Sections 8 & 11 from PCGIN annual report 2005/06 (approved 16/06/06)

Section 8: Summary of progress

Overview:

The project initiation was finalised in April 2005, and agreed that its timing would be backdated to the beginning of the year to take account of several activities that had been undertaken earlier in the year. Our activities have progressed under all objectives with the exception of objective 4, Reverse genetics. Actions in all areas are summarised below. For objective 4, the lack of activity does not correspond to a lack of progress. At the time of preparing this project we considered the access to pea gene sequence very poor for many purposes and therefore intended PCGIN to undertake some cDNA sequencing in order to rectify this problem. However the negotiation process for the project took much longer than initially anticipated so JIC undertook the sequencing of ~1000 ESTs as a matter of urgency. This was because the development of a small oligonucleotide array was about to be completed within the framework of the EU FP6 integrated project 'Grain Legumes'. Without intervention this array would have comprised mainly root expressed sequences and therefore not necessarily of maximal benefit to the intended stakeholders of the then proposed PCGIN. This gave us access to a total of 6000 EST sequences which were used to generate the oligonucleotide array. This array is available to PCGIN through the GL-TTP. Thus objectives 4a and b were completed before the project began. The generation of primers from these (and other) sequences developed within the EU FP6 integrated project 'Grain Legumes' is available to the PCGIN in a similar manner. JIC is currently in negotiation with the University of Melbourne where a large collection of pea meristem cDNAs is available and we may engage in some additional EST sequencing in collaboration with this group.

Within objective 1, 'Communication and Delivery' we have held several stakeholder and network management meetings and have established the PCGIN website, www.pcgin.org.
In objective 2, 'Phenotyping' we undertook some preliminary actions to attempt to harmonise and establish the small scale trials at JIC, NIAB and PGRO. This very useful exercise (initiated before the final project agreement was signed) identified difficulties that would otherwise have arisen in the 2006 growing season.
Objective 3 'Performance' has been a little delayed because of appointment problems at JIC, but we have used this delay for the collation of the relevant trial data from NIAB (3a) and consultation with the stakeholder group concerning the selection of cultivars for genotyping (3b). The genotyping of selected cultivars (3c) is about to begin.
The 'Genetic Mapping in Crop Legumes' (Objective 5) has progressed exceptionally well. Within 5(a, b), so far seven FN lines have been examined by AFLP analysis that has led to the identification of a good candidate for one pea gene regulating a clear trait. This is a strong vindication of this approach as a way of defining pea genes. Objectives 5 e to h remain to be finalised in discussion with the stakeholder group.
For objective 6 'Genetics of Seed Quality Traits', consultation with stakeholders and end-users has led to the definition of priority traits for pulse export markets and vining crops, as well as for animal feed; further input is being sought *via* the web-site (www.pcgin.org), where a summary document, available to registered members, seeks to involve the industry further in the choice of lines and protocols for Objective 6.

Detailed comments concerning each objective:

Objective 1: Communication and Delivery

To establish and promote effective communication between the major players responsible for the genetic improvement of pulse crops.

PROGRESS:

A dedicated web-site (www.pcgin.org) has been set up for the PCGIN in 2005, providing links to the other Defra-funded crop improvement networks: Wheat Genetic Improvement Network (WGIN: www.wgin.org.uk); Oilseed Rape Genetic Improvement Network (OREGIN: www.oregin.info) and Biomass for Energy Genetic Improvement Network (BEGIN: www.biomass4energy.org).

Two formal meetings were held to discuss organisational aspects of the other objectives. These meetings have been logged through the web-site. The agendas and minutes of the first planning meeting (20th June 2005) and the stakeholders meeting (20th September 2005) are available through the web-site. A display of novel genetic selections of pea plants, together with a demonstration of simplified marker-assisted selection procedures applicable to field-use, was included in the stakeholders' meeting. In addition, several informal interactions took place, including visits to JIC plots by PGRO and Cebeco, and a meeting of representatives from JIC, NIAB and PGRO to view and discuss the JIC plots of exotic germplasm (1st July 2005), also reported on the web-site.

The PCGIN has been advertised through additional interactions, including poster presentations, hand-outs and displays at a PGRO members' day (7th June 2005), Cereals 2005 (15th/16th June, 2005) and a PGRO Trade Day* (12th July 2005). JIC contributed to a presentation 'A Co-ordinated Approach to Crop Improvement in the UK' at a symposium on diversity for breeding at NIAB (14th/15th December 2005). JIC and PGRO representatives participated in a BEPA discussion meeting (18th November, 2005) and JIC contributed a lecture to the HGCA/PGRO Oilseeds and Pulses Conference: 'Facing New Challenges' (15th March 2006).

Articles describing the activities and objectives of the PCGIN have been published in 'Pea & Bean Progress' (the official journal of the PGRO; Winter 2005 edition, pp. 14-15) and in 'Grain Legumes' (the magazine of the European Association for Grain Legume Research; Grain Legumes 43, p. 6 [2005]). A collection of diverse legume germplasm was assembled to provide both demonstration material at the BEPA and HGCA/PGRO meetings, and a photograph for the cover of issue number 44 of 'Grain Legumes'.

SASA has been involved through the stakeholder meeting and has provided help and advice in relation to Objective 3 (see below). The PCGIN has been linked formally to EU-GLIP (www.eugrainlegumes.org) through joining the Technology Transfer Platform (GL-TTP).

The web-site now provides for registration of all interested parties. Registration of interested parties was established primarily to collect information on UK pulse research and related applied activities and interests, as requested by the stakeholders. The registration information is searchable, and registered members can access certain preliminary documents within the password-protected areas. This allows for input and feed-back on key PCGIN decisions, such as the selection of lines to be genotyped in Objective 3 and to be studied within Objective 6 (see below). Most of the information posted on the PCGIN web-site will be available on the 'open' part of the site. The registered part allows us also to post preliminary data for discussion and other scientific information and data prior to publication in journals.

A joint Unilever/JIC studentship was set-up during the formation of the network. A CCFRA/JIC proposal was drafted in the area of vining crop quality and submitted to Defra. A research project pre-proposal, linked to the PCGIN satellite project at CSL, York, and supported by both Advanta and Unilever, was submitted to the BBSRC-funded Crop Science Initiative (CSI) in December, 2005 by JIC. The proposed project 'Metabologenetics and quality traits' aims to study traits of interest within Objective 6 (see below). Similarly a proposal to develop collaborative crosses for association mapping was submitted to the CSI jointly with NIAB. This proposal was accepted for the development of a full proposal, but with the explicit exclusion of the legume part of the project.

* Prize won by THNE, JIC (Yield trial competition)

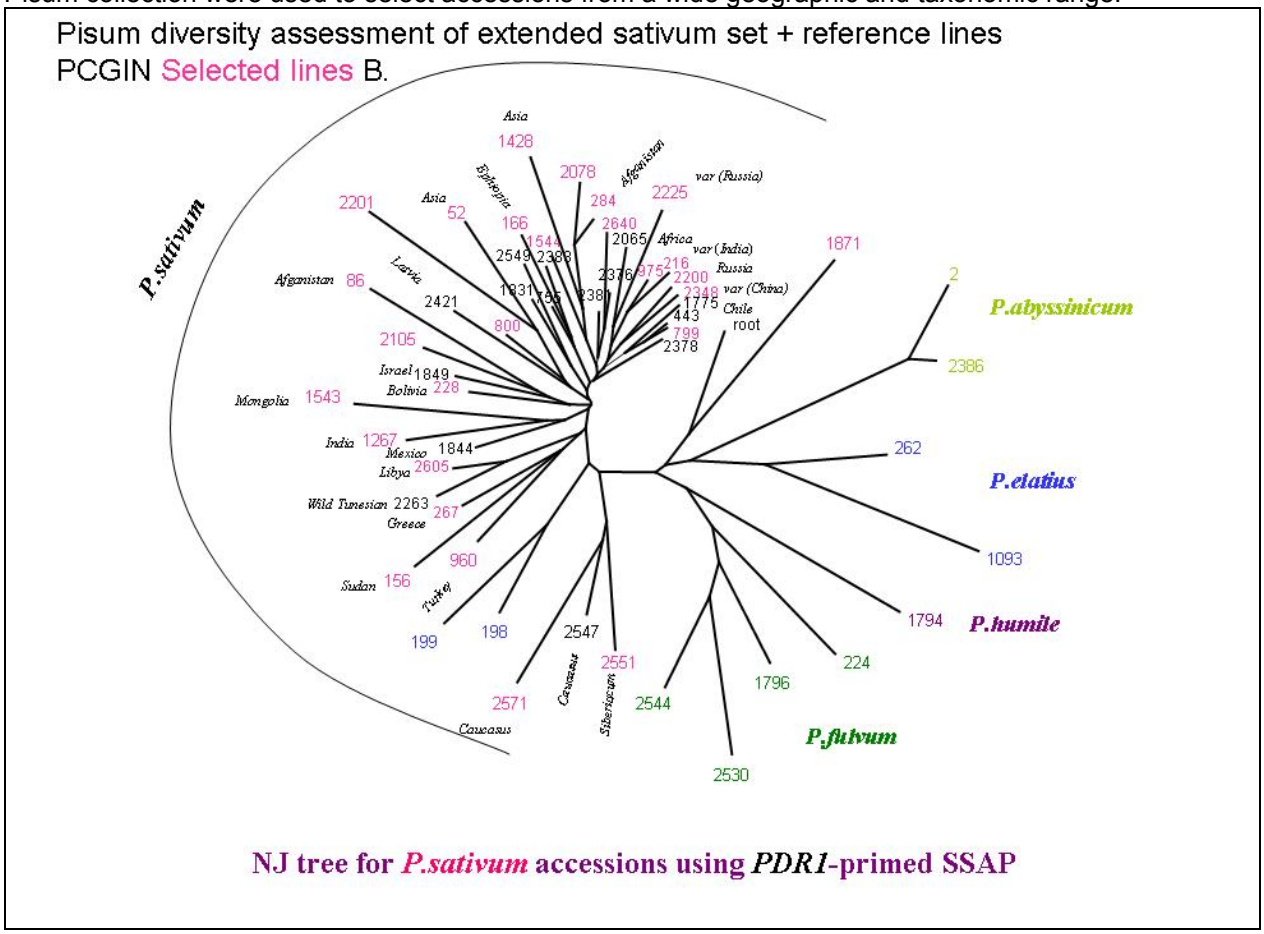
Objective 2: Phenotyping

Phenotypic characterisation of novel legume germplasm

PROGRESS:

Activities in Year 1 (Pea)

Pre-existing results from molecular marker studies on exotic cultivated germplasm from the John Innes Pisum collection were used to select accessions from a wide geographic and taxonomic range.



Five lines were included on the basis of their being parents of key mapping populations maintained at JIC, for which a lot of genotypic data is held (JI 15, 399, 281, 813, 1194). One line (JI 2282) was selected on the basis of its additional use in the project as the initial line for the Fast Neutron mutagenesis programme (Objective 5). Passport data for all lines was presented at the Stakeholder meeting on the 20th September (See www.pcgin.org, Meeting reports).

Microplots of the 47 exotic lines were grown at JIC, primarily for seed multiplication and as a pre-trial to help inform and highlight potential problems to be overcome in Year 2 onwards, when the multiple site trials proper would begin. The plots were not replicated within sites, due to the fact the fact that stock levels for germplasm are generally not sufficient to meet such needs. The plots were regularly monitored and scored for flowering time, height at flowering, downy mildew and lodging. Photographic records of the plots were undertaken from the end of May through to the middle of July when a complete set was taken of all plots. Photographs of a selection of plots were presented at the Stakeholder meeting held on the 20th September (See www.pcgin.org, Meeting reports).

A subset of six of the exotic lines grown at JIC (JI 181, 228, 281, 284, 804 and 2424) was grown in short rows at PGRO and NIAB. A meeting of all those involved in growing these lines and participating in the planned multi-site microplot experiment met to view all JIC plots on the 1st July 2005, and to discuss husbandry and data recording. (See www.pcgin.org for a report on 'PCGIN meeting 1st July). Following the plot visit, there was a discussion of the experiences and issues that had arisen with this exotic germplasm on the separate sites. Germination was found to be very variable with the exotics and one line (JI 181)

was particularly poor. In the early seedling stage, significant weevil damage had been incurred on all lines and, later in the season, pigeon and crow damage to plants (stripping of foliage and damage to young pods) was heavy on both sites. Measures to deal with both these problems and other plant husbandry issues were discussed. The key points that emerged from the discussion were:

- Our efforts should be geared to produce the best plots possible for evaluation in order to record the potential of the lines. Responses to diseases and pests would be assessed as a separate exercise. The material should therefore be kept as free as possible from pests and diseases.

- Plots would require netting to prevent bird damage (pigeons, crows, rooks) and appropriate measures taken to keep out rabbits and hares.

- Pre- and post-emergence herbicides should be used. There is no difference in the sensitivity of the exotic material compared with modern commercial material.

- Small-seeded exotic germplasm is in some cases slower to establish. Seed treatment against weevil, damping off and downy mildew was considered essential to ensure good establishment.

A proforma for phenotypic data recording was produced, and common protocols for plot husbandry and data recording for priority traits developed.

[See www.pcgin.org for a report on 'PCGIN meeting to view JIC plots of exotic germplasm, 1st July 2005' and the agreed timescale for Year 2]

An excel file containing the data recorded in 2005 at the three sites is available via *the PCGIN web site, together with the agreed proforma for data scoring, with templates, which are also available on request.*

Common protocols for plant husbandry have been agreed and have been applied in 2006. These protocols are also available via *the web site.*

Activities in Year 1 (Faba bean)

- 80 germplasm accessions at JIC and INRA (Dijon) were multiplied.
- A web-searchable database of a JIC collection is under development.
- A set of exotic lines has been sourced by JIC for observation at the three sites in 2006.
- A single field plot of a Portuguese landrace was sown in October at JIC from seed obtained by PGRO; the seed will be multiplied for a preliminary characterisation of the line.

Activities begun in Year 2 (Pea)

In March 2006, triplicate micro-plots of 20 lines have been sown at the three locations: 18 of the lines were selected from the 47 grown at JIC in year 1. The selection was based on including the maximum diversity between lines for plot height, flowering time and seed availability but excluded lines that had yielded poorly or were recorded as badly lodged in 2005. As suggested and agreed with breeders, two commercial lines have been included at all sites; the cultivars Bilbo and Cooper, were chosen, based on availability of appropriate quantities of seed.

Activities begun in Year 2 (Faba bean)

26 germplasm accessions from the JIC collection are being grown under glasshouse conditions. Different methods for encouraging seed set will be evaluated. Basic characterisation of these lines will be undertaken and added to the database.

Objective 3: Performance

Extant varietal performance data will be associated with genotype data

PROGRESS:

The UK pulse crop characters of interest to breeders have been analysed statistically at NIAB and

cultivars grouped according to performance. Databases for years 1988 – 2004 have been analysed in groups as shown in the Table below. Based on this information, cultivars have been sourced based on information from SASA and through dialogue with the relevant breeders. Some of the older cultivars are no longer available, as anticipated. Details of the varieties that have been obtained by JIC are available through the project web-site, where input has been requested from PCGIN-registered members.

Seeds from forty-five lines (see www.pcgin.org; Objective 3 documents) have been sown for genotyping and, on the basis of these data, appropriate parents will be selected for crossing.

Brief summary of methodology for variety selection according to performance

- Variety means were extracted from the definitive corporate VCU trial evaluation database. Initially all varieties harvested in years 1988-2004 across all trial groups were extracted.
- The variety means were grouped in two different ways:
  1) Across a three-year rolling group with a year overlap (e.g. all trials in 1988-1990, 1990-1992).
  2) By variety grouping characteristic (e.g. white, large blue etc).
- Each set of variety means was analysed to produce a Genotype + Genotype by Environment interaction (GGE) Biplot. This analysis takes into account the main effects as well as the interactions of the variety with environment. This is an interactive system; therefore is it is not automated but exploratory.
- Varieties that are positioned at the edges of the Biplot were noted and selected for further study as these define the multi-dimensional envelope of varietal expression – the extremes for one or a number of characteristics.
- A small number of varieties were selected because they sit in the middle of a few Biplots. These varieties appear to be insensitive to the set of individual characteristics or the overall effect of the characteristics and are robust in terms of GxE interaction.
- Further work involved grouping the extracted varieties by wet/dry conditions, which effectively gives a geographical split into western and eastern regions of England. Separate GGE Biplots for these groups were compared with the equivalent GGE biplots (above) without groupings.

Table 1: An example of the varieties identified by their positions at the edges of the GGE Biplots when analysed as three-year rolling groups. These are the varieties that are likely to show G x E interaction. The varieties in blue (afp numbers outside the largest circle) have the potential for the most interaction, whereas those in red (afp numbers touching the largest circle) are also of interest.

Graph yrs	afp Nos	Variety names	afp Nos	Variety names
88-90	t51	CONQUEST	118	TSARINA
	151	HAJ51845	145	VIRGO
	107	572 PAN 15		
	146	SANTON		
	127	KAZAR		
	128	MONITOR		
	129	BOOSTER		
90-92	228	SETCHEY	233	4/9073
	114	ECHO	254	ELAN
	171	MIKO	a75	HELKA
	139	RENATA		

92-94	130	MASCOT		g49	BUNTING *
	264	BN52		228	SETCHEY
	268	NSA90/0184		269	TWY89/102
	283	PBINC14-2		309	ATHOS
	t51	CONQUEST			
94-96	191	PROFI		348	RACER
	130	MASCOT		336	BL 841
	t51	CONQUEST		344	BELUGA
				290	TURUL
96-98	g49	BUNTING *		124	GUIDO
	191	PROFI		257	CELICA
	va5	MINERVA		280	MICKEY
	422	BIGDADDY		398	CDC VIENNA
				443	LUMINA
				122	TRIFFID
				e40	SALOME
				315	SUPRA
98-00	379	PYRAMIDE		438	PR 1157
	388	GRANADA *		458	JAVLO
	448	SW 965451		444	CEBECO 1467
	457	A7026.2		562	PROPHET
	153	NOT KNOWN		431	GA 93P15
	295	ASTINA		433	NOR96.1550
	122	TRIFFID		437	CM 989.43.06
	113	MAGNUS		251	SPECTRUM
00-02	o22	MARO		475	CRATOS
	422	BIGDADDY		468	XBP10AI
	395	SAMSON		465	ADV3154.7
	315	SUPRA		509	IVANHOE
	340	FLORINE		454	FAUST
	480	BL 651-1		498	DS 49499
	441	PIDGIN		501	A 8017
	479	CEBECO 1315		485	NAB 751
	477	CEBECO 1162		495	CEBECO 4100
	467	SCHW93189.10			
	536	LOGIC			
	487	LW9223.4			
	480	BL 651-1			
	493	VERTOP			
02-04	o22	MARO		519	DS 49579
	315	SUPRA		578	ZERO4
	568	02-NCP10		567	ATALANTE
				556	BRAZIL
				395	SAMSON
				175	ALEX
Yield only	129	BOOSTER			

128	MONITOR
187	SONATA
104	LOVELOCK
176	MESSIRE

Objective 4: Reverse genetics

TILLING *for genes that regulate the development of the aerial part of the legume plant*

PROGRESS:

As discussed in the overview, objectives 4 a to c were completed prior to the start of the project because of the timetabled requirement for the generation of the Ps6k oligo array. This array is available from the University of Bielefeld (http://www.cebitec.uni-bielefeld.de/groups/glp/microarrays/) or the oligos can be purchased from Operon primers.

Objective 5: Genetic mapping in crop legumes

5a Provide novel germplasm for trait analysis (Fast Neutron mutant analysis and mapping)

PROGRESS:

The mutant phenotypes available within the Fast Neutron population have been tabulated and 54 FN lines have been assigned to 19 phenotypic classes; of these 16 allelism tests have been confirmed. A set of AFLP analyses (512 primer combinations) have been performed on five FN lines as an initial analysis of this FN population and molecular markers co-segregating with the mutant phenotype have been identified.

5b Integrated Genetic Maps

Work on this part of the project is just beginning.

The emphasis on *Pisum sativum* and *Vicia faba* reflects Defra's investment in these crops within the PCGIN. Work on lupins and clover has been funded elsewhere and these data will be included, therefore, in PCGIN-based overviews of UK research and development of legume genetic maps. A mapping population and markers for lupins, developed at the University of Reading in a Defra-funded project, are being used in a LINK project, which includes PGRO. The legume programme at IGER has developed resources to underpin genetic improvement of clover with Defra core funding. (All resources developed in the Defra-funded projects are freely available). IGER has participated in the PCGIN stakeholders' meeting in September 2005 (see www.pcgin.org/meetings).

Objective 6: Genetics of Seed Quality Traits

PROGRESS:

This objective links closely with Objective 1 and depends on established links with the wider stakeholder group that includes end-users. Definition and prioritisation of target traits is based on wide consultation and aims to provide tools and resources for industry. The priority targets for seed quality traits have been discussed at the formal meetings of the PCGIN (management and stakeholders meetings) as well as at the different events and meetings that are logged under Objective 1. Input and feed-back is being sought *via* the web-site (www.pcgin.org), where a summary document, available to registered members, seeks to involve the industry further in the choice of lines and protocols for Objective 6.

It is clear that, to a large extent, the different end-uses must be considered separately with regard to traits that are relevant, and also that the importance of the traits is related to the monetary value of their end-use. Traits relevant to three defined end-use areas have been discussed, in addition to brief considerations given to new markets. These are summarised below. Overall, the aim is to define the genetics of traits of interest and to simplify genetic screens for 'field' use, which will benefit crop improvement generally, but is of particular value for seed characteristics where these can be screened at a very early plant stage.

A: Animal feed

It was acknowledged that there are difficulties in obtaining a consensus on what the over-riding limitations to UK pulse crops are for this market. A recommendation from the management meeting (June 2005) was that we establish close ties with animal nutritionists. This has been established through contact with PULTAC, Premier nutrition (the leading UK independent supplier of nutritional services and animal feed supplements), and Dr Julian Wiseman, School of Biosciences, University of Nottingham, a specialist in animal nutrition, who was then invited to the stakeholders' meeting (September 2005). The technical information and guidance issued by Premier nutrition, and the problems that are highlighted *via* leaflets issued to farmers can be summarised as follows:

1. A higher inclusion rate can be recommended for peas in pig and poultry diets than is acceptable for either field (faba) bean or lupin.
2. When anti-nutritive compounds are inactivated by extrusion, peas can be included at higher amounts (40%) and such diets can reduce animal skatole by 40%. [Skatole or 3-methylindole leads to unacceptable carcass taint].
3. The higher protein content of lupins is not reflected in animal performance; digestible amino acids, rather than total amino acid content, must be considered to avoid an over-valuation of lupins.

B: Vining crops

The lack of scientific knowledge to underpin the selection of 'good' and 'bad' variants for the frozen vegetable market has been discussed. Clearly, knowledge of metabolites, that are relevant to the perception of taste panels, is highly desirable. Tests for such metabolites that can be exploited as alternatives to taste panel and 'tenderometer' tests, would be valuable. The development of such tests is likely to be highly informative for the development of any assay that could be used in early generation selection in a breeding programme. An alternative (but difficult) approach may be to undertake QTL analyses of taste panel perceptual data and of 'tenderometer' performance in relation to taste panel data.

C: Pulses

Various discussions have highlighted the fact that there are growing and good markets for UK pulses, particularly in Japan and Egypt. The problems that have affected these markets in recent years are principally **1)** bleaching problems in seeds, particularly marrowfats, where good colour retention is closely linked to their value and **2)** the increasing problem of bruchid beetle attack in *Vicia* (field or faba beans).

As with B, scientific knowledge to define quality in, for example, a marrowfat pea is lacking.

D: Other markets

Additional niche markets exist that utilise pulse crops in other products. Contacts with industries suggest interests in a variety of seed genetic variants, should these become available, including, for example, novel colours and shapes for the vegetable market. In addition, further discussion is needed in the areas of diet, health (and allergens), in addition to opportunities for non-food uses, e.g. the role of pulse crops in future UK bioenergy markets.

Definition of traits in relation to end-use:

A: Based on earlier Defra funding, a study of the biochemistry and genetics of a family of anti-nutritional proteins in pea seeds has led to a facile DNA marker screen that is being used currently by two companies. We can build on this work to isolate mutants in the pea trypsin-chymotrypsin inhibitor genes that will yield lines with very reduced amounts of anti-nutritional proteins. The facility available through the EU GLIP project is being exploited to screen and identify mutants.

Improvements to home-grown sources of animal feedstuffs are relevant to Defra's objectives for improved quality, linked to a reduction in processing, energy use and minimisation of waste. Improved quality in feed, coupled with improved digestibility, will be linked to a reduction of potentially eutrophicating waste, with associated effects on natural resources.

B: NMR analysis and metabolite profiling techniques have been established at CSL, York (represented by Adrian Charlton at PCGIN meetings) and robust protocols are in place for the analysis of mature pea seed material. These analyses facilitate small molecule biochemistry, where large numbers of samples can be processed and their metabolites profiled and quantified; we anticipate that these methodologies will facilitate studies of seed quality, even where quality has not been defined biochemically as yet.

A research project pre-proposal, entitled 'Metabologenetics and quality traits', linked to PCGIN, and supported by both Advanta and Unilever, was submitted to the BBSRC-funded Crop Science Initiative in December 2005 by JIC and CSL. This project proposed to identify metabolites relevant to the definition of quality in both vining and pulse crops (**C** above) for human consumption. (Unfortunately, the project was not selected for funding, so an alternative funding strategy is required).

An understanding of the scientific definition of food quality is linked to Defra's overall objectives for improved food quality and nutritional value, coupled with a reduction in processing and waste. More generally, improved quality selection procedures will lead to more efficient supply chains, with reduced energy use, waste and carbon emissions.

C: 1) A literature search suggests that colour bleaching in seeds is a complex trait, with major effects exerted by genetic loci on linkage groups III and V. The former is close to *tl*, and may be represented by *pa*, determining colour in foliage, pods and seeds. Candidate loci on linkage group V include *Lox* and *vim*. The former includes genes that encode enzymes capable of bleaching carotenoids, whereas *vim* has a similar effect to that of *pa*. Genetic variants for these three loci are available (*Pa/pa*; *Vim/vim*; and a line, L-3, having a reduced quantity of an enzyme, lox-3, implicated in carotenoid bleaching) in order to examine genetic effects on seed bleaching.

Seeds of the four marrowfat pea lines from the 2006 NIAB/PGRO recommended list (cvs. Kahuna, Samson, Princess and Orka) have been sown along with JI 516 (cv. Maro) and these will be crossed initially with the L-3 line (a white-seeded line). Input from stakeholders is being sought in order to define the best crosses to progress; input from the industry will be required in order to establish optimal conditions for the commercial analysis of progeny lines. The genetic locus controlling the quantitative variation in lox-3 will be determined.

2) There is a knowledge base for resistance to bruchid pest problems in pea, based on research carried out in Australia and the US. As yet, the pea bruchid has not been reported in UK but, in 2005, serious problems occurred with *Vicia*, that seriously damaged foreign markets. Current insecticide sprays are unlikely to be available in the future. Genetic resistance to bruchids has been engineered in peas through the use of an α-amylase inhibitor gene derived from *Phaseolus*, although the potential risks mean this crop will not be developed commercially. Natural resistance has been reported in pea; one is attributable to the locus, *Np*, where neoplastic growths form on pods in response to (among other stimuli) chemicals from the bruchid eggs; these growths push the eggs away from the pod, providing a natural barrier. Another source of resistance has been reported in *Pisum fulvum* accessions. The possibility that there is some equivalent natural source of resistance in *Vicia* should be examined; novel sources of germplasm are being sourced by JIC in collaboration with INRA-Dijon, France (see Objective 2 above). UNIP (France) has reported that field screens will be performed in France in 2006, assuming levels of natural infestation comparable to those of 2005. Discussions have been held with UNIP and the JIC insectary unit as to the feasibility of a controlled analysis of any apparently resistant lines. Further discussion is required on the best way in which screening should be done; the possibility of small-scale laboratory screening of *Vicia* germplasm for possible neoplastic growth responses to bruchid chemicals should be explored.

The problems outlined in both 1 and 2 can lead to the use of undesirable chemicals. Biological solutions to these problems therefore contribute directly to Defra objectives for improved food quality and nutritional content, together with waste minimisation.

D: The role of pulse crops in future UK bioenergy markets was discussed briefly at the stakeholders' meeting (September 2005). There was support from ADAS for any feasibility work looking at the development / use of high starch peas for bioethanol production, which could link with a proposed programme to enhance the efficiency of bioethanol production using enriched-starch feedstocks from wheat. The use of pulse crops will be essential for nitrogen provision to support other 'biofuel' crops.

Future markets for legumes aimed at 'health improvement' are likely to expand, as in the US (Monsanto and soybeans).

More discussion is required on the screening for novel mutants with altered seed composition, based on these considerations.

In terms of relevance to Defra objectives, pulse crops must remain on the agenda in discussions on sustainable agriculture involving crops as biorefineries; the overall goal of including biofuel at significant percentages by 2010 will only be achievable where nitrogen fertiliser costs are minimised to meet future carbon certification under Renewable Transport Fuel Obligations. Pulse crops can contribute indirectly

and directly to these goals.

Within A-D above, there are several good candidates for proposed PCGIN 'spin-off' LINK programmes. These will be discussed in more detail at the next PCGIN management meeting.

Section 11: Publications and other outputs

11a: Papers and presentations

Presentations:

Pulse Crop Genetic Improvement Network, British Edible Pulse Association, Annual Meeting, PGRO, July 2005 (THNE)

Presentations at Stakeholders' meeting, NIAB, September 2005 (THNE, CD, MA, JT, HP, GG)

BEPA discussion meeting, Peterborough, November, 2005 (CD, GG)

A Co-ordinated Approach to Crop Improvement in the UK: Pulse Crop Genetic Improvement Network, Diversity for Breeding Symposium, NIAB, December 2005 (THNE)

Pulse Crop Research: the next 10 years, HGCA/PGRO Oilseeds and Pulses Conference: 'Facing New Challenges', Peterborough, March 2006 (CD)

Comparative Genomics and Genome Diversity in Pea, Third International Conference on Legume Genetics and Genomics, Brisbane, April 2006 (THNE)

Publications:

Improving UK pulses. Pea & Bean Progress, pp. 14-15, Winter, 2005

PCGIN: a new UK national project. Grain Legumes 43: p. 6, 2005

(written by C Domoney, JIC)

11c: Knowledge transfer

The engagement of PCGIN with the GL-TTP has been made, and this platform was discussed at the management meeting on 20th June 2005 and presented at the stakeholder's meeting on 20th September 2005.

The Web site (and the linked portion of the JIC open access web site) has been populated with marker data, as was suggested by one of the Stakeholders at the first Stakeholders' meeting. This data set will be enlarged during the course of the project.