gene pools in the wild is supported by morphological differences – Andean wild beans having slightly larger seed than Mesoamerican wild beans, and diversity analysis with various marker technologies. Additional diversity of wild beans exists in Colombia, northern Peru and Ecuador and indeed this germplasm is thought to represent a different and more ancestral genepool. Freyre *et al.* (4) studied 78 wild accessions and found that in addition to Andean and Mesoamerican gene pools there was an intermediate gene pool of wild accessions from the Northern Andes. Tohme *et al.* (12) compared 114 accessions within a core collection of wild beans and found four gene pools among the germplasm, one from Mesoamerica and the other three from the Andean region. Among the wild common bean gene pools from South America, two were centered in the Northern Andes, one each in Colombia and Ecuador, and one was centered in the Central and Southern Andes. Beebe *et al* (1) found that the cultivated Andean gene pool was likely to derive from the southern range of the wild bean distribution, namely from populations in Bolivia and northern Argentina and had relatively low diversity while the Northern Andean wild accessions from Ecuador and northern Peru were very distinct. Chacón *et al.* (3) analysed 157 wild and weedy accessions and found evidence for additional diversity in the wild beans of Central America and predicted multiple domestications and wild x cultivated introgression events in Mesoamerica.

Why use wild beans?

Wild genetic resources of common bean have rarely been used in the improvement of cultivated common bean, this despite the fact that the genetic diversity of wild common bean is thought to be larger than that of cultivated common bean and that a genetic bottleneck is thought to have occurred during crop domestication (3). Genetic diversity results suggest that wild common beans are very diverse and can therefore be a useful source for enhancing the variability of cultivated common bean especially of the domesticated Andean gene pool which has low diversity. Several factors make wild common beans useful sources of diversity for incorporating novel and potentially useful characteristics into the cultigen: i) wild beans do not have genetic barriers that prevent them from being crossed with cultivated beans, ii) a large range of ecotypes exists in wild beans from which to select; iii) wild beans have been subjected to natural selection which has resulted in potentially useful novel alleles and iv) most wild alleles were not involved in domestication and remain untapped in the wild (8, 5).

Wild bean germplasm used in breeding

Gene transfer from wild to cultivated beans has been successful in one notable case: the transfer of monogenic Arcelin-based weevil resistance against the bruchid *Zabrotes subfasciatus* from a wild common bean to CIAT breeding lines. Singh *et al.* (9) made an early attempt to use wild common beans for improvement of seed yield in a breeding programme. These authors employed simple crosses and mass

Generation	Maternal		Paternal
F_1	ICA Cerinza (cult.)	x	G 24404 (wild)
BC_1F_1	ICA Cerinza (cult.)	x	F_1
BC_2F_1	ICA Cerinza (cult.)	x	BC_1F_1
$BC_2F_{1:2}$	Single plant selections		
$BC_2F_{2:3}$	Single plant selections		
$BC_2F_{3:4}$	Bulk harvest		
$BC_2F_{3:5}$	Yield test		

Figure 1. Advanced backcross breeding scheme for the cross between G24404 (wild bean accession) and ICA Cerinza (cultivated Andean bean variety).

*CIAT – Centro Internacional de Agricultura Tropical, Cali, Colombia. (m.blair@cgiar.org)

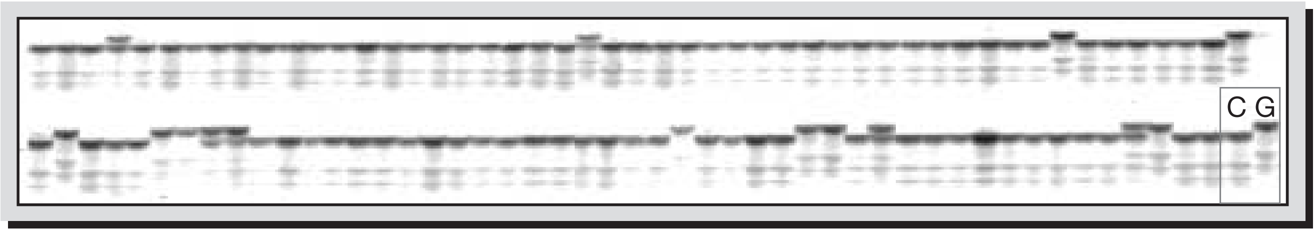


Figure 2. Evaluation of introgression with a microsatellite marker in the advanced backcross population Cerinza x (Cerinza x (Cerinza x G24404).

selection but had inconclusive results and recommended the use of backcrossing to assess the value of wild beans for yield improvement because of concurrent reductions in seed size that were observed in their progeny. Limitations to using wild common beans for breeding include: i) the undesirable agronomic characteristics of wild beans including poor architecture, small-seededness and long growing period, ii) the practical difficulty of crossing wild beans to cultivated beans given their very different flowering and maturity regimes and iii) the lack of breeding methodologies in the past to efficiently undertake wild x cultivated common bean crosses, as well as the labour involved in crossing schemes to incorporate genes from wild beans into cultivated types.

Advanced backcrossing for bean improvement

Advanced backcrossing has been shown to be a valuable method for using wild relatives in breeding programmes (11). Advanced backcrossing is based on the inbred backcross technique that was first applied to common beans by Sullivan and Bliss (10) to introgress seed protein content into bean cultivars from unadapted landraces. The advantage of this method applied to wild x cultivated crosses is that they transfer favourable alleles from unadapted germplasm into elite breeding lines while avoiding the negative effects of deleterious genes found in the wild. A further advantage of the advanced backcross method is that QTL (Quantitative Trait Locus) analysis of the resulting progeny can be used to identify positive alleles from the wild donor parent and these can be tracked in further crosses via marker assisted selection (11). While the advanced backcross-QTL method has been applied to wild relatives of a large number of inbreeding crops especially among the cereals, the method has not been applied extensively to the legumes. To date in common bean the International Center for Tropical Agriculture has made most use of the methodology by creating a set of advanced backcross populations from wild common beans crossed with several common bean cultivars (ICA Cerinza, INIFAP Tacaná and INIFAP Pinto Villa). In practical terms, the advanced backcross populations have been used to create a large set of advanced lines that have been tested in various environments. In one notable case, a black-seeded cultivar has been derived from a population derived from INIFAP Tacaná crossed with one of the wild accessions.

QTL analysis of an advanced backcross population

One of the advanced backcross populations, created from the cross of a Colombian large red-seeded commercial cultivar, ICA Cerinza, and a wild common bean accession from Colombia, G24404, was used to evaluate QTL for agronomic performance (2). Figure 1 describes the development of the 157 $BC_2F_{3:5}$ introgression lines which were evaluated for phenological traits, plant architecture, seed weight, yield and yield components in replicated trials in three environments in Colombia. Simultaneously the population was genotyped with microsatellite markers (Figure 2) that were used to create a genetic map that covered all eleven linkage groups of the common bean genome. Composite interval mapping analysis identified a total of 41 significant QTL for the eight traits measured, of which five for seed weight, two for days to flowering and one for yield were consistent across two or more environments; and 13 QTL for plant height, yield and yield components along with a single QTL for seed size showed positive alleles from the wild parent (2). It was notable that some QTL co-localised with regions that had previously been described to be important for the traits evaluated, while segregation distortion was most severe in regions of linkage group b01, b02 and b08 that were important for the domestication syndrome genes for determinacy, seed shattering and seed colour as described by Koinange *et al.* (7). Future work with this advanced backcross population as well as several others developed at CIAT will concentrate on analysing additional useful traits inherited from the wild accessions such as high seed iron accumulation and wide spectrum rust resistance. ■

(1) Beebe, S. E. *et al.* (2001). Crop Sci. **41**, 854–862.

(2) Blair, M. W. *et al.* (2006). Theor. Appl. Genet. **112**, 1149–1163.

(3) Chacón, M. I. *et al.* (2005). Theor. Appl. Genet. **110**, 432–444

(4) Freyre, R, *et al.* (1996). Econ. Bot. **50**, 195–215.

(5) Gepts, P. (2002). Crop Sci. **42**, 1780–1790.

(6) Gepts, P. and Debouck, D. (1991). In: Common beans: research for crop improvement, 7–53 (Ed. A. V. Schoonhoven). CIAT, Cali Colombia.

(7) Koinange, E. M. K. *et al.* (1996). Crop Sci. **36**, 1037–1045.

(8) Singh, S. P. (2001). Crop Sci. **41**, 659–1675.

(9) Singh, S. P. *et al.* (1995). Can. J. Plant Sci. **75**, 807–812.

(10) Sullivan, J. G. and Bliss, F. A. (1983). J. Am. Soc. Hort. Sci. **108**, 787–791.

(11) Tanksley, S. D. and Nelson, J. C. (1996). Theor. Appl. Genet. **92**, 191–203.

(12) Tohme, J. *et al.* (1996). Crop Sci. **36**, 1375–1384.

PhD thesis

Analysis of the mitotic chromosomes of the narrow-leafed lupin (*Lupinus angustifolius* L.) using molecular cytogenetics and computer measurement methods

*Charakterystyka chromosomów mitotycznych łubinu waskolistnego (*L. angustifolius *L.) przy zastosowaniu metod cytogenetyki molekularnej i analizy komputerowej*

by Anna KACZMAREK*

The main goal of this PhD dissertation was the characterisation of the mitotic chromosomes of the narrow-leafed lupin (*Lupinus angustifolius* L., 2*n* = 40), cv. Sonet. The identification of individual lupin chromosomes by traditional cytological methods is not possible due to their high numbers, size gradient, and similar morphology. Hence, molecular cytogenetics methods have been applied to physically map the *Lupinus* genome. In order to find chromosome markers in lupins, fluorescence *in situ* hybridisation (FISH) and primed *in situ* DNA labelling (PRINS and C-PRINS) methods were applied. FISH is an efficient and widely used method for establishing cytogenetic physical mapping and the location of DNA sequences on plant chromosomes. PRINS and C-PRINS procedures, analogous to the polymerase chain reaction (PCR) but performed directly on microscope slides, are suitable for localising short DNA sequences on chromosomes.

To obtain a preparation with sufficient metaphases, a cell cycle synchronisation procedure was applied, with hydroxyurea to block DNA synthesis and oryzalin for the accumulation of cells in metaphase. Permanent squash preparations were made from root meristems and the slides were stored at –20 °C.

In our studies, the rDNA (45S rDNA, 5S rDNA) and other telomeric sequences as well as BAC clones from a genomic BAC library of *L. angustifolius* (random clones and connected with the anthracnose and phomopsis stem blight resistance genes) were used as molecular labelled probes for FISH. For PRINS and C-PRINS procedures four DNA sequences were chosen: the fragment of the *Fok*I element from *Vicia faba*, the coding sequence from the cDNA library of the yellow lupin, the marker sequences for the anthracnose and phomopsis stem blight resistance gene of *L. angustifolius*.

The photographs of three metaphase plates were used for chromosome measurements by the computer program MicroMeasure 3.3. The mean values of absolute chromosome length ranged from 1.9 μm to 3.8 μm and of the relative length from 1.6% to 3.3%. All cytogenetic chromosome markers obtained, together with measurements of the chromosomes enabled us to construct the idiogram of *L. angustifolius* and identification of *L. angustifolius* chromosome pairs.

The results obtained provided a basis for further analysis with the aim of integrating the created cytogenetic map with the genetic map and verifying the linkage groups of *L. angustifolius*. ■

*PhD thesis 2007, Institute of Plant Genetics, Polish Academy of Sciences, Poznań, Poland. (azie@igr.poznan.pl)

EVENTS

May 20, 2008
Pre-Convention Symposium on Pulse Health and Nutrition
Puerto Vallarta, Mexico
Web: http://www.cicilsiptic.org

June 22–26, 2008
4th EPSO Conference 'Plants for Life'
Toulon (Côte d'Azur), France
Web: http//www.epsoweb.org/catalog/conf2008.htm

July 18–22, 2008
3rd Euroscience Open Forum – Barcelona, Spain
Web: http://www.esof2008.org/#l

August 30 to September 3, 2008
8th European Nitrogen Fixation Conference
Ghent, Belgium
Web://http//nfix2008.psb.ugent.be

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

November 5–7, 2008
7th Canadian Pulse Research Workshop
Winnipeg, Manitoba, Canada
Email: cprw@cici.mb.ca

November 24–27, 2008
BREEDING 08 'Conventional and Molecular Breeding of Field and Vegetable Crops'
2nd GL-TTP workshop as satellite event
Novi Sad, Serbia
Web: http://www.ifvcns.co.yu/breeding08/

June 28 to July 2, 2009
Ascochyta 2009
Washington State University, Pullman, USA
Web: http://capps.wsu.edu/conferences/ascochyta/

April 26–30, 2010
5th International Food Legume Research Conference (IFLRC) and 7th European Conference on Grain Legumes (AEP)
Antalya, Turkey
Web: http://www.grainlegumes.com

Give peas a chance – economic and environmental analysis in GLIP

Donnez aux pois leur chance! Analyse économique et environnementale dans GLIP

Europe imports over 70% of the protein concentrates required for animal feed, mostly as soyabeans or soyabean meal. This situation is problematic in several economic and environmental respects.

The objectives of Work package 2.2 (Economic and Environmental Analysis) of the European project GLIP[1] were twofold: 1) to assess the economic and environmental impacts of grain legumes in animal feed and human nutrition and 2) to identify constraints to the increase of grain legume use. Two tools were used to analyse these questions: (i) economic feedstuff modelling (linear programming), allowing the calculation of optimal feedstuff formulas based on the composition and price of raw materials and the cost of transport and (ii) life cycle assessment (LCA), addressing the environmental impacts of products and production systems throughout the whole life cycle. In this special issue we present a summary of the main results.

In the first paper we overview the animal production sector in Europe and highlight the potential uses of grain legumes for the different animal categories. The potential use of peas in the compound feed industry of several countries is estimated in the second contribution by means of feedstuff modelling. The third paper analyses the environmental impacts of replacing imported soyabean meal with European grain legumes in five LCA case studies for pig, poultry and dairy cows. The last contribution shows the environmental impacts of four human meals with different ingredients; with two types of meat, partial meat replacement and a fully vegetarian meal. ■

[1]Work package 2.2 of the Grain Legumes Integrated Project (grant no. FOOD-CT-2004-506223) was undertaken by a research team consisting of seven partners from six countries (see page 24)

L'Europe importe plus de 70% des concentrés protéiques nécessaires à l'industrie de l'alimentation des animaux, essentiellement sous forme de graines ou tourteaux de soja. Cette situation pose des problèmes d'ordre économique et environnemental.

Une des parties du projet GLIP1 (le sous-module 2.2 des analyses économiques et environnementales) a eu un objectif double : 1) évaluer les impacts économiques et environnementaux des légumineuses à graines pour l'alimentation animale et humaine ; 2) identifier les contraintes à une utilisation accrue des protéagineux. Pour cela, deux outils ont été utilisés : (i) un modèle de simulation économique pour les aliments composés permettant de définir les formules optimisées à la fois sur la composition et le prix des matières premières et sur leur coût de transport, et (ii) l'analyse du cycle de vie étudiant les impacts environnementaux des produits et des systèmes de production sur l'ensemble du cycle. Ce dossier présente un résumé des principaux résultats obtenus.

Le premier article brosse le secteur de l'alimentation animale en Europe et analyse le potentiel d'utilisation des protéagineux pour les différentes espèces animales. Le potentiel d'utilisation du pois dans l'alimentation des aliments composés est dans le deuxième article à l'aide d'outils de modélisation. Puis les impacts environnementaux de la substitution du tourteau de soja importé par des protéagineux européens sont examinés dans cinq cas d'étude à l'aide d'ACV pour le cas du porc, de la volaille et des vaches laitières. Le dernier article analyse l'impact environnemental de quatre types d'aliments pour consommation humaine avec différents ingrédients, deux à base de viande et deux avec substitution partielle ou totale par des protéines végétales. ■

[1]Work package 2.2 of the Grain Legumes Integrated Project (grant no. FOOD-CT-2004-506223) was undertaken by a research team consisting of seven partners from six countries (see page 24)

European animal production and self sufficiency in plant proteins

Les productions animales et l'indépendance en protéines végetales en Europe

by Katell Crépon* and colleagues**

Current EU self-sufficiency in plant proteins is only about 30%. Although the EU increased its production of plant proteins by 230% between 1973 and 2003, the protein requirement for animal feed increased by 170% over the same period. The EU has never been self-sufficient in plant proteins, despite strong efforts to encourage the growth of protein crops. In the EU, self-sufficiency in protein concentrates varies widely in the different member states, from 4% in the Netherlands to 46% in France). This is due both to the diversity of crop production possibilities in the EU but also to the diversity of animal production systems.

Self-sufficiency is a function of the supply of protein crops and the demand for protein raw materials. The demand can be influenced by factors including the type of animals fed, the production system, especially the duration and intensity, and the energy raw materials available. This article examines some factors influencing EU self-sufficiency in plant proteins.

Plant protein deficit varies

The supply of plant proteins varies throughout Europe. For example, the Dutch agricultural area represents only 1% of the European agricultural area, but the Netherlands produce about 10% of European compound feed. As a result, the Netherlands import 96% of the plant protein needed for feed from the world market. At the other extreme, France, whose agricultural area is the largest in the EU, imports only 55% of its required protein. Spain and Germany import 80% and 70% of their protein concentrates, respectively.

Imported proteins are predominantly soyabean, in the form of meal or seed. The average level of inclusion of soyabean meal in European feed formulas ranges from 17% in Belgium or the UK to 26% in Denmark, the Netherlands or Spain (Figure 1). The reasons for a high level of inclusion of soyabean are both technical and economic (2). Technical reasons include the steadily increasing levels of protein in feed formulas, and the use of large quantities of energy feeds such as maize and cassava which have low protein levels. Economic reasons could be the greater competitiveness of soyabean meal, especially in areas near ports like Le Havre and Hamburg.

Energy sources of feed formulas

Among the raw materials used in the feed industry, the energy sources (cereals, cassava, fat and oil) may represent up to 60% of the formula. Most high-energy feeds have relatively low protein contents, and therefore need to be complemented by a raw material like soyabean meal which is rich in protein. Therefore peas are a good complement to wheat, but not to maize or cassava. Wheat and barley are usually the main energy sources used in the EU feed industry, except in Spain, where maize is the major source. Cassava is not widely

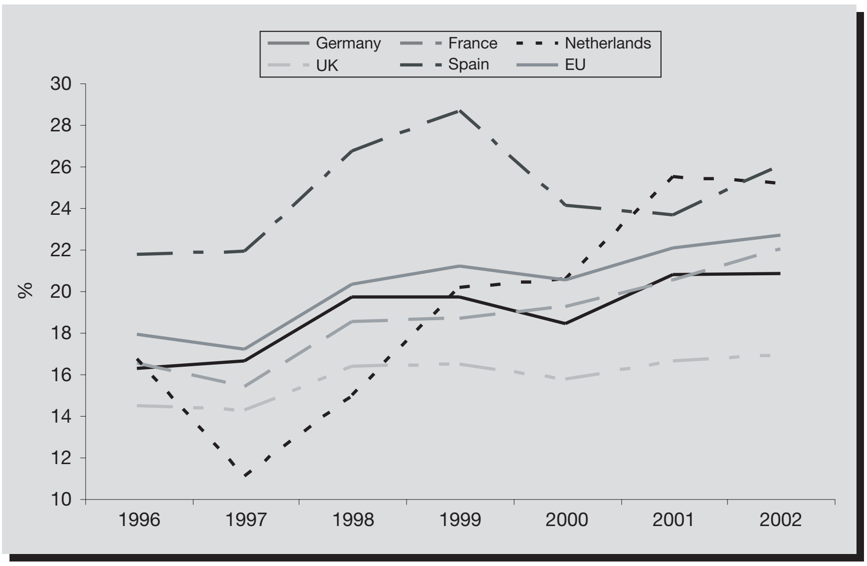


Figure 1. Average level of inclusion of soyabean meal in compound feed in the EU. (Source: EUROSTAT)

*UNIP, Paris, France. (k.crepon@prolea.com)

**Marta Busquet (CESFAC, Madrid, Spain), Lukáš Cechura (CZU, Prague, Czech Republic), Bruce Cottrill (ADAS, Wolverhamption, UK), Jan Hucko (CZU), Mónica Móntes (CESFAC), Frederic Pressenda (CEREOPA, Paris, France.)

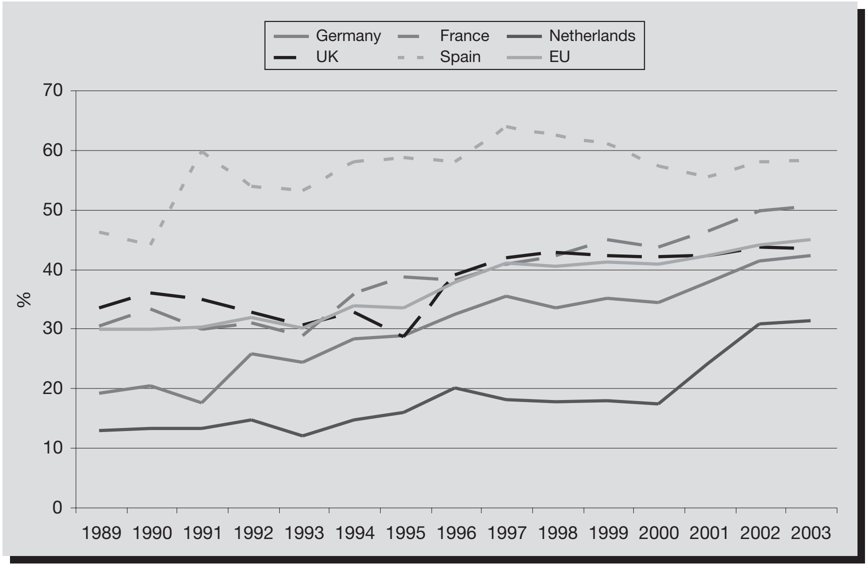


Figure 2. Average level of inclusion of cereals in the EU feed. (Source: FEFAC)

used except in Belgium and the Netherlands. This may explain the high level of use of soyabean in these countries.

The level of cereals in the diets is also variable (Figure 2): Belgium and the Netherlands use little cereals (about 30% of diets), whereas the average level in the EU is 44%. In contrast, Spain seems to be a huge consumer of cereals, using in excess of 50% of the diets.

Feed production in the EU

The simplest way to overview EU animal production is to study compound feed production. Feed production in the EU reached 140 millions tonnes in 2007. It has decreased since 2004 as a result of animal diseases (avian influenza) but has increased again since 2006. Pigs represent the largest sector of European compound feed production (34%), but in a few countries the main sectors are poultry feed (France, UK) or cattle feed (Ireland, Sweden). The type of feed is important when considering the supply in protein sources, because opportunities to substitute soyabean meal are more numerous in pigs or cattle feed than in poultry feed.

Protein deficit can be reduced for pig feed

The two main EU producers of pigs are Germany (26 million animals) and Spain (23 million animals). Together, they produce one-third of the EU-25 production. France, the Netherlands and Denmark, with about 12 million animals, produce 11%, 7% and 9% of EU production, respectively. The main differences between the member states are the pig farm structure, the environmental rules, and the availability of raw materials.

Pig farm size does not really influence their protein supply, which is not the case for the available agricultural areas per farm (Figure 3). In Spain and the Netherlands, about half the sows belong to farms which have less than 10 ha. At the other extreme, in the Czech Republic, Denmark, and the UK, the majority of sows are on farms that have more than 100 ha. On such farms, it is usual to produce feed with raw materials grown on the farm, and so possible to produce home-grown protein such as peas. A study in France on pig farms able to produce their own feed showed (based on economic optimisation) that when the rotation is optimised according to the pigs' requirements for raw materials, peas are frequently introduced in the crop rotation. This is not the case, however, when the crop rotation is optimised to maximise its gross margin. Moreover, this study showed a slight increase in farm profits when the crop rotation was optimised according to the pigs needs rather than to the crop gross margin (4). The use of peas in pig feed could save as much as 60% of imported soyabean meal (3).

Use of soyabean meal depends on the poultry rearing system

In 2003, the EU-15 produced about 9 million tonnes of poultry meat, of which 70% was chicken meat. The rest was mainly turkey meat (20%) and duck meat. France produced nearly a quarter of the total European poultry production, and the UK (17%), Spain (15%) and Germany (12%) were also important producers. The rearing period for chickens ranges from 35 to 80 days depending on the genetic type of the bird. From a nutritional perspective, the longer the rearing duration the lower the protein and energy levels of the feed (Table 1). The consequence of a long rearing duration is a lower inclusion level of soyabean meal in the feed and a higher opportunity price for pea. Increasing the length of the breeding duration could be a way to decrease the plant protein deficit, but currently, this kind of production system is less common in the EU. In France, 16% of the chickens are slaughtered at 80 days,

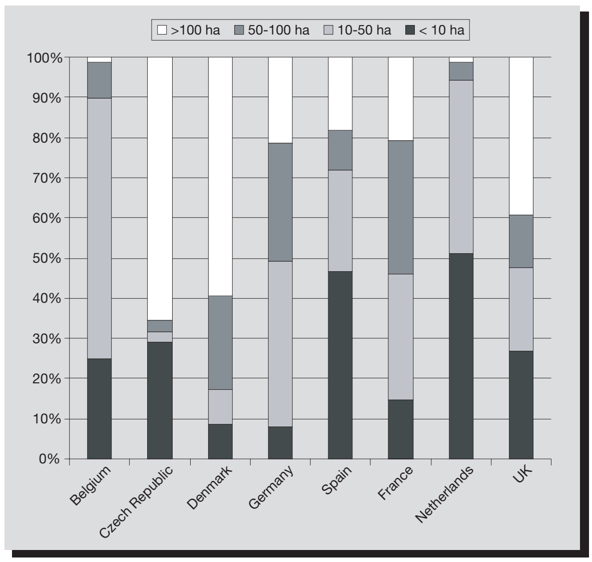


Figure 3. Distribution of sows according to the agricultural areas of pig farms. (Source: EUROSTAT)

Table 1. Opportunity price of pea according to the nutritional constraints of the formula (and the slaughtering age).

	Finishing standard (slaughtered at 42 days)	Finishing « medium » (slaughtered at 56 days)	Finishing « label » (slaughtered at 81 days)
Minimum energy (kcal/kg)	3200	3000	2900
Minimum crude protein (%)	20	17	16
Opportunity price of pea (€/tonne)*	118.4	132.9	136.8

*Raw material prices: March 2005. Source: UNIP, according to the ARIANE model.

8% at 56 days and the rest are slaughtered by 40 days. In the UK, less than 5% of chickens are slaughtered at more than 56 days of age.

High milk yields require high protein feed

Dairy cows are the main consumers of soyabean meal in the EU. Although dairy farms occur throughout the EU, the main production areas are located in the North of Europe: western France (9% of EU production), central and western UK (14%), the Netherlands (10%), Bavaria and western Germany (18%). Dairy farms are very similar from one country to another, and rearing systems are based mainly on the Holstein breed. Milk yield performance is heterogeneous and may vary from 5,600 kg/cow per year in Spain to 7,900 kg/cow per year in Denmark. Higher milk production requires higher protein supply whereas the intake capacity remains relatively stable (Figure 4).Therefore, higher milk production requires raw materials such as soyabean with a high level of protein. However, soyabean meal can be substituted easily by rapeseed meal to meet dairy cow nutritional requirements. In Germany, France and the UK, where rapeseed meal is increasingly available, it tends to replace soyabean meal in feed.

The other main difference between dairy systems in the EU is the nature of forage. Grazing systems based on herbage (pasture and grass silage) represent 36% of dairy farms in the EU, but account for only 32% of milk production. They are predominant in Sweden (95%), Finland (91%), northern UK (88%) and Ireland (83%) (1). In contrast, feeding systems based on maize (maize crops represent more than 30% of the forage area) represent only 11% of the dairy farms in the EU but 17% of the milk production. These systems are predominant in western France, Belgium and the Netherlands. Forage type may have an impact on protein supply, since maize has a lower protein content than grass.

The protein deficit can be reduced

The diversity of the European animal production sector, illustrated above, shows that the deficit in plant protein is the result of several causes including the type of predominant animal production (pigs or poultry), and the available agricultural areas at both the farm level and the national level. We have seen that some solutions exist to reduce this deficit, but situations are different between member states. For instance, a country like the Netherlands will never be self-sufficient in protein or energy sources, at least if the animal production sector remains at the same level! That's why self-sufficiency in protein must be considered at a larger scale.

Nevertheless, at the European scale, several leads can be investigated:

– Less intensive animal production (decrease the milk production, increase the rearing duration for poultry)

– Use cereals richer in protein (wheat rather than maize)

– Favour, when possible, the use of pasture for ruminants

– Increase and promote the use of other protein sources (pea, faba bean, rapeseed meals)

The combination of several solutions could help to reduce the European deficit in protein sources, while taking European diversity into account. ■

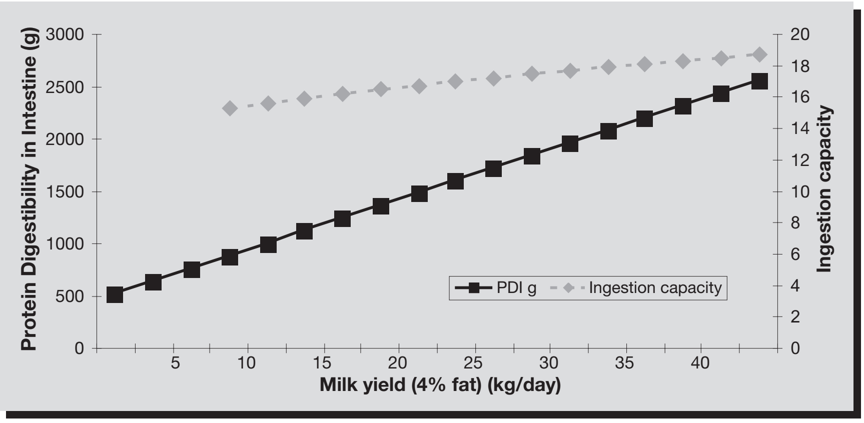


Figure 4. Evolution of intake capacity and protein needs as a function of the milk yield (kg milk per day with 4% fat).

(1) Chatellier, V. and Jacquerie, V. (2003). La diversité des exploitations laitières européennes et les effets différenciés de la réforme de la PAC. INRA production animale, Paris, France.

(2) Delplancke, D. and Lapierre, O. (1998). L'approvisionnement européen en protéines : un handicap relatif ? Oléagineux Corps gras Lipides Vol 5, No. 4

(3) Pressenda, F. and Lapierre, O. (2002). Stratégies d'approvisionnement en protéines des fabricants d'aliments composés, CEREOPA, Paris.

(4) Teffène, O. (1999). Le porc dans les exploitations de grandes cultures. Institut Technique du Porc, Paris.

Peas in the feed industry and ways to increase their use

Place du pois dans les aliments composés et potentiel d'augmentation de ses utilisations

by Frédéric PRESSENDA* and colleagues**

The feedstuffs market for compound feed production was modelled in seven European countries, namely Germany, Denmark, Spain, Netherlands, Belgium, UK and the Czech Republic (1). This study showed that 90% of the peas used in this sector are incorporated in pig feed, significantly in excess of poultry (8%) and ruminant (2%) feeds. This article outlines the results, which are reported fully in (2).

Price per tonne curve

Models based on the market price of feedstuffs rely on the principle of animal feeding at least-cost.

A price per tonne curve for peas, showing the way in which the incorporation of peas in compound feed varies according to price, was constructed using data from each country (Figure 1). At a high price, the raw material is only occasionally included in compound feed formulas, or not at all (section C of the graph), and the market price of peas is higher than the shadow prices (the price a raw material must reach to be incorporated in a feed) in most of the compound feed formulas.

In part B of the graph, a small decrease in the price of peas results in a significant increase in use of the raw material. Inclusion levels are high, and many feed formulas include the raw material since the market price is lower than the shadow price.

Finally, in section A of the graph, the raw material inclusion increases only slightly in response to changes in ingredient price: in most of the formulas the maximum inclusion level has been reached (for nutritional or technical reasons).

Assessing the potential of peas

The maximum potential use of peas in compound feed is indicated at the left side of Figure 1. However, this maximum may be reached for very low prices which are not always affordable if they are lower than the production cost for the farmer. Potential levels of use based on the market prices of peas collected from official price publications in each country appeared to be a more reasonable approach. As shown in Figure 2, for most of the countries for which models were developed the potential use of peas is greater than the statistical data would indicate. This may be explained by the small volume of peas available on the market, as a result of which the market price of peas is not representative of a dynamic market. Sufficient tonnages and regular availability of peas throughout the year are required for feed manufacturers to establish a purchasing policy.

According to the feedstuffs models the amount of peas used for animal diets could be much higher if they were available in greater amounts: a fourfold increase or more in the use of peas in the study areas of the different countries could be possible if prices were close to the market prices observed. The greatest potential for increasing the use of peas was found in Spain (+1.6 Mt), Germany (+0.54 Mt), Denmark (+0.34 Mt) and the Netherlands (+0.29 Mt). With the exception of Germany, these countries are pea importers and/or small pea producers.

In all the countries, peas are particularly suited to pig feeding but could also be included in diets for ruminants or poultry if available in larger tonnages (Figure 3).

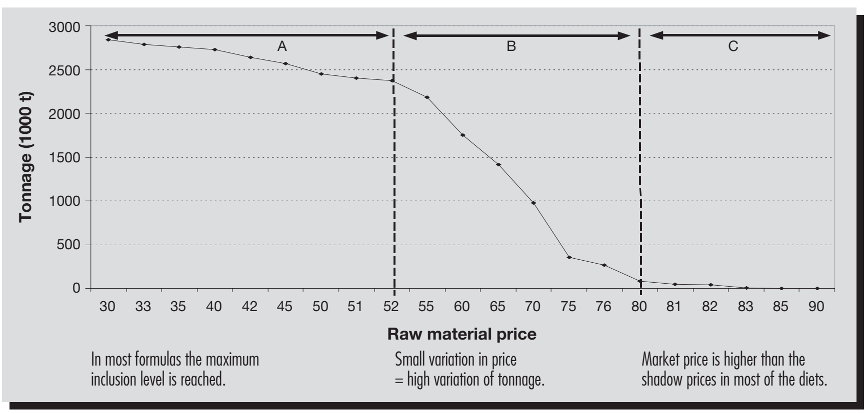


Figure 1. Example and explanation of a price/tonnage curve.

*CEREOPA, Paris, France.
(frederic.pressenda@agroparistech.fr)
**Katell Crépon (UNIP, Paris, France), Bruce Cottrill (ADAS, Wolverhampton, UK), Marta Busquet (CESFAC, Madrid, Spain), Lukáš Chechura (CZU, Prague, Czech Republic), Jan Hucko (CZU), Mónica Montes (CESFAC).

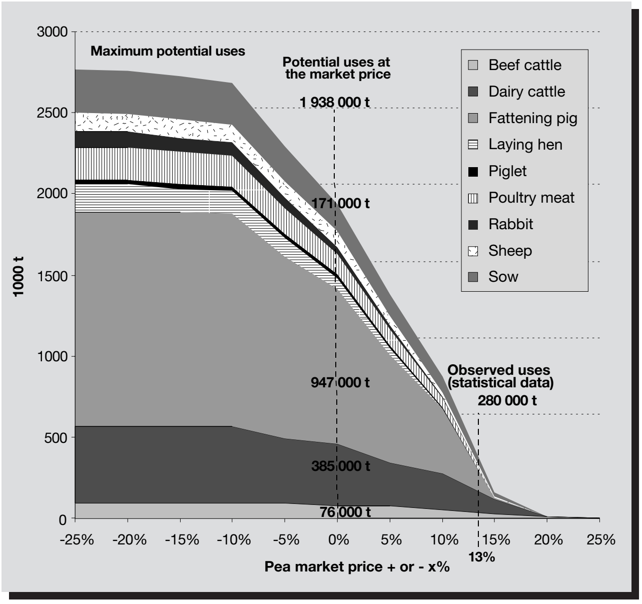


Figure 2. Assessment of pea potential uses by animals according to the variation of its market price in Spain in 2004.

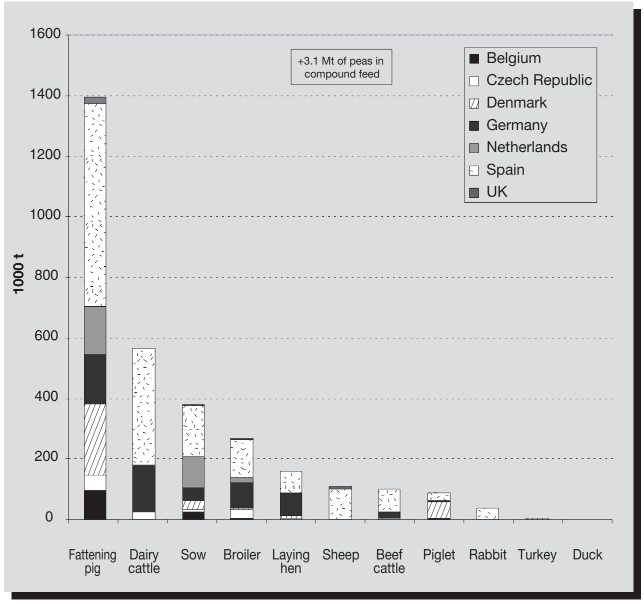


Figure 3. Potential increase in pea uses in some European countries by animal in 2004.

Table 1. Example of composition and cost of a fattening pig formula.

Raw materials	Level	Price (€/t)	Formula cost (€/t)
Wheat	60.00%	138.72	83.2
Wheat middling	15.00%	118.63	17.8
Rapeseed meal	10.00%	162.95	14.7
Barley	7.93%	131.56	12.3
Soyabean meal	2.47%	228.53	7.2
Palm oil	0.94%	400.76	
Mineral and amino acids	3.65%	–	18.4
TOTAL	100.00%		155.58

Table 2. Example of the nutritional composition of a fattening pig formula and the contribution of the constraints to the formula cost.

Constraints[1]	Level reached	Reduced cost (€/t)	Contribution to the formula cost (€/t)
Energy Pig (Mcal/kg)	2.30	52.35	120.41
Lysine (g/kg)	8.40	2.43	20.39
Threonine (g/kg)	5.50	2.40	13.20
Methionine (g/kg)	2.40	2.27	5.45
Tryptophan (g/kg)	1.50	3.39	5.08
Phosphorus (g/kg)	2.50	1.25	3.12
Mini Premix (%)	1.00%	250.22	2.50
Calcium (g/kg)	8.50	0.16	1.32
Maxi rapeseed meal (%)	0.10	-2.06 –	0.21
Maxi wheat middling (%)	0.15	-6.24 –	0.94
Maxi wheat (%)	60.00%	-4.49 –	2.69
Weight (%)	100.00	-0.12 –	12.05
		Total	155.58

[1]Only the constraints that are limiting have a reduced cost value (positive for minimum constraints and negative for maximum constraints), therefore not all the constraints contribute to the shadow cost of the formula or to the shadow price of the raw materials.

If greater volumes of peas were available on the market they could easily be used in compound feeds balancing pea price with available pea tonnages. In order to increase the quantity of peas used in compound feed, better communication of their benefits for animal feeding is necessary.

Shadow price v. shadow cost concepts

To increase the use of peas in compound feed, the real question is how to increase the shadow price of peas?

In order to minimise the cost of the formula, feed manufacturers usually use linear programming tools to define the composition of the compound feed they produce.

After optimising, the cost of the formula can be calculated by multiplying the percentage of each raw material by its price then adding the results (Table 1), or by multiplying the nutrient level of each constraint by its reduced cost then adding these results as shown in Table 2 for a fattening pig formula. In effect feed manufacturers buy raw materials but pay for nutrients.

The reduced cost corresponds to the amount that the formula cost would change if the nutritional constraint changed by one unit. For example, if the energy level requirement was increased by 0.01 unit (2.31 instead of 2.30 Mcal/kg of feed), the cost of the formula would increase by 0.52 €/t (from 155.58 €/t to 156.10 €/t). It is clear that the main nutritional constraint affecting the cost of the formula is the energy requirement and the contribution of this constraint reaches 120.4 €/t.

Economic interest in peas can vary

Analysis of the structure of the shadow prices for raw materials indicates that energy is the main element determining the value of the feed, especially in monogastric formulas.

The choice of nutritional system used for diet formulation can affect the potential use of peas. Using digestible energy (DE), metabolised energy (ME) or net energy (NE) gives ratios of 'pea energy value: soyabean meal energy value' of 0.95 (DE), 1.05 (ME) and 1.21 (NE). Peas clearly have an advantage compared with soyabean meal when rations are formulated using the NE system. When comparing the same energy value ratios for peas and wheat, only small differences between DE and ME (1.01 and 0.99) are observed. For net energy, the ratio reached is 0.92. Although the energy value of peas is then lower than that of wheat, the NE system favours peas because peas are more competitive than soyabean meal.

Environmental constraints may also influence the use of pulses. To avoid diets with high nitrogen contents, maximum limits for crude protein (CP) have been introduced in countries such as Germany and the Netherlands. Soyabean meal, with a CP content of 44% to 50% may then be less attractive than pulses (20% to 34% CP), particularly if synthetic amino acids are available to adjust the amino acids requirements of the diet.

Essentially, an increase of crude protein or amino acids content is only likely to have a positive impact where it is not associated with a decrease in energy value, while environmental constraints are more likely to favour raw materials with low protein but high amino acids content and digestibility.

Lack of market supply

All the tonnages of peas available on the market are consumed in the producing country or partly exported to neighbouring countries. The first limit to an increase in the use of peas in livestock diets is production capacity or import possibility.

Furthermore, feed manufacturers do not regard peas as an essential raw material. They can easily substitute peas with cereals and soyabean meal. Throughout the year the market price for peas may vary, both above and below their shadow price, particularly for poultry and ruminant formulas, and this can act as a further deterrent to feed formulators. ■

(1) Crépon, K. *et al.* (2005). Animal production sectors in seven European countries. Synthetic report, GLIP, FOOD-CT-2004-506223.

(2) Pressenda F. *et al.* (2007). Report on the economic analysis of the animal feed sector. The place of peas in the feed industry and ways to improve pea uses. Grain Legumes Integrated Project, EU contract FOOD-CT-2004-506223, Deliverable D 2.2.1b., 61 pp.

European grain legumes – environment-friendly animal feed?

Les protéagineux européennes – des aliments écologiques en production animale ?

by Daniel U. BAUMGARTNER, Laura de BAAN, Thomas NEMECEK* and colleagues**

Products of animal origin form an important part of the human diet in Europe. At the same time, animal production is economically the largest branch of European agriculture. In 2002, 37 million tonnes of meat, 33 million tonnes of milk and 5 million tonnes of eggs were consumed in the EU-15 (3). The large count of livestock needed to supply these products puts pressure on the environment by using non-renewable resources and by emitting nutrients and pollutants in water, soil, and air. Animal feedstuff production is known to contribute considerably to the environmental impacts of animal production.

Today, the European Union imports more than 70% of its protein sources for animal feed, mostly as soyabean meal from North and South America. Besides the adverse environmental impacts of long transport distances, the conversion of rainforests into arable land and the cropping of genetically modified varieties act negatively on consumers' acceptance. Cultivation of more grain legumes in Europe is expected to be an interesting alternative to the importation of soyabean meal, particularly since grain legumes, being capable of symbiotic nitrogen fixation, do not need any nitrogen fertilisation.

Case studies on meat, milk, and eggs

To analyse the environmental impacts of introducing grain legumes into animal feed in Europe, five case studies were conducted in four regions: pork production in North-Rhine Westphalia (NRW, Germany) and in Catalonia (CAT, Spain), chicken and egg production in Brittany (BRI, France), and milk production in Devon and Cornwall (DAC, United Kingdom). The selection of these regions was based on their national importance in producing the respective animal products (1). For all five case studies, a life cycle assessment (LCA) was calculated, comparing different feeding alternatives. In the life cycle approach, all stages of the agricultural production were included: the production of inputs and infrastructure (e.g. production of energy, machinery, fertilisers, seeds), crop production (e.g. fertiliser and pesticide application, harvesting, crop processing and storage, land transformation), and animal production (e.g. transport of feeds, direct animal emissions, manure management). Finally, the environmental impacts (emissions and resource use) for producing one kg of meat, eggs, or milk were assessed. Slaughtering and processing of the animal products are not considered here, but are part of the LCA of the food chain in the following article (2). The LCA calculations were performed with the Swiss Agricultural Life Cycle Assessment methodology (SALCA) as described in (5).

*Agroscope Reckenholz-Tänikon Research Station ART, Zurich, Switzerland. (daniel.baumgartner@art.admin.ch)

** Frédéric Pressenda (CEREOPA, Paris, France), Katell Crépon (UNIP, Paris, France), Bruce Cottrill (ADAS, Wolverhampton, UK), Marta Busquet, Mónica Montes (CESFAC, Madrid, Spain), Lukáš Chechura, Jan Hucko (CZU, Prague, Czech Republic), Jennifer Davis, Ulf Sonesson (SIK, Gothenburg, Sweden).

Table 1. Environmental impact of feed formulas with European grain legumes (GLEU alternatives) as a percentage of feed formulas with soyabean meal from overseas (SOY) for all five case studies (per kg animal product) in North Rhine-Westphalia (NRW), Catalonia (CAT), Brittany (BRI) and Devon and Cornwall (DAC) (++ = very favourable, + = favourable, 0 = similar, – = unfavourable, – – = very unfavourable; EDIP and CML are two alternative ecotoxicity impact assessment methods.)

	Region	NRW		CAT		BRI		BRI		DAC	
	GLEU as % SOY	Pork		Pork		Chicken		Egg		Milk	
Resource use-driven impacts	Energy demand (MJ-equivalents)	99%	0	94%	+	93%	+	94%	+	91%	+
	Global warming potential (kg CO_2-equivalents)	95%	+	98%	0	89%	+	89%	++	96%	0
	Ozone formation (g Ethylene-equivalents)	98%	0	106%	–	97%	0	95%	+	97%	0
Nutrient-driven impacts	Eutrophication (g N-equivalents)	93%	0	117%	–	105%	0	106%	0	102%	0
	Acidification (g SO_2-equivalents)	98%	0	98%	0	98%	0	99%	0	99%	0
Pollutant-driven impacts	Terrestrial ecotoxicity EDIP (points)	96%	0	126%	–	125%	–	124%	–	97%	0
	Aquatic ecotoxicity EDIP (points)	111%	0	127%	–	89%	0	125%	–	82%	+
	Terrestrial ecotoxicity CML (points)	376%	--	165%	--	108%	0	116%	–	95%	0
	Aquatic ecotoxicity CML (points)	176%	--	105%	0	104%	0	110%	0	95%	0
	Human toxicity CML (points)	103%	0	108%	0	100%	0	102%	0	97%	0

The different feeding alternatives were calculated using an economic optimisation model (6), providing the necessary nutrients for every animal category with a realistic feedstuff composition. The formulas contained five categories of feedstuffs: soyabean meal (origin: Brazil, USA, Argentina), different protein rich feeds (e.g. rapeseed, sunflower and palm kernel meal, maize gluten feed), European peas and faba beans, energy rich feeds (e.g. wheat, wheat middlings, barley, maize, beet and citrus pulp, cassava, oils), and mineral feeds (e.g. limestone, di-calcium phosphate, synthetic amino acids, vitamins). Dairy cows also had roughage feed (fresh or conserved grass) in their ration.

The following feeding alternatives were compared: SOY, standard feed formulas with soyabean meal (and in the milk case study with other protein rich feeds) as the major source of protein; GLEU, alternative feed formulas, where most of the soyabean meal was replaced by grain legumes from Europe (i.e. peas and faba beans) and different protein feeds. As grain legumes provide both protein and energy, a partial replacement of energy rich feeds also took place in those feed formulas. In two case studies additional feeding alternatives were analysed: the FARM alternative in NRW, i.e. simplified feed formula based on GLEU, with fewer feed ingredients, produced on the animal farm; and short-SOY in BRI, a more common chicken production system with a shorter fattening length, where inclusion of peas instead of soyabean meal was not possible for nutritional reasons.

Feedstuffs have a large environmental impact

As known from earlier studies, feedstuffs contribute greatly to the environmental impact of animal products. In nearly all case studies, feedstuff production (crop production, transport, and processing) accounted for more than half of the energy demand and the eutrophication potential (nutrient enrichment), for about two-thirds of the global warming potential, and for most of the ecotoxicity. For dairy cows, the impact of concentrate feeds on the environmental burden was still high, but was slightly lower because the cows, fed mostly on grass and grass silage, consumed less concentrate feed than other animal categories.

Overall, the environmental impacts of the feeding alternatives were in the same order of magnitude, with the GLEU alternative ranging from very favourable to very unfavourable compared with the SOY (Table 1). In Table 1 detailed results are presented classified in three environmental impact groups: resource use, nutrients and pollutants, defined by (4).

Lower energy demand and global warming potential

Introducing grain legumes into animal feeds reduces the demand for non-renewable energy in all case studies except in NRW, where the GLEU alternative is similar to SOY (Table 1). The favourable effect of the GLEU alternative results from reduced transport and from the fact that pea and faba bean production is less energy intensive than the combination of soyabean meal and energy rich feeds that they are replacing. This effect is illustrated clearly in the milk case study (Figure 1). In the GLEU alternative, most of the beet pulp and wheat is replaced by faba beans, resulting in a twofold reduction in energy demand: i) reduced use of N fertiliser (its production is energy intensive) and ii)

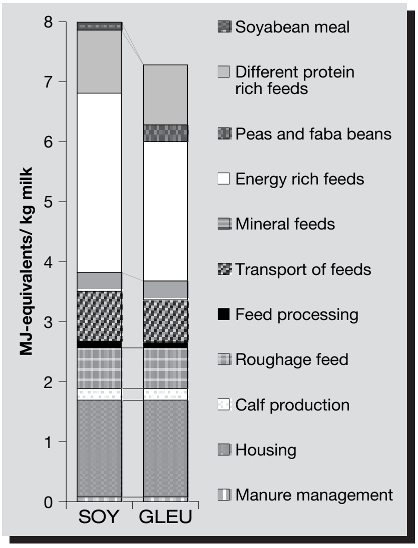


Figure 1. Demand for non-renewable energy resources for producing one kg milk in Devon and Cornwall (UK) with the two feeding alternatives, soyabean meal from overseas (SOY) or European grain legumes (GLEU).

reduced energy inputs for drying and processing crops. Of particular note is the low energy demand of roughage feed, although it accounts for 70% of the feed ration. As in the other case studies, housing (i.e. construction and operation of the buildings) has an important contribution to the total energy demand.

Global warming potential is reduced in all case studies except for CAT. This is largely due to the high global warming potential of soyabeans. The transformation of Brazilian rainforest and Argentinian savannas into soyabean cultivation areas leads to large releases of CO_2 from biomass and soils.

Sometimes higher eutrophication

Replacing soyabean meal with grain legumes had little effect on eutrophication (nutrient enrichment) (Table 1). In the pork case study in CAT, the GLEU alternative was unfavourable compared with SOY (Figure 2). This was mainly due to the lower yield levels of Spanish peas, resulting in high nutrient losses per kg of peas. Low yield levels combined with a twofold incorporation rate of peas in the feed formulas explain why producing one kg of pork meat in CAT caused nearly twice as much eutrophication as in NRW. Other reasons are a lower feed conversion rate in CAT, implicating an increased use of feed raw materials and increased losses of nitrogen and phosphorus through excretion, and unfavourable manure management (ammonia emissions from an uncovered slurry lagoon).

Higher ecotoxicity

The overall trend for terrestrial and aquatic ecotoxicity ranged between a similar to unfavourable effect of GLEU compared with SOY (Table 1). Only in the milk case study was the ecotoxicity of GLEU slightly reduced.

For the terrestrial ecotoxicity (according to EDIP97 methodology), cereals, rapeseed meal and peas dominated the results, while soyabean meal contributed little to this impact category. The reason lies in the applied active ingredients (pesticides) during the cultivation of the above mentioned crops. The detailed analysis shows that two active ingredients are responsible for the largest part of the terrestrial ecotoxicity according to EDIP97, namely i) the fungicide propiconazole, which is used in cereals and ii) the insecticide lambda-cyhalothrin, which is applied in pea, oilseed rape and cereal cultivation. Since the results for ecotoxicity are very dependent on the applied active ingredients and the method chosen to assess them, a careful interpretation of the results is required.

On-farm production is favourable

Transport can be reduced by using European instead of overseas protein sources, especially if feedstuffs and livestock are produced locally, or on the same farm. This option was assessed for the pork production case study in NRW. The results show clearly (Table 2) that, compared with SOY, the FARM alternative had a very favourable effect on resource use-driven impacts, a favourable effect on nutrient-driven impacts, and a similar to very unfavourable effect on pollutant-driven impacts. The reduced non-renewable

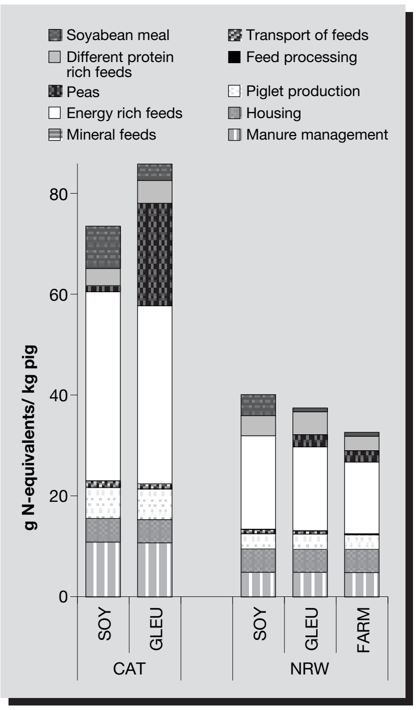


Figure 2. Eutrophication potential per kg pork produced in Catalonia (CAT) and North-Rhine Westphalia (NRW) with soyabean meal from overseas (SOY), European grain legumes (GLEU), or on-farm feed production (FARM).

Table 2. Environmental impacts of on-farm feed production (FARM) for pork in North Rhine-Westphalia (NRW) and standard feed formulas containing soyabean meal for the most common fattening length of 41 days (short-SOY) and 60 days (SOY) for chicken in Brittany (BRI), both expressed as a percentage of SOY (the standard feed formula with soyabean from overseas) per kg of animal product.
(++ = very favourable, + = favourable, 0 = similar, – = unfavourable, – – = very unfavourable; EDIP and CML are two alternative ecotoxicity impact assessment methods.)

	Region	NRW		BRI	
		FARM as % SOY		short-SOY as % SOY	
Resource use-driven impacts	Energy demand (MJ-equivalents)	81%	++	94%	+
	Global warmig potential (kg CO2-equivalents)	84%	++	111%	–
	Ozone formation (g Ethylene-equivalents)	75%	++	105%	–
Nutrient-driven impacts	Eutrophication (g N-equivalents)	81%	+	102%	0
	Acidification (g SO2-equivalents)	90%	+	113%	–
Pollutant-driven impacts	Terrestrial ecotoxicity EDIP (points)	124%	–	79%	+
	Aquatic ecotoxicity EDIP (points)	103%	0	102%	0
	Terrestrial ecotoxicity CML (points)	317%	--	62%	++
	Aquatic ecotoxicity CML (points)	131%	–	65%	++
	Human toxicity CML (points)	97%	0	89%	0

energy demand and global warming potential were achieved mainly by reduced transport, but also because energy intensive crops such as grain maize were replaced partly by the incorporated grain legumes. This replacement was also the reason for the favourable effect on eutrophication and the unfavourable effect on terrestrial ecotoxicity in the FARM alternative.

The feeding alternatives in the broiler case study were all based on a medium fattening length of 60 days, except for the short-SOY alternative (41 days), which is actually the most common broiler farming system in BRI. The short-SOY alternative was favourable compared with SOY in terms of energy demand and ecotoxicity, but unfavourable in terms of global warming potential (CO_2 releases from clearing of rainforests), ozone formation (due to longer transport distances), and acidification (higher ammonia emissions, because of higher N-content in excretion). Thus, medium fattening length did not improve the overall environmental performance of chicken production, but was favourable for some environmental impacts.

Ecological feed optimisation?

Introducing European grain legumes into feedstuffs was expected to improve the environmental performance of animal products. The results of the five case studies on meat, egg, and milk production revealed that replacing soyabean meal with grain legumes did not lead to an overall environmental improvement. Clear benefits could only be found regarding the resource use-driven impacts due to less transport, reduced incorporation of energy rich feeds and absence of land transformation. There was little effect on nutrient-driven impacts, as the positive effects of the reduced use of soyabean meal and energy rich feeds were often (over) compensated by the negative effects of the cultivation of the grain legumes themselves or the accompanying protein rich feeds, especially sunflower and rapeseed meal. For the pollutant-driven impacts, the introduction of grain legumes in feedstuffs tended to be negative. Again the reason lies in the crop production, where the feed ingredients replacing the soyabean meal involve using particularly harmful pesticides. However, these results should be checked with improved ecotoxicity assessment methods, as in some case studies they vary considerably depending on different methodologies.

(Photo G. Braendle, Agroscope Reckenholz-Taenikon Research Station ART, Zurich)

Home-grown peas are useful in pig diets.

It must be underlined that replacing soyabean meal by grain legumes changes the whole composition of the feed formulas not only the part of the protein rich feeds. Consequently, the results are more determined by the whole composition of the feed formulas than by the replacement of soyabean meal by grain legumes.

The diverging results across the different environmental aspects highlight the importance of a holistic approach to the evaluation of the integration of European grain legumes in animal feed, enabling shifts to be detected from one environmental problem to another. As the feedstuff production has a major share in the environmental impact of animal products, improvements should target this part of the life cycle. As a possible measure we propose the integration of environmental criteria into feedstuff models, allowing the optimisation of feed formulas in terms of economic *and* environmental aspects.

Several factors have been identified that improve the environmental performance of animal products:

- Local feedstuff production is favourable.
- Manure management can be improved (e.g. by covering the slurry lagoon, adjusting the timing of slurry spreading and use of appropriate spreading techniques).
- Feedstuffs that need low levels of inputs for crop production *and* processing are favourable. Here, it is important to consider inputs in relation to yield levels; lower yields often lead to higher emissions per unit of the commodity.
- Improved feed conversion of animals reduces the consumption of feedstuffs and hence the overall environmental impact of animal products.

Finally, the consumption of large amounts of animal products has to be questioned, and this is discussed in the following paper (2). ■

(1) Crépon, K. *et al.* (2005). Animal production sectors in seven European countries: Synthetic studies preceding the building of models simulating the raw materials supply of feed compounders. GLIP report. 80 pp.

(2) Davis, J. and Sonesson, U. (2007). Grain Legumes **50**, 21-23.

(3) EUROSTAT, accessed November 2007. http://epp.eurostat.ec.europa.eu/portal/page?_pageid=0,1136206,0_45570467&_dad=portal&_schema=PORTAL.

(4) Nemecek, T. *et al.* (2005). Ökobilanzierung von Anbausystemen im schweizerischen Acker- und Futterbau. Agroscope FAL Reckenholz, Zürich; Schriftenreihe der FAL 58, 155 pp.

(5) Nemecek, T. *et al.* (2007). Environmental impacts of introducing grain legumes into European crop rotations, Eur. J. Agr. (in press).

(6) Pressenda, F. *et al.* (2007). Grain Legumes **50**, 15-17.

Acknowledgements:
In addition to the European Commission (Grain Legumes Integrated Project), this research was supported by the Swiss State Secretariat for Education and Research SER, Berne, Switzerland.

We would like to express our thanks to J.-S. von Richthofen (proPlant GmbH, Münster), H. Jebsen (Agravis Raiffeisen AG, Münster), as well as R. Fechler and W. Sommer (North Rhine-Westphalia's Chamber of Agriculture, Münster) for providing data and information.

Pork or peas for a better environment?

Porc ou pois pour un meilleur environnement ?

by Jennifer DAVIS*, Ulf SONESSON* and colleagues**

Food products cause environmental impact throughout the whole food chain, from extraction of raw materials used in farming and farming itself, through energy use in transport and processing as well as in the household. Moreover, production and waste management of the packaging used also contributes. To give an example of the impact of food production systems globally, it is estimated that 25% of the total emissions of greenhouse gases are due to the food chain.

The environmental impact of different food products varies a lot between products, depending on the type of raw material, level of processing and packaging, and also transport distances. For greenhouse gas emissions the difference between one kg of potatoes and one kg of beef can be two orders of magnitude. The way the food is grown can also cause large differences between seemingly similar products; tomatoes grown in fossil fuel heated glasshouses cause about four times the global warming potential as similar field grown tomatoes, even if transport differences are considered. There are however some rather general conclusions that can be drawn on the environmental impact of foods. One conclusion is that products of animal origin generally cause more impact than products of vegetable origin, although one exception is the produce of glasshouses heated with fossil fuels. Another exception is air freighted fruits and vegetables. Nevertheless, as a hypothesis, it can be stated that substituting vegetable protein for animal protein is good for the environment.

*Swedish Institute for Food and Biotechnology, SIK, Göteborg, Sweden. (jd@sik.se)

**Daniel U. Baumgartner, Thomas Nemecek (Agroscope Reckenholz-Tänikon Research Station ART, Zurich, Switzerland).

The question we wanted to address was the following: What are the environmental benefits of introducing more grain legumes in human nutrition?

Four meals in two regions

We studied four different meals which included varying amounts of grain legumes. We chose a meal as the basis of comparison because it is not possible to look at individual components: meat and peas, for example, provide partly different nutrients. Therefore, if meat is replaced by peas, other ingredients must be adjusted to keep the nutritional value of the meals as similar as possible; hence a meal is the appropriate level of comparison. We looked at the function of the meal in terms of delivering nutrients. This is only part of the story because factors such as taste, not included here, are also important.

We also placed the studied meals in two countries, Sweden and Spain. The rationale for that choice is that these two countries are rather different in terms of food habits, waste management and electricity production. Moreover, there are differences in how food is cooked. It was thought that the results from two regions would facilitate a more general discussion about the importance of different factors than if only one region was studied. In both regions pork is a commonly consumed meat.

A complete presentation of the study, with all input data and detailed results can be found in (1).

The meals

The meals differed in the choice of protein source: pig meat produced with contemporary protein feed largely based on soyabean meal, pig meat produced with peas grown in Europe, part of the meat replaced with peas and finally a meal where all meat was replaced by peas. The composition of each meal was put together so that each meal provided the same (or similar) amount of protein, energy and fat, and also with the intention that the overall size of the meal and the proportions between the meal components were reasonable. The meals were as follows:

1. **SOY pork chop**: Pork chop produced with conventional feed (based on soyabean meal and cereals), potatoes, raw tomatoes, wheat bread and water;
2. **GLEU pork chop**: Pork chop produced with alternate feed (based on peas, rapeseed and cereals grown in Europe and some soyabean meal), potatoes, raw tomatoes, wheat bread and water;
3. **Sausage partial GLEU**: Meal with partial replacement of pig meat by peas; a sausage in which 10% of the animal protein is replaced by pea protein (the pork is produced with GLEU feed), raw tomatoes, wheat bread and water;
4. **GLEU burger**: Meal with full replacement of meat by a pea burger, accompanied by raw tomatoes, wheat bread and water.

The pork chops, sausage and burger were fried in a frying pan, the potatoes were boiled (Sweden) or oven baked (Spain), the tomatoes were eaten raw, the bread was made from wheat and baked in a large scale bakery. The water was tap water (Sweden) or bottled water (Spain).

Producing the meal components

The systems for delivering the meals are briefly described below.

Meat

The pigs were reared on a farm, and transported by truck to a slaughterhouse where the meat was produced and delivered to the retailer, possibly via a wholesaler. At the retailer the meat was stored in a cold cabinet. The bones were used for producing meat and bone meal; the hides were used, for example, for gelatine production or as leather. The stomach content and sludge generated at the slaughterhouse was sent to the waste management system.

Sausage with pea protein

The sausage was produced from meat, pea protein, potato starch and water. The process consisted mainly of mincing and mixing the ingredients, forming the sausage, and heat treatment. The primary package was LDPE plastic, and secondary (transport) packaging was also added. The sausages were delivered by truck to the retailer and stored in a cold cabinet.

Vegetarian burger

The burger was produced from ground dried peas, potato starch, rapeseed oil and water. The burgers were fried and then deep frozen with liquid nitrogen, packed in cardboard packaging and then stored. They were delivered to the retailer by truck and then stored in a freezer cabinet.

Bread

The wheat was transported to a mill, where it was milled. The flour was delivered to a bakery where bread was baked. The bread was delivered to the retailer by truck.

Vegetables

The vegetables, potatoes and tomatoes, were transported to a packer, where they were cleaned and packaged. The packaged products were delivered to a wholesaler and thereafter distributed to retailers.

Bottled water

Water was pumped from the source and filled in plastic bottles, and subsequently delivered to retailers via storage at the wholesalers.

Households

The consumer bought the components of the meal at the retailer and transported them home either by car, on foot or by bus. At home the products were stored in the freezer (burger), refrigerator (pork chop, sausage) or at room temperature (bread, tomatoes and potatoes). The pork chop, sausage and vegetarian burger were fried in a pan, the potatoes were boiled or oven baked. The other meal components were served as they are.

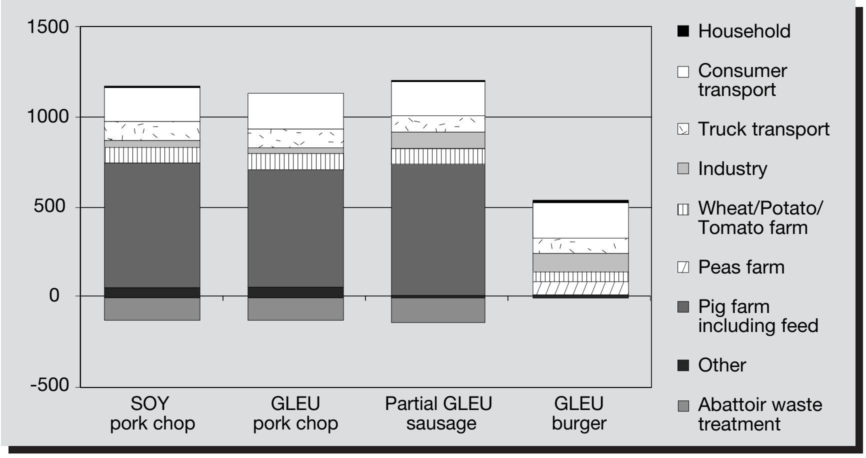


Figure 1. Global warming potential for the Swedish meal scenarios (g CO_2 equivalents/meal).

Vegetarian meal has low emissions

The results presented include the total life cycle environmental impact, including the production of farm inputs (feed, fertilisers and fuels), farm activities, transport, processing, retail, home transport and cooking. Production and waste management of packaging is also included. Selected results are presented here, but the full results can be found in (1).

Figure 1 shows the contribution to global warming for each of the Swedish meals. When comparing the two pork chop meals, there was very little difference between the pork that was produced with soyabean based feed and the pork produced with feed based on peas. The meal with sausage had a higher contribution to global warming than the pork chop meals. This is because all the meals had to contain similar amounts of protein and energy and therefore the amount of pork had to be higher in the sausage meal compared with the pork chop meals in order to fulfil these requirements. The pork chop meals contained a lot of potatoes in order to fulfil the recommended energy levels for the meal. The amount of sausage in the sausage meal had to be as high as it was in order to achieve the same level of protein as in the pork chop meals (which contained protein from both pork and potatoes). The contribution to global warming from the production of peas for the pea protein in the sausage meal was negligible, so one way of decreasing the impact from the sausage meal would be to increase the share of pea protein in the sausage (which was 10% of the total protein in the sausage in our case), but of course, this is also a matter of sensory quality. The

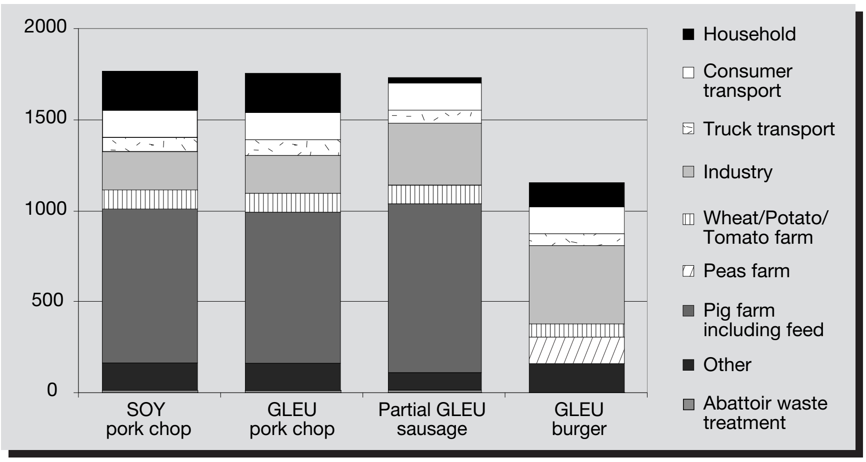


Figure 2. Global warming potential for the Spanish meal scenarios (g CO_2 equivalents/meal).

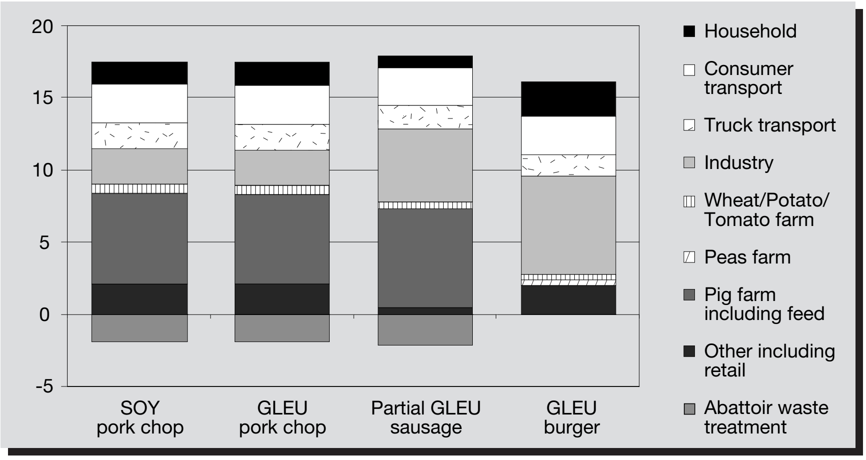


Figure 3. Use of non-renewable and renewable energy for the Swedish meal scenarios (MJ-equivalents/meal).

negative contribution in the first three meals was due to 'avoided emissions'; we assumed that waste from the slaughter process (fat and bones) was incinerated to generate heat, and that this heat replaced the combustion of oil (which is the marginal energy source). The vegetarian meal had a much lower contribution to global warming than the meal with animal protein.

For all meals, the consumer transport, i.e. the transport between the shop and the household, contributed considerably to global warming.

The results for the Spanish meals, shown in Figure 2, were similar to the Swedish meals in that the internal correlation between the meals was the same, but overall the contributions to global warming were higher than for the Swedish meals. One reason for this is the electricity production in Spain, which is based partly on the combustion of coal; as the figure shows, industry contributed significantly to global warming, due to the use of electricity. As the pea burger meal required a lot of electricity, the contribution was higher in the Spanish scenario than the Swedish case, but the contribution was still only two-thirds of that of the meals with animal protein. Furthermore the production of the food raw materials led to higher emissions.

Energy use similar for all meals

Figure 3 and 4 show the use of primary energy (non-renewable and renewable) for the Swedish and Spanish meals, respectively. The energy use for all four meals in each scenario was in the same order of magnitude, but the overall energy use was higher for the Spanish meal, mostly due to the energy needed to oven bake the potatoes (which were boiled in the Swedish meal).

The pea burger meal was as high in energy use as the other meals because we assumed that the pea burgers were sold as a frozen product; hence a lot of energy would be used for freezing it during industrial preparation, then storing it in a freezer both at the retailer and at the consumer.

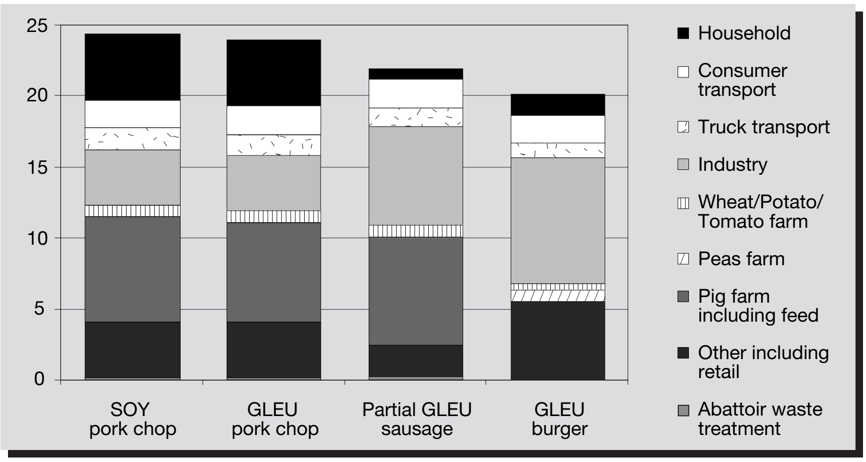


Figure 4. Use of non-renewable and renewable energy for the Spanish meal scenarios (MJ-equivalents/meal).

Benefits, but scope for improvement

The conclusions and recommendations of the study were as follows:

– The vegetarian pea based meal had a significantly lower environmental impact than the animal protein based meals in both the Swedish and Spanish scenarios. However, the energy use did not differ much between the meals.

– To achieve an environmental gain by replacing animal protein with pea protein in meat products, a larger share than 10% of the animal protein needs to be replaced. It is significantly more environmentally beneficial to provide a fully vegetarian meal, than to replace 10% of the animal protein in a meal with vegetable protein.

– The potential to develop more energy efficient processing for pea based food products needs to be explored.

– Raw material efficiency, that is, reducing wastage at all stages in the production chain, is a key issue to lower the environmental impact of all meal types, especially for food products such as pork, which have a high impact at the farm level.

– The resource efficiency at the farm level (for example, yield) plays an important role in the overall environmental impact of a meal, but the stages after the farm are also very important. In terms of energy use, a significant amount is used in industry, at the retailer, transporting the food from the retailer, and also for storing frozen foods and cooking food in the home. Further work is needed to explore ways of improving the energy efficiency of all these steps. ■

(1) Davis, J. and Sonesson, U. (2008). Environmental potential of grain legumes in meals. Life cycle assessment of meals with varying content of peas. SIK Report 771, Swedish Institute for Food and Biotechnology (SIK), Göteborg, Sweden.

EU grain legumes for feed uses – conclusions

Les protéagineux en alimentation animale en UE – conclusions

by Thomas Nemecek* and GLIP partners**

Our results show that the European deficit in protein concentrates could be reduced by increased grain legume production in Europe, but the situation varies greatly between countries. Peas as the main species are well suited for pig compound feed and also for poultry and dairy cows, as long as the production intensity is not too high. The feedstuff model yielded surprising results: the potential use of peas in the seven countries examined (Belgium, the Czech Republic, Denmark, Germany, the Netherlands, Spain and UK) was estimated at 4.1 million tonnes, whereas current production is only 1.0 million tonnes! This discrepancy is explained mainly by the limited availability of peas on the market. But why do we have this discrepancy between the demand for peas and their supply on the market? As the GL-Pro results presented in *Grain Legumes* **45**, 13–22) have shown already, the profitability of crop rotations with grain legumes is at least as high as that of common crop rotations. Further research is needed to better understand the functioning of the pulse feed market.

In contrast with many people's belief, the main economic value of peas was in the energy and not the protein, especially for monogastric animals. Furthermore, the feed evaluation method used for ration formulation strongly affects the inclusion of peas: the net energy system leads potentially to higher pea use than the digestible or the metabolised energy systems. The feedstuff model showed that peas are not an essential part of compound feed formulas, since they can be substituted easily by other raw materials.

The life cycle assessment (LCA) studies of animal production systems showed that replacing soyabean meal by peas and faba beans in animal feed reduced transport impacts significantly, but did not bring an overall environmental advantage. That depended much more on the composition of the feed. There is not a direct 1:1 replacement of soyabean meal by peas. Since the nutritional properties are different, the whole feed formula must be changed. As the feedstuff optimisation model has purely economic goals (minimum price), it is not surprising that the environmental impacts are not necessarily reduced. By including environmental criteria in the optimisation models, an overall improvement could probably be achieved. This would require information on environmental impacts for all feedstuffs, but this is not available currently. The studies showed also that other options exist to reduce the environmental burdens of animal production, regional or on-farm feedstuff production and improved manure management being the most important ones.

As the differences between pork produced with soyabean-based feed and pea-based feed were small, so were the differences between human meals which included pork chops produced from these two feeds. The meal with partial replacement (10%) of meat by pea protein had a slightly higher environmental impact, since in such a meal much more meat would need to be replaced in order to achieve a substantial reduction in the environmental burdens. The fully vegetarian alternative clearly had lower overall environmental impacts, but needed a lot of energy for processing, showing a great need for optimisation. Environmental impacts can be reduced further by reducing food waste at all stages (increasing efficiency of food use) and by improvements in food ingredient production in agriculture.

The economic and environmental analysis in the GLIP project showed that there is potential for peas on the feedstuff market, but that a simple replacement of soyabean meal by peas in animal feedstuff does not guarantee more environment-friendly animal production or human food sectors. Further efforts are needed to give grain legumes their place in a sustainable agriculture. ■

*Agroscope Reckenholz-Tänikon Research Station, ART, Zurich, Switzerland. (thomas.nemecek@art.admin.ch).

**Daniel Baumgartner and Laura de Baan, ART, Zurich, Switzerland. (Daniel.Baumgartner@art.admin.ch; laura.debaan@art.admin.ch),
Katell Crépon UNIP, Paris, France. (k.crepon@prolea.com),
Frédéric Pressenda, CEREOPA, Paris, France. (pressend@inapg.fr),
Ulf Sonesson and Jennifer Davis, SIK, Göteborg, Sweden. (ulf.sonesson@sik.se; jd@sik.se),
Bruce Cottrill, ADAS, Wolverhampton, UK. (bruce.cottrill@adas.co.uk),
Lukáš Cechura and Jan Hucko CZU, Prague, Czech Republic. (cechura@pef.czu.cz; hucko@pef.czu.cz),
Marta Busquet Sole and Mónica Montes CESFAC, Madrid, Spain (busquet@cesfac.com) (montes@cesfac.es)

Acknowledgement: We would like to thank the European Commission and the Swiss State Secretariat for Education and Research (SER, Berne, Switzerland) for their financial support.

The dynamics controlling the grain legume sector in the EU – analysis of past trends helps to focus on future challenges

Les dynamiques de la filière économique des protéagineux dans l'UE – analyse pour faire face aux défis de demain

by Anne Schneider* and colleagues**

The technico-socio-economic analysis of the development and dynamics of the grain legume economic chain in Europe was discussed with experts (scientists and stakeholders, in the AEP network and the Eurocrop project) in order to assess its strengths and weaknesses, the actors and factors influencing its functioning and the opportunities and threats that this sector faces (2, 3, Figure 1). These discussions form a basis for defining a strategy in which legume crops really contribute to sustainable agriculture.

Grain legumes in brief

Between 2003 and 2006, the world production of grain legumes averaged 268 million tonnes per year, 78% of which was soyabeans. Grain legumes other than soyabeans amounted to 60 million tonnes. In recent years, EU production of grain legumes amounted to 5.9 million tonnes (2.2 million ha) and was composed of 45% pea and 22% faba beans. In general, the EU outlets are mainly animal feed (about 80%) with some expanding added value markets, such as food exports and food ingredients. The area dedicated to grain legumes in the EU is relatively low: only 1% to 7% of the arable crops area according to member states compared with 10% to 30% outside Europe.

*AEP, Paris, France
(a.schneider-aep@prolea.com)

**Colleagues from the Grain Legumes Working Group of Eurocrop: Anthony Biddle, Benoît Carrouée, Yves Crozat, Gaetan Dubois, Gérard Duc, Noel Ellis. Eric Steen Jensen, Marie-Hélène Jeuffroy, Tanja Moellman, Fréderic Muel, Thomas Nemecek, Fréderic Pressenda, Olaf Sass.

Following the rapid increase in the 1980s, EU production of grain legumes reached a kind of ceiling between 1998 and 2000 with variations among years followed by a decreasing trend since 2005 (Figure 2). Their development has been accompanied by research and development but the on-going enhancement of these crops is in fact recent compared with other arable crops such as cereals, oil-crops and potatoes. (See also Insert 1.)

Major strengths

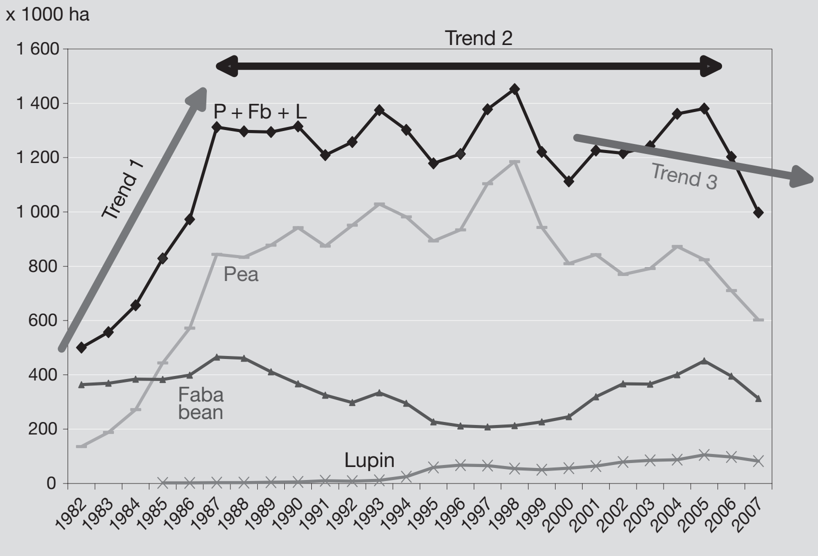
The fact that grain legumes are nitrogen-fixing plants is their unique characteristic and key strength. They do not need fertilisers to grow well and therefore have economic, agronomic and environmental advantages. The yield of the following crop is higher, the rotation costs lower and soil quality is maintained. The consumption of fossil energy and the emissions of greenhouse gases (and other pollutant substances) are significantly reduced when farm rotations include legumes. In addition, the different properties of the grains, providing protein and starch[1] (meeting protein and energy demands), and having health and functional properties (ingredients for food or non-food uses) are important benefits.

Opportunities

The current climate of increasing energy prices is an opportunity for low energy demanding legume crops. Development of grain legume production is also favoured

Strengths	Weaknesses
- Energy efficiency - Decrease GHG emissions - N-fixing plants - Increase following crop yield - Source of protein + starch	- Low volumes - Unstable yields - Substitutable feed materials - Few GL-specific industries
- Environment-friendly claims - Outlets largely available - Capacities & resources in R&D - Human health concerns - Increase in energy prices - Environmental taxes	- Loss of interest from farmers or from cooperatives selling chemicals - Genetic progress slower than other crops
Opportunities	**Threats**

Figure 1. SWOT analysis of the grain legumes economic sector in the EU: strengths, weaknesses, opportunities and threats (1).



Trend 1: a phase with a very positive trend: incentives for protein sources: guaranteed price for farmer and subsidy for the first user; rapid increase in peas which is adapted to most regions.

Trend 2: a kind of ceiling: Maximal Guaranteed Quantity (since 1988); Specific aid (€56) kept in CAP reform; Aphanomyces root disease.

Trend 3: recent negative trend: Climate accidents in spring; competition with other crops benefiting from policy, market and industrial support.

Figure 2. Trends in areas of grain legumes in the EU and major factors related to each of the major phases (Eurocrop-GL-WG, 2008). *(Areas from UNIP, with EU-15 until 2003, EU-25 until 2006, EU-27 in 2007).*

by their beneficial effects on the environment: low emissions of greenhouse gases (GHG) (Kyoto protocol), photo-oxidants and acidification (Göteborg protocol).

Furthermore, the outlets for grain legumes, which can provide both energy and protein, are far from saturated: the EU deficit in materials rich in proteins for the feed industry is 75%. Their seed composition is complementary to other raw materials and so there are several market opportunities. There are also niche markets with added value being developed (ingredients for industries, diet and healthy food). More added value markets could also increase interest in this crop chain.

Grain legumes represent only 3% of the arable area in the EU whereas a possible target could be up to 10% to 15% of arable areas because there are legume species adapted to all EU arable regions.

Insert 1.

Grain legumes and EU agricultural policies

There were no dry peas and very limited areas of faba beans and lupins in the EU at the beginning of the 1980s. Following the American embargo on soya in 1973, areas of peas, faba beans and lupins in Europe increased impressively during the 1980s as a result of a pro-active EU policy for protein-rich sources and a standardising of the market: a minimum price guaranteed to farmers growing peas, faba beans or lupins, and a use subsidy for the first user (usually the compound feed manufacturers) within the framework of the EU Common Agricultural Policy (CAP). Peas, which are adapted to most regions, were the most successful species representing 80% of production.

In 1998, a Maximum Guaranteed Quantity (MGQ) was fixed at 3.5 Mt for grain legumes, but this was essentially the CAP reform applied from 1 January 1993 (CAP reform 1992 called 'Mac Sharry') which changed things radically: the guaranteed prices were reduced to be nearer the market prices, especially for arable crops, and direct subsidies were applied with mandatory set-aside. Despite the aid, grain legumes related income decreased sharply for farmers in this period. The reform in 2000 (Agenda 2000) strengthened these trends without compensating fully the decrease in the guaranteed prices and kept a small differential for grain legumes which was not a great enough incentive compared with the minimum prices of cereals.

The new CAP reform of 2004 transferred aid per tonne into aid per hectare and grain legumes got a standard decoupled aid of €55.57/ha in the EU with Maximum Guaranteed areas of 1.6 million ha for the EU-25.

Grain legume outlets

The price of feed pea is directly linked to the prices of the two main raw materials used in animal feed: wheat (or other major cereals such as maize or barley) and soyabean (1). There is a high variability in the market prices of raw materials but the current prices are quite attractive. The major exporting countries of peas, faba beans and lupins in the world are France, Canada, the UK and Australia.

In terms of end use, the major competitor of EU grain legumes is imported soyabean meal (4). Therefore exploiting the benefits of local raw materials should be the main lever for EU grain legumes: for example, exploiting the environmental benefits of local production, health claims and regional specificities, inputs for regional rural development and local industrial contracts.

Why is the EU area decreasing?

Since 1990, grain legume areas have fluctuated between 1,200,000 and 1,400,000 ha (EU-15) (Figure 2). In the 1980s agricultural policy incentives had a strong impact on grain legume developments to meet feed industry requirements. However the policy changes put in place before this sector reached maturity made the economic chain weaker since the grain legume sector was not yet established as a 'major crop chain'. These changes occurred at the same time as some technical problems that were not yet controlled because genetic progress was only beginning for these crops. The occurrence of Aphanomyces root disease affecting pea (the most frequently grown species) impacted on the grain legume areas and yields in the 1990s. In the most recent campaigns, the high temperatures and water stress at some critical stages of the cycle (spring time, April, May or June) also impacted strongly on the yields of grain legumes.

Therefore the changes in market policies, the attractiveness of other lower-risk crops backed by political strategies, combined with the diseases and climatic accidents in the campaigns of the past decade, have resulted in reduced volumes of grain legume crops. This in itself creates problems for the durability of the grain legumes chain unless voluntary strategies are set up.

Insert 2.

Major challenges for the grain legumes chain now and in the future

1. Reinforce chain organisation to reach self-sufficient stage of development: information, references, partnerships, policies and market rules
2. Increase the yield stability of legume crops for more predictable yields (while maintaining quality of end products): boost genetic progress and accelerate transfer to breeding applications
3. Optimise agricultural systems by exploiting the benefits of legumes: improved crop rotations and farm systems; allocating an economic value to the environmental benefits
4. Meet the new demands and develop new outlets: using health and functional properties

Insert 3.

How legumes can contribute to sustainability?

In order to reconcile economy and environment, the EU is looking for sustainability.

The declared objectives of EU agriculture are to produce more high quality food and non-food materials and to manage crises and risk (soil- or climate-based risk and market fluctuations), with the obligation of reducing the possible negative impact of agricultural activities on the environment (water quality, biodiversity, green-house gas emissions and public health).

The sustainability of agriculture requires especially (i) energy efficient production and utilisation systems, (ii) a diversification of crops and a reduction in environment-damaging emissions, (iii) a local supply of safe and healthy raw materials for all uses and (iv) consideration of nature and biodiversity.

Since nitrogen is the key factor for agricultural productivity and competitiveness and also for environmental quality, legumes with their ability to use renewable nitrogen can contribute significantly to all these different needs.

For productive and sustainable farming, crop diversity is necessary to maintain soil quality, ensure the diversity of wild flora and fauna, and reduce pressure from diseases and weeds: increasing the yields of crops and reducing the quantity of crop protection chemicals – critical for water quality and human health, are only possible by alternating crops in diversified rotations.

The key issue is how farmers and industrialists should utilise the ability to use renewable nitrogen for added value in economic systems – whether it should it be through favouring diversified rotations with low nitrogen inputs or by other procedures.

Identifying weaknesses and threats

The major technical weaknesses, such as the lack of reliable yields, and the current low volumes of production, make the chain fragile. The poor contractual links with industry is certainly also a weakness, and so the current increase in interest in innovative agro-industrial uses for grain legumes might play a positive role. The major threat is associated with the threshold of supplies, and this makes the technical advice, collection and distribution stages of the economic chain more difficult.

Economic and market factors

At the farm level, rotations that include grain legumes are as profitable as other crop rotations when well managed: with the current specific aid for protein crops taken into account, similar rotation margins are obtained. However farmers and advisors usually consider only the crop margin and therefore the benefits of the preceding pea (higher yields and lower input costs for the cereal) are included in the margin of the following cereal. The margin of the whole rotation ('rotation margin') should be the indicator used to demonstrate effectively the benefits of diversification in crop rotations.

In addition, local stakeholders must commit to grain legumes so as to ensure favourable logistics for the supply of inputs and seed collection in the regions. The decisions of farmers at the beginning of the agricultural campaign are also based on a wish to minimise risk. Therefore they are currently more easily attracted by crops supported by policy strategy and/or under contracts with industrial users (malting barley or biofuels).

Action?

Currently, it is a matter of urgency to develop the grain legume sector up to a minimum stage (volumes, technical advice, logistics) so as to create a self-sufficient economic chain (Insert 2). Since the outlets are not the major problem, the key issue is to make these crops more attractive for growers: improve crop competitiveness and risk management for farmers, through (i) policy and industry support (general strategies, incentives and contracts) as well as through (ii) systems that put an economic value on the environmental benefits.

At the same time, the level and stability of legume crop yields should be tackled: greater investments in breeding to accelerate the tolerance of grain legume crops to major yield constraints and the development of winter types, and also technical innovations to facilitate crop management.

A joint strategy is needed

Past experience with legume crops shows the joint impact of agricultural policies, technical problems, and commercial opportunities offered to farmers.

Given the current EU challenges, legume crops could provide a clue for the development in the EU of more sustainable agriculture, that would be energy efficient, less polluting and based on home production (Insert 3). Therefore we need to define further the joint strategy among scientists, economic players and policy makers, to fully exploit this legume sector in Europe and take advantage of the human scientific resources that have been mobilised for legumes.

Currently, it seems that increasing the attractiveness of grain legumes so that EU farmers want to grow them is the most important challenge.

The grain legume sector in the EU is still a relatively new and fragile arable crop chain and needs to be consolidated in the current fluctuating socio-economic context, so that its strengths in using home renewable nitrogen can be exploited for the benefits of a sustainable EU agriculture. ■

---

[1]except soya and lupin which produce protein and oil.

(1) Carrouée, B. and Lacampagne, J.-P. (1999). *Grain Legumes* **26**, 22–23.

(2) Collective (2008). Grain legumes chain – Synthesis report by the GL working group of Eurocrop (FP6-2004-SSP4-022757) – Version 2.

(3) Collective (2008). La filière protéagineuse-quels défis? Editions QUAE, INRA grain legume group ISBN 978-2-7592-0072-6, 148 pages.

(4) Schneider, A. *et al.* (2007). Dynamics and prospects for grain legumes in the European feed market, *Grain Legumes* **49**, 20–21.

On-farm conservation of the genetic diversity in Moroccan faba beans

Conservation à la ferme de la diversité génétique dans les fèves marocaines

by Mohammed SADIKI*

Faba bean (*Vicia faba* L.) is one of the most ancient crops in Morocco. This crop represents 50% of the 500,000 ha planted annually to grain legumes. Grain yields average less than 0.7 t/ha whereas the potential of the crop is far higher, approaching 6–7 t/ha.

More than 97% of the cultivars currently used by farmers are local varieties and landraces that have been selected by them for different conditions. These local populations, adapted to climatic stresses and local pests in the various environmental niches and social cultural conditions, provide a rich source of germplasm.

For this reason *in situ* on-farm conservation has been advocated as an approach to maintain the genetic diversity of faba bean in the ecosystems where it has been generated.

On-farm conservation of landraces raises issues of quantifying and assessing genetic diversity in relation to geographic distribution and to farmers' named and managed varieties.

Phenotypic diversity associated with geographic origin

Local populations of faba bean (2088 entries) were collected together with information from on-farm surveys throughout the main production areas in Morocco. To classify this germplasm into gene-pools to facilitate its conservation and use, the analysis of an extracted sample of 312 accessions generated from 10 main geographical zones was analysed for seed characteristics, and 33 phenotypic traits were evaluated in the field. 71 lines were used to conduct molecular analysis to describe the collection diversity, to cluster the accessions based on similarities for the measured traits and to reveal 168 different markers.

The study revealed substantial variability in this local faba bean germplasm and demonstrated a tendency for the lines to cluster according to their geographical origins.

Farmers' perception of diversity reflects genetic diversity

The structure of genetic diversity in relation to farmers' perception of the distinction between local types of faba bean varieties was studied in order to: i) understand the genetic distinctiveness and population structure of faba bean populations maintained on farm with respect to farmers' criteria for naming and managing these varieties; ii) assess the consistency of farmers' naming of the faba bean cultivars they grow; iii) suggest options for strengthening on-farm conservation and promoting local faba bean cultivars.

Results showed that farmers in different villages use different names to designate faba bean varieties described by the same set of seed and pod traits. Names and farmers' descriptions of local faba bean varieties in northern Morocco were collected together with seed samples from 185 randomly selected farms in 15 villages belonging to five communities of three provinces. The farmers were asked to list the names and describe the local types of faba bean varieties they know and grow. Characteristics of each cultivar were listed along with distinctive traits according to each farmer's statement. The consistency among farmers for naming the local varieties of faba bean was assessed by the percentage of farmers recognising the same variety by the same name and description (2). Some varieties have different names, such as *Foul Sbaï Lahmar, Foul Roumi* and *Lakbir Lahmar,* but are described by the same traits by farmers. In other instances, varieties such as *Moutouassate Labiade* are described differently by different farmers. Finally, other cases were found where the varieties were not given specific names, but were designated by a generic name 'Beldi', although farmers were able to distinguish different units within this 'Beldi' category without giving precise names. Consistency in names of faba bean varieties was noted among farmers of eight Moroccan villages in three different communities using a non-parametric correlation coefficient for pairs of villages based on Chi-square. Additionally, the consistency of variety names was compared to consistency of sets of traits farmers used to describe varieties and found that sets of traits to describe a variety had much higher consistency over geographical areas than variety names (2). Consistency of variety names among farmers is highest between close villages (villages of the same community). The consistency index (correlation coefficient) decreases as geographic distance between villages increases, significantly more rapidly for names than for traits (Figure 1), indicating that sets of agromorphological traits have the potential to be more consistent over geographical space than names.

The final confirmed list consists of 10 different named varieties or types distinguished by farmers and based on seed characteristics, plant morphology, cooking ability and taste. Nevertheless farmers also asserted that within each type there were variations among seed lots grown by different farmers. To identify the genetic structure of these named varieties,

*Institut Agronomique et Vétérinaire Hassan II (IAV), Rabat, Morocco. (m.sadiki@iav.ac.ma)

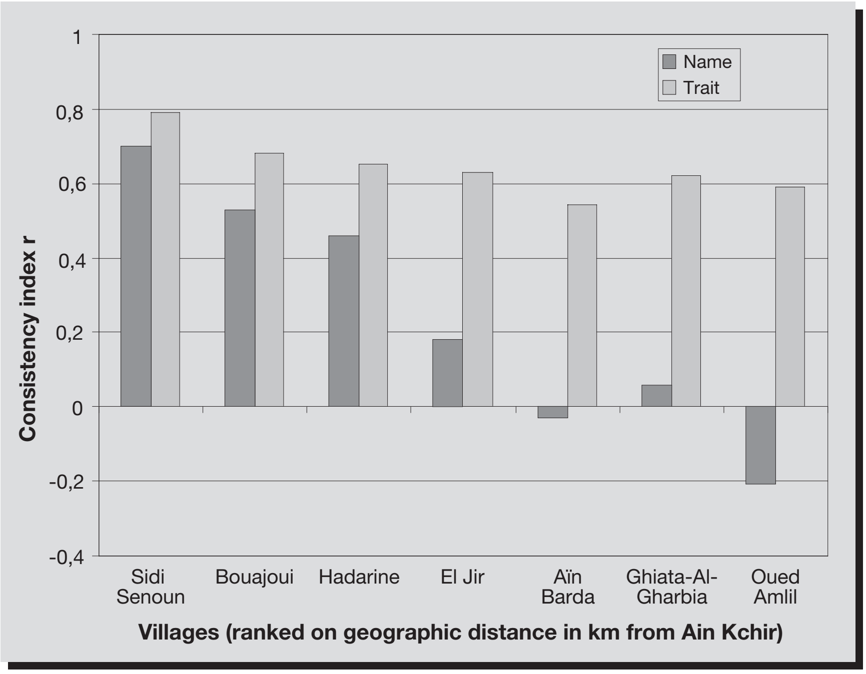


Figure 1. Comparison of consistency of names with consistency of traits among villages for the faba bean variety Foul Sbaï labiade based on consistency index (r)[1].

morphological characterisation was conducted on-station and on-farm. The phenotypic variability was analysed within and between the 10 described types based on seven seed lots per type. A large amount of phenotypic diversity was shown among these variety types for most analysed characteristics. Hierarchical Cluster Analysis and Multivariate Discriminant Analysis revealed that the seed lots bearing the same name generally clustered together. The accessions ranking pattern established for these 10 local varieties based on phenotypic traits is very consistent with the farmers' descriptors of faba bean variety. Indeed 94% of the 70 accessions analysed were correctly classified in their variety types based on similarities of agromorphological traits. Therefore, the phenotypic clustering pattern closely agrees with farmers' descriptions of the local varieties. The distinction of the varieties based on the phenotypic characters corresponds to the farmers' perceptions in designating the varieties (2).

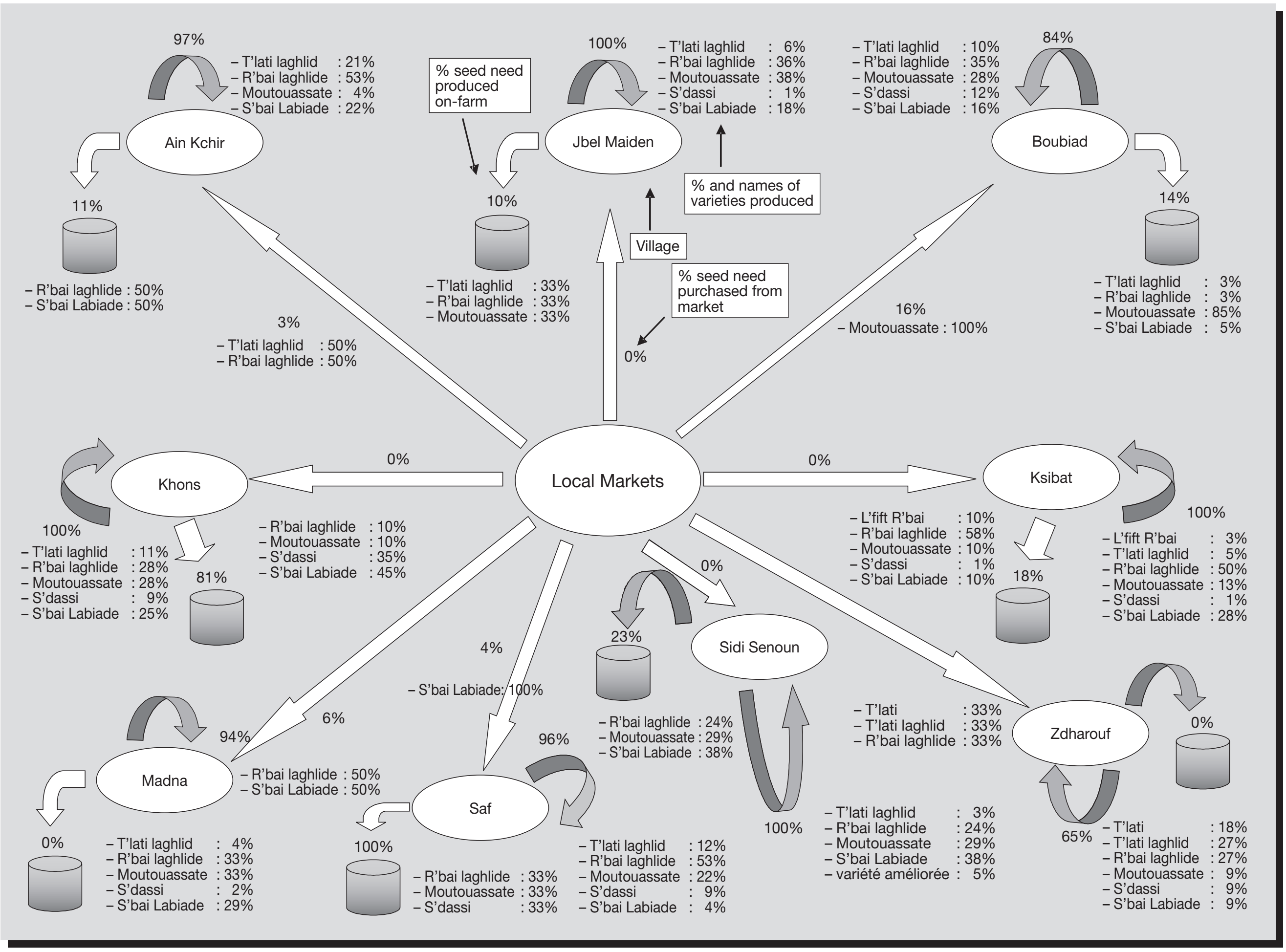


Figure 2. Synthesis scheme of the faba bean seed flows and composition in and out of villages in Ourtzagh community following a good production year.

(Photo AEP, Paris, France)

Technical discussion in a faba bean field in Taouanate in Morocco.

Local seed management is important

In the informal sector local seed systems that are mainly in the hands of rural communities play an important role in the distribution of local genetic diversity and the shaping of its structure (3). For this reason it was decided to assess the potential of seed systems as a way of supporting *in situ* conservation and use of genetic diversity on farms. The objective was to quantify the seed flows in local networks and determine how they relate to the spatial and temporal distribution of genetic diversity in the faba bean crop on farms (1).

The analysis was based on on-farm investigations of the local seed exchange, supply and farmers' named varieties. The consistency of the names used in the distribution system for the faba bean crop, was conducted in the province of Taounate in Morocco for a good rainy season, a medium season and a dry season. All faba bean cultivars used in the region are local farmers named varieties. Among the surveyed farms, 88% produce their own seed, but only 17% produce their entire seed requirement. The rest of the farmers use more than one seed supply source and choose seed each season. The composition of the seed flow was analvsed in terms of each local varietv (Figure 2). Drought has an important impact on the diversity by influencing seed composition over time through increasing seed renewal frequency. Nevertheless drought does not affect the spectrum of varieties cultivated in each village.

Prospect

The results of this work provided the basis for a new initiative 'Conservation and Use of Crop Genetic Diversity to Control Pests and Disease in Support of Sustainable Agriculture', a global project jointly developed by Bioversity International and four partner countries (China, Ecuador, Morocco, and Uganda) and funded by UNEP/GEF. The focus is to enhance the use of crop genetic diversity by farmers, farmer communities, and local and national institutions to minimise pest and disease damage on farms as a way to strengthen conservation. A key component of the project will be the recommendation of diversity-rich practices as a substitute for pesticide use. The project will develop tools to determine when and where intra-specific crop diversity can be used to manage pest and disease pressures by integrating existing farmer knowledge, belief and practices with advances in the analysis of crop–pest/disease interactions. Unlike Integrated Pest Management (IPM) strategies, which have focused on using agronomic management techniques to modify the environment around predominantly modern cultivars, this project is unique in that it concentrates on the management of local crop cultivars themselves as the key resource, making use of the intra-specific diversity among cultivars maintained by farmers. ■

(1) Sadiki, M. *et al.* (2005). In: Seed systems and crop genetic diversity on-farm' Proceedings of a workshop, 16–20 September 2003, Pucallpa, Peru, 83-87 (Eds D. I. Jarvis *et al.*). IPGRI, Rome, Italy.

(2) Sadiki, M. *et al.* (2007). Variety names: an entry point to crop genetic diversity and distribution in agroecosystems? In: Managing biodiversity in agricultural ecosystems, 34–76 (Eds D. I. Jarvis, C. Padoch and D. Cooper). Columbia University Press, New York, USA.

(3) Hodgkin T. *et al.* (2007). Seed systems and genetic diversity in agroecosystems. In: Managing biodiversity in agricultural ecosystems, 77–116 (Eds D. I. Jarvis, C. Padoch and D. Cooper). Columbia University Press, New York, USA.

[1]Coefficients of correlation between r (consistency index) and d (distance in km from Aïn Kchir to other seven villages) for names and traits = –0.537 and –0.173, respectively; degrees of significance of correlation for names and traits = 0.002 and 0.280, respectively.

AROUND THE WORLD NEWS

Canada

According to Agriculture Canada pea areas should continue to increase in 2008 because of high market prices, low stocks from previous campaigns and high costs of nitrogen inputs that handicap other crops such as cereals and oilcrops. On the other hand chickpeas are likely to decrease strongly because of the less interesting prices and large stocks.

United States

Pea areas are also increasing in the USA and now the USA has its share of pea exports to India and to East Africa.

India

In 2006–2007, India imported 1.4 million tonnes (Mt) of yellow pea, which is its main imported grain legume, used to replace part of the local chickpea (the winter crop) or pigeon pea (the summer crop) when the production of these crops is in deficit.

Australia

Drought is again the cause of low faba bean production in Australia. After the record harvest of 329,000 tonnes two years ago, Australian stakeholders estimate production at 125,000 tonnes.

Soya in the USA and South America

In the USA, production of soya in the previous summer (70.4 Mt) was slightly lower than in previous years and there was also a 16% decrease in area. In South America, the current Brazilian harvest could amount to 60–62 Mt and the Argentinian one to 47–48 Mt. The world production of soyabeans is estimated to be about 220 Mt for 2007–2008 harvest, and this is similar to the level of the 2005–2006 harvest. Meanwhile soya consumption is still increasing and, according to USDA, stocks were restricted to 63 Mt at the beginning of the 2007–2008 campaign.

Source: UNIP compilation from international sources.

GRAIN LEGUMES

The magazine of the European Association for Grain Legume Research

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

AEP
12, avenue George V, 75008 Paris, France
Tel: +33 1 40 69 49 09 · Fax: +33 1 47 23 58 72
http://www.grainlegumes.com
Grain Legumes magazine is available on subscription to anyone interested in grain legumes.
Subscription prices and ordering information are available from the AEP secretariat
or the AEP web site (http://www.grainlegumes.com)

Electronic prepress/*Infographie*
Printing/*Impression:*
Herald Graphics, Reading (UK)

Subscriptions/*Abonnements:*
AEP Executive Secretariat
Email: aep@prolea.com

Quarterly magazine/*Revue trimestrielle*
ISSN 245-4710
Commission paritaire n° 74 616

COVER PHOTO:
Photocomposition (Herald Graphics): Dairy cows, pig and chickens, faba beans and soyabeans / *vaches laitières, porcs et volaille, féveroles et soja*.
(Photos G. Braendle, Agroscope Reckenholz-Taenikon Research Station ART, Zurich)

GRAIN LEGUMES
Sponsorship list

AEP
European Association for Grain Legume Research
Association Européenne de recherche sur les Protéagineux

12 Avenue George V – 75008 Paris – France
Tel: +33 1 40 69 49 09 • Fax: +33 1 47 23 58 72
Email: aep@prolea.com • http://www.grainlegumes.com

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

12 Avenue George V – 75008 Paris – France
Tel: +33 1 40 69 49 14 • Fax: +33 1 47 23 58 72
Email: unip@prolea.com • http://www.prolea.com/unip

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

Research Station – Thornhaugh
PE8 6HJ Peterborough – United Kingdom
Tel: +44 1780 78 25 85 • Fax: +44 1780 78 39 93
Email: info@pgro.org • http://www.pgro.org

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
Passage des déportés, 2 – 530 Gembloux – Belgium
Tel: +32 81 62 21 37 • Fax: +32 81 62 24 07 • Email: appo@fsagx.ac.be

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

3 rue Joseph et Marie Hackin – 75116 PARIS
Tel: 33 (0)1 44 31 10 00 • Fax: 33 (0)1 44 31 10 10
Email: infos@arvalisinstitutduvegetal.fr • http://www.arvalisinstitutduvegetal.fr

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

Claire-Waldoff-Straße 7 – 10117 Berlin – Germany
Tel: 0049 30 31 904 202 • Fax: 0049 30 31 904 485
Email: info@ufop.de • http: //www.ufop.de

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
Rue de Liroux 8 – 5030 Gembloux (Belgique)
Tel: +32 81 62 67 70 • Fax: +32 81 61 58 68
Email: prodanim@cra.wallonie.be • http://cra.wallonie.be

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

1212–220 Portage Avenue – Winnipeg
Manitoba – Canada R3C 0A5
Tel: 204-925-4455 • Fax: 204-925-4454
Email: office@pulsecanada.com • http://www.pulsecanada.com

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.