**PGRO R and D strategic priorities 2019-2022**

1. Improve AGRICULTURAL PRODUCTIVITY by delivering YIELD STABILITY and improved QUALITY. Improve understanding and quantification of factors that influence yield and quality:

* Plant breeding and genetic improvement
* Agronomy
* Varietal evaluation
* Production continuity
* Resource management
* Crop protection – pest, disease and weed management
* Integrated Pest Management

1. SOIL HEALTH and plant and soil biological interactions greatly influence pulse crops. Improve understanding of factors affecting soil health:

* Soil structure
* OM content
* Microbial populations
* Impacts of soil health on pathogens
* Management practices to improve soil health

1. Deliver CROP NUTRITION plans for modern production techniques providing recommendations for optimum performance of UK pulses:

* P and K requirements
* Trace elements
* Root development
* Protein content

1. ENVIRONMENTAL CHANGE will influence future cropping techniques. Measure impacts of changing environment on legume production and investigate techniques for remediation:

* Sustainable systems
* Climate impact on pest and disease occurrence
* Greenhouse gas emissions
* Environmental benefits of legumes in farming systems
* Irrigation

1. LEGISLATION UPDATES: To provide relevant information that can be used to impact and promote production and consumption. Review crop protection priorities based on changes to pesticide approvals.

* Promote production and consumption of legumes
* Update on Environmental Land Management Scheme (ELMS)
* Update on impacts of Brexit
* Identify and anticipate changes in product registration
* Develop new IPM systems for improved crop management

1. KNOWLEDGE EXCHANGE: For all priorities identified, disseminate outcomes of work carried out at PGRO, and in collaboration with other organisations and institutes, to provide improved crop production recommendations:

**Summary of PGRO R&D project activities**

**Crop year 2020**

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**Yield Enhancement Networks – peas and beans – co-funded by PGRO and industry (L2020-7 and L2020-8)**

The Yield Enhancement Network (YEN) connects agricultural organisations and farmers who are striving to improve crop yields. The pea YEN and bean YEN are not competitions, they are grower to grower learning programmes through coordinated widescale benchmarking and sharing. The YENs are open to any interested individual or organisation, commercial or academic. The YENs are run entirely with industry sponsorship and membership fees. There are currently six crop-specific networks: Cereal YEN; Oilseed YEN; Grass YEN; Pea YEN; Bean YEN; and Potato YEN. There are additional YEN’s for crop Nutrition and GHG Emissions.

Twenty-five pea crop entries were monitored throughout the 2020 season, including crop growth stages, images, root samples, grab samples for yield, quality samples and crop nutrition tests. All work was carried out to a simple but detailed protocol to maintain consistency between crops. A stakeholder meeting was held on 14 December 2020 to review outputs.

There were 39 bean YEN entries in 2020, seven field bean crops closely monitored by PGRO throughout the season, with an additional 32 grower entries. Of a total 52 entries in 2019 and 2020, 15 were winter beans and 37 spring beans. Evaluation included soil nutrient analysis, soil measurements for moisture, temperature, VESS and compaction, crop growth stages, tissue nutrient analysis, grab samples for yield and quality samples. Monitoring was carried out by PGRO employees and growers and results are being analysed. A stakeholder meeting was held on 15 December 2020 to review outputs. Further information about pea YEN and bean YEN can be found at <https://www.yen.adas.co.uk/about> or at [www.pgro.org](http://www.pgro.org).

Addresses strategic priorities 1, 2, 3, 4, 5 and 6.

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**Variety evaluation of vining peas (G2020-1, AHDB FV462), combining peas and field beans (L2020-10)**

The existing Pulse Recommended List changed to a Descriptive List following consultation with the industry during 2019 and 2020. Full Pulse Descriptive List (DL) tables for 2020 were launched on 19th November 2020 and are available at <https://www.pgro.org/pgro-pulse-descriptive-lists/>. The data is gathered in the same rigorous independent manner, but the new system introduces the flexibility to present all the data gathered in an open and non-judgemental manner, giving growers the opportunity to balance their needs for variety performance with the demands of the market. PGRO is free to assess varieties for all characteristics identified as potentially relevant and publish verified data accordingly. The result is a more open system that gives breeders the freedom to innovate in the knowledge that their products will be independently trialled and presented without judgement and therefore the opportunity to react more quickly to market interest. Lists are presented in a sortable list format for the online edition on the PGRO web site. Growers can search for and list varieties by their preferred characteristics.

The DL trial series uses a 5 year rolling data set, the same as the previous RL with Years 1 and 2 coming from National List. Year 3 varieties are new to the list and established varieties are in year 5. The method of calculating the mean of the control varieties has changed from being just 2 varieties per crop to a more robust selection of varieties that have been in the trial series for 4 or 5 years and applies across all types.

2020 yields were lower than 2019 due to wet weather conditions in winter 2019-20, and very dry spring and early summer conditions in 2020 leading to poor establishment in some cases. The control yields for 2020 were: Peas – 2.72t/ha; spring beans – 3.68 t/ha; and winter beans – 2.67 t/ha.

As part of the series of trials to assess performance of pulses, disease observation trials were carried out by PGRO in conjunction with those carried out by NIAB to evaluate downy mildew susceptibility. Rust was recorded in spring beans in 2020. All ratings are reported in the RL.

The production of the PGRO Descriptive List of Vining Peas is derived from a series of trials beginning in year 1 with a Preliminary Trial and then continuing in years 2 and 3 in Main Trial. Varieties included petits pois (grown on a light silt soil) and standard peas (currently grown at Nocton, Lincs). These trials were funded by seed companies and PGRO levy. Between 2012 and 2018, to provide data from contrasting soil types, all varieties in the standard pea main trial at Nocton were also grown in South Lincolnshire on a silt soil (funded by AHDB-Horticulture) and data were used to provide a descriptive list of standard peas for silt soils. For 2019 and 2020, AHDB-Horticulture funded a variety trial, where the site and varieties were chosen by representatives of the vining pea grower groups and members of the Legume Panel. Varieties included standard and petits pois types.

NB: FV462 Horticulture Strategic Centre for Vegetables: In 2019, a proposal was accepted for funding under the AHDB call for proposals relating to ‘31510062: Horticulture Strategic Farms – Innovation Hub - To undertake a programme of work designed to identify and deliver practical, adoptable solutions to address a range of technical and cultural issues identified by growers’. This call included variety trials for vining peas, onions, carrots and Brassicas. Add-on trials were included to demonstrate/investigate priority topics relevant to each crop species. In line with current Legume Panel priorities, the following topics were selected for inclusion in the add-on program for peas in 2020: Vining pea varietal tolerance to downy mildew; distribution of the bean seed fly; cultivation techniques to manage bean seed fly damage in vegetable legumes. Project duration is 3 years.

Addresses strategic priorities 1, 4, 5 and 6.

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**Improvement of soil health using cover crops in peas – co-funded by EIP-Agri (via the Rural Payments Agency), the Green Pea Company and PGRO (L2020-18)**

The objectives were to evaluate cover and catch crops for improving soil structure, organic matter content, nutrient retention and management of soil moisture. In addition, soil-borne pathogen levels were monitored using standard plate tests to indicate the influence of improved soil structure on soil-borne pathogens over several years. Grant funding was in place until January 2020. An additional evaluation of the influence of vetch and Berseem clover in the cover for disease impact was carried out. Reports are available at <https://www.pgro.org/r-d-news/>.

Although being carried out in vining peas, results will be relevant to combining peas. Cover crops were established in August/September 2016, 2017, 2018, 2019 and 2020. Results showed improvements in soil structure following inclusion of cover and catch crops, and as yet no detrimental effects following the inclusion of vetches or Berseem clover in the cover crops.

Addresses strategic priorities 1, 2, 3, 4 and 6.

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**Downy mildew varietal tolerance screening** **(geographical trials) – funded by PGRO levy (L2020-32)**

This project planned to evaluate downy mildew varietal tolerance at several field sites across the UK, including pea varieties selected by the vining pea groups and from the Descriptive and Recommended List varieties. The aim is to determine in which regions of Eastern UK different varieties show better tolerance to downy mildew. A summary of 2019 results is available at <https://www.pgro.org/r-d-news/>.

2020 work was postponed due to Covid-19.

Addresses strategic priorities 1, 4 and 6.

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**Downy mildew control using foliar sprays in vining peas – funded by PGRO levy (L2020-4)**

Trials have been established for several years to evaluate the efficacy of different products to control downy mildew infection in vining peas, including the screening of new and existing foliar active ingredients.

2020 work was postponed due to Covid-19.

Addresses strategic priorities 1, 5 and 6.

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**Bioremediation of *Aphanomyces* infected soils using plant baiting technique – funded by PGRO levy (L2020-17)**

The aim is to investigate the potential to interrupt the Aphanomyces disease life cycle using alternative host plants. The selected alternative hosts would, if successful, cause Aphanomyces oospores to germinate and the life cycle would be disrupted before they can produce new oospores. Two trials were carried out in 2020 but no conclusive results could be obtained. Small pot trials do not seem to be the appropriate testing method due to differences in root structures and unevenness of disease development. A new trial method will be developed before any more potential trials are carried out.

Addresses strategic priorities 1, 2, 4 and 6. …………………………………………………………………………………………………………………………………………………..………

**Foliar applied active substances for control of downy mildew in field beans – funded by PGRO levy (L2020-3)**

Evaluation of new active substances has been undertaken for several years.

2020 work was postponed due to Covid-19.

Addresses strategic priorities 1, 3, 5 and 6.

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**Combining pea optimum populations – funded by PGRO levy (L2020-2)**

A summary of results from work since 2015 was published in the winter 2019 edition of Pulse Magazine at <http://www.graphicgeneweb.co.uk/flipbook-winter/mobile/index.html>. The work was repeated in 2020 using the white pea, Karpate. 2020 results showed that gross margins increased with population density for the variety Karpate, although the target population was not always achieved due to dry conditions leading to reduced establishment. Target plant density ranged from 30 to 120 plants / m² and actual plant density ranged from 20 to 90 plants / m². Despite the reduced emergence, returns (considering the seed costs but no other inputs) were better at higher populations 70 – 90 pl/m2 even though much more seed than would be expected was drilled to achieve them.

Addresses strategic priorities 1, 4 and 6.

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**Intercropping peas to improve standing ability – funded by PGRO levy (L2020-12 and L2020-13)**

Intercropping trials, both at small plot scale and field scale trials with farmers have been undertaken in 2018, 2019 and 2020. Improvements have been recorded in standing ability of peas inter-sown with oats and beans, and the yield of mixtures was greater in all cases than the yield of sole crops, giving Land Equivalent Ratio’s (LER) in excess of 1 in most cases. A summary of 2018 results can be found at: <https://www.pgro.org/downloads/pulse-mag-spring-2019-v0.pdf>.

2019 results are available at <http://www.graphicgeneweb.co.uk/spring2020-flipbook/mobile/index.html>.

2020 results will be reported in the spring 2021 edition of Pulse Magazine. In summary, the trials showed some reduction in bean rust where intercrops were sown, compared to sole crops. Work will be repeated to test this finding.

Addresses strategic priorities 1, 4 and 6.

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**Pea and bean weevil control – screening products in field beans (applicable to peas also) – funded by PGRO levy (L2020-24)**

Several active substances are included in trials each year, to evaluate efficacy and support future EAMU approvals.

2020 work was postponed due to Covid-19.

Addresses strategic priorities 1, 5 and 6.

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**Bean seed fly (*Delia platura*) management – funded by PGRO levy (L2020-6)**

Bean seed fly (*Delia platura*) affects many plant species world-wide and is an important pest of UK legumes. Crop losses due to bean seed fly (BSF) are reported to be up to 60% due to failure of establishment and seedling damage. BSF has been identified as high priority for UK vining peas, picking peas, green and runner beans, as well as alliums, asparagus and leafy salads, due to increasing incidents of damage and the loss of key insecticidal substances. There are no approved seed treatments available in UK legumes that control BSF, and ground sprays are not always effective. Crops at most risk are those planted in late spring and early summer (from mid-late April onwards), and it is reported that the presence of germinating seeds, with recently disturbed soil and high levels of organic material are the key factors that attract the flies. Preliminary findings from 2019 farm-scale trials and surveys showed that the period between cultivation and drilling influenced damage levels in peas, with fields cultivated shortly before drilling in the spring having higher levels of damage to seed and seedlings compared to those that were cultivated in the autumn only or several weeks prior to drilling. This was tested in a replicated small plot trial at Stubton in Lincolnshire in 2020 with the period between cultivation and drilling varying between 0 and 28 days (co-funded by AHDB **FV462**). Initial results indicated that the longer period between cultivation and drilling led to lower levels of damage to crops. The trial will be repeated in 2021 so that a recommendation can be given to growers. A prediction tool to determine timing of peak attack in crops will also be useful to help growers plan cultivations and drilling at high-risk sites, and work is being undertaken in a PhD with Warwick University to further investigate this.

Addresses strategic priorities 1, 2, 4, 5 and 6.

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**AHDB Surveillance approaches, impact and epidemiology of virus diseases to improve management strategies – co-funded with PGRO and FERA Science Ltd. (AHDB FV459, G2020-10)**

The aim of the project is to develop a cost-effective generic approach to allow surveillance of any horticultural crop for the presence of both known and unknown viral pathogens, and to also allow quantification of the incidence of such pathogens. In 2019 twenty pea crops were sampled to provide virus incidence data and to identify fields for focused further study of virus yield impact assessment. High-throughput sequencing (HTS), also known as Next-generation sequencing, was used early in the sampling process to allow identification of the pathogens present in each field, followed by quantification using ELISA and PCR.

The project uncovered turnip yellows virus (TuYV) a virus common in brassicas, not previously recorded in UK pea crops but recently reported from pea crops in Australia and Germany. The viruses traditionally associated with pea crops, such as pea enation mosaic virus (PEMV), were present in 6 of the 20 crops tested, at levels ranging from <1% through to around 30%. By comparison TuYV was found to be present in 13 of the 20 crops and at levels ranging from 2% to 93% incidence. TuYV causes major issues in oilseeds and brassicas but the impact on pea crops is not yet known. Soya bean dwarf virus was also found at two sites, at levels of around 5% and this is a first record for the UK, though again the virus has been reported from pea crops in continental Europe. Through the project the yield impacts of the viruses identified in the study will be investigated. Preliminary results for the 20 sites in 2019 do show some differences in yield impact between the viruses, but further work is required to validate results and ensure that growers receive the right messages about management of previously unrecorded viruses.

The project started at the beginning of 2019 and continues for 38 months.

2020 work was postponed due to Covid-19.

Addresses strategic priorities 1, 4, 5 and 6.

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**Integrated pest management (IPM) in faba beans (Vicia faba): the combined effects of trap cropping and semiochemical attractants on the management of pea and bean weevil *(Sitona lineatus)* and bruchid beetle *(Bruchus rufimanus)* – funded by the Ekhaga Foundation and PGRO levy (G2021-01)**

Bruchid management has become more difficult in recent years, due to increasing populations and potential resistance to pyrethroid insecticides. Although thiacloprid has been available to use for bruchid management, this has been revoked and will not be available for the 2021 season. As a result of these difficulties, in 2019 PGRO investigated the potential for trap cropping approaches, using early sown beans as the trap, to help manage the pest. Initial results showed that this approach gave a small benefit to control of bruchids in the later sown main crop. A proposal was submitted to the Ekhaga Foundation to expand this work to include pea and bean weevils, using trap crops containing legume mixtures that include vetch and lucerne, know alternative hosts for each pest. In addition, pheromone and plant volatile attractants will be used to help attract the pests into the trap crop areas. The funding starts in January 2021, but work began in 2020 to establish three trial sites for 2021.

Addresses strategic priorities 1, 4, 5 and 6.

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**Bruchid beetle – screening products for best timing and control – funded by PGRO levy (L2020-25)**

2020 work was postponed due to Covid-19.

Addresses strategic priorities 1, 4, 5 and 6.

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**Impact of bruchid seed damage on field performance of field beans (L2020-14)**

A replicated, small-plot experiment was conducted at Stubton, Lincolnshire, to determine the effect of high levels of bruchid damage to seed on field bean establishment, vigour, disease and pest incidence, and yield in-field. Varying levels were tested. Seasonal difficulties with establishment meant that trends are inconclusive, and the work should be repeated in 2021.

Addresses strategic priorities 1, 4, 5 and 6.

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**Fertiliser Manual (RB209), PLANET and MANNER-NPK updates – funded by AHDB, PGRO and BBRO**

**Peas and beans (L2020-21)**

In February 2020, The AHDB Nutrient Management Guide (RB209) was updated as follows: Section 1: Principals of nutrient management and fertiliser use; Section 4: Arable crops – guidance for cereals; Section 6: Vegetables and bulbs – improved information for courgettes and pumpkins. The digital version of RB209 can be found at <https://ahdb.org.uk/nutrient-management-guide-rb209>. There are currently no changes for legumes.

Priorities for review and further research are in place, as per steering group meetings. PGRO has a place on the steering group and in the technical working groups. The update is available as a downloadable pdf document containing basic principles and crop sections <https://ahdb.org.uk/projects/RB209.aspx>.

Addresses strategic priorities 1, 2, 3, 4, 5 and 6.

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**Biostimulants, bio-control agents and nutritional products in vining peas, combining peas and field beans for legume disease management – funded by PGRO levy (L2020-1)**

The project aims to test a variety of biostimulants, biocontrol agents and nutritional products in field conditions. The project was agreed by the Pulse and Legume Panels and knowledge transfer was part funded by AHDB FV462 Horticulture Strategic Centre for Vegetables in 2019. In 2018 and 2019, soil applied products were TFP Pro Soil and Serenade ASO. Seed treatments were Radiate ST, Start-Up ST, Take-Off ST, MultiMax GPA ST and Kick-Off ST. TFP Pro-Tect, Zynergy Na13, Agrihit Foliar Tonic, Phorce and Prestop were foliar applications made on two occasions.

Based on feedback from the Legume Panel an additional trial testing biostimulant products under glasshouse conditions was performed in 2019. The aim of this project was to evaluate the effectiveness of several different seed treatments on *Fusarium solani* and *Didymella pinodella* infection, nodulation and plant health under simulated ‘early season’ conditions. Reports for these trials are available at <https://www.pgro.org/r-d-news/>.

2020 work was postponed due to Covid-19.

Addresses strategic priorities 1, 2, 3, 4, 5 and 6.

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**Improving productivity in pea and bean growing through advanced data analytics, machine learning and artificial intelligence techniques – co-funded by Innovate UK and Hummingbird Technologies, with PGRO as a partner (IUK 104473, G2020-9)**

The project aimed to develop a remote sensing software analytics platform for peas and field beans. The platform will allow growers to better understand the health of crops and aid decision making. Experiments and ground truthing focused on soil health, nutrition and crop growth to stabilise and improve yield and quality in vining peas and field beans. The project started in October 2018 and ended in December 2020, following a three-month extension. During 2020 data were collected for the following: Soil nutrient analysis; soil structure, texture, temperature and moisture content; compaction; measurements of plant growth; foliar nutrient analysis; disease infection; pest damage; yield and maturity. Large datasets were generated for each of the sites and were analysed by PGRO and Hummingbird Technologies. As well as developing tools to aid decision making, the project has helped to determine the key factors affecting pea and bean yield and crop growth. Hummingbird Technologies has developed tools for: Canopy coverage; weed mapping; desiccation aid. Tools to determine Visual Evaluation of Soil Structure have been developed and may become available.

Addresses strategic priorities 1, 2, 3, 4, 5 and 6.

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**Knowledge transfer partnership** **No. KTP011104 – vining pea crop development modelling – funded by PGRO and Innovate UK (G2020-10) with Nottingham University**

Vining peas must be harvested within a 1 to 2-day window and time between harvest and processing must not exceed 150 minutes. These constraints lead to wastage and processing inefficiencies which are addressed in this project by predicting yield and quality to enable efficient scheduling of harvest and processing.

The associate, Leah Howells, started this three-year Innovate UK KTP project between PGRO and the University of Nottingham in October 2019, and progress so far is promising. 2020 research continued with a small trial of eight vining pea varieties, drilled at the Nocton variety trial site in March. Aerial stationary cameras were positioned above four plots, each taking three daily photographs throughout the season to map changes in canopy cover and green area. Data suggested that it may be possible to sense various growth stages remotely, with certain changes in green area over time corresponding to the onset of flowering. Predictions of harvest date for each plot were generated in advance, based on data collected by an on-site weather station and combined with forecasted weather data. This resulted in a mean absolute error (MAE) of 0.625 days between observed and predicted harvest dates, and the ability to produce these predicted dates over a week in advance. Although a small study, the results are encouraging. Taking into account other factors and the use of open-source and large-scale remote sensing data available online, and using field and harvest data supplied by the Birds Eye grower groups, the prediction models developed so far give an MAE of 0.98 days and 0.78 t/ha between observed and predicted values for harvest date and yield, respectively.

A more detailed report can be found in the 2020 winter edition of Vegetable Magazine <http://www.graphicgeneweb.co.uk/VEG2021/veg-magazine-20-21.html>.

Addresses strategic priorities 1, 4, 5 and 6.

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**Pulse Crop Genetic Improvement Network –** **combining** **peas, field beans and lupins – funded by DEFRA and led by the John Innes Centre (G2020-2)**

The network, formed in 2005, is based on collaboration between a strong research base and the UK plant breeding industry to promote development of peas, beans and lupins and assist with more sustainable development of the arable sector.

Field trials were not undertaken at PGRO in 2020 due to the risk of loss of genetic material posed by Covid-19 restrictions and their potential impact on completion and harvest of trials. There was a virtual meeting for stakeholders on 26th November 2020, to discuss the latest developments within genetic research on UK pulse crops.

Please go to the website for further details <https://www.jic.ac.uk/pulse-crop-genetic-improvement-network-pcgin/pcgin-meetings/>.

Addresses strategic priorities 1, 2, 4, 5 and 6.

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**PeaGen - Genetic improvement of pea to replace soyabean in the diets of poultry and monogastric livestock – peas – BBSRC Link with Aberystwyth University (IBERS), Stonegate Holdings Ltd., Gressingham Foods, Moy Park Food Company, Senova Ltd., The John Innes Centre, Dalehead Foods, iDNA Genetics, PGRO and Phytatec UK Ltd. (G2020-6)**

In this LINK project new genetic approaches to enhance the nutritional value (protein and water-soluble carbohydrate) of the pea seed will be developed and applied. The aim is to increase the use of peas as a high-quality feed in animal diets, reducing the UK protein deficit from the import of soya products and delivering environmental benefits to livestock production systems. The project started in October 2017 and duration is 5 years. Field trials were not undertaken at PGRO in 2020 due to the risk of loss of genetic material posed by Covid-19 restrictions and their potential impact on completion and harvest of trials.

Addresses strategic priorities 1, 3, 5 and 6.

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**Fostering sustainable legume-based farming systems and agri-feed and food chains in the EU (LEGVALUE) – funded by EU Horizon 2020 (project no. 727672, G2020-3)**

The goal of LEGVALUE is to develop routes to sustainable and competitive legume-based farming systems and agri-feed and food chains in the EU. The project assesses both the economic and environmental benefits for the EU agro industry to widely produce and use legumes in a sustainable manner. PGRO is a work package manager for dissemination of findings, as well as a partner to develop farm networks and supply chain case studies. Within this project three UK farm networks have been created to provide further information about the following:

Field beans – benefit of N to following crop;

Vining peas – effects of cover crops on soil health;

Combining peas – PEA YEN is used in the first instance to start the pea farm network and show examples of best practice.

Other case studies across the EU are being used to demonstrate best practice and novel interventions for pulses. There are several combining pea networks <http://www.legvalue.eu/>.

Addresses strategic priorities 1, 2, 3, 4, 5 and 6.

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**Transition paths to sustainable legume-based systems in Europe (TRUE) – funded by EU Horizon 2020, project no. 727973 (G2020-4)**

The aim of TRUE is to identify and enable pathways to successful legume-supported production systems and agri-feed and -food chains. PGRO is a partner for dissemination and stakeholder engagement.

<https://www.true-project.eu/>

Addresses strategic priorities 1, 2, 3, 4, 5 and 6.

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**Variety evaluation of lentils (L2020-20)**

23 lentil varieties were evaluated in a small plot trial in 2020. Crop development (emergence, time of flowering, vigour, canopy cover, maturity) and disease occurrence were monitored. Noticeable differences in vigour and timings of crop development were observed. Disease development was very low, a few plants seem to be affected by *Fusarium* root infections. Maturity varied between varieties but in several cases, pods seemed to be fully mature well before start of senescence. Five days prior to harvest, plant maturity varied between 12.5 and 82.5%. All plots were combined at the same time. Yields were very good in several varieties achieving between 1-4 t/ha. Promising varieties will be trialled in slightly larger plots in 2021.

Addresses strategic priorities 1, 2, 4, 5 and 6.

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**Pea powdery mildew screening (L2020-34)**

Four products were screened for their effect on pea powdery mildew. An abandoned trial was used, and crop cover was uneven. Products were applied once after powdery mildew had started to develop. At assessment, the control plots were completely covered by powdery mildew. Microthiol Special (sulphur) reduced powdery mildew by around 50% in comparison to the control. Caramba 90 and Signum had a slightly reducing effect, Prevam (orange oil) did not have any effect. A designated trial will be set up in 2021.

Addresses strategic priorities 1, 3, 4 and 6.

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**Development of a molecular test to determine presence and species of stem and bulb nematodes (*Ditylenchus gigas* and *D. dipsaci*). (L2020-19)**

For three years, and in conjunction with Nasamu Musa, PhD student at Harper Adams University, PGRO has been developing a molecular test to determine the presence and species of stem and bulb nematodes in both seed and soils. We have for many years provided a seed-testing service to determine the presence or absence of nematodes in seed samples, and we have developed a molecular technique to distinguish whether *D. gigas* or *D. dipsaci* are present in bean seed. This has also been expanded into soil testing to provide a service to help predict the risk of stem nematode infection prior to drilling. The test became commercially available for the 2020-21 seed and soil-testing season.

Addresses strategic priorities 1, 2, 4, 5 and 6.

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**PGRO PhD program (**[**http://www.pgro.org/phd-studies/**](http://www.pgro.org/phd-studies/)**):**

**Developing novel seed treatments for legumes: Optimising sustainable outcomes in agricultural systems – Co-funded by the University of Stirling, Legume Technology Ltd., PGRO and The James Hutton Institute (P2020-1)**

Successful root nodulation relies upon agricultural soils having a sufficiently high inoculum potential. Intensively farmed soils are often lacking in populations of rhizobia due to the rotation of non-leguminous crops and high application rates of synthetic nitrogenous fertilisers. A strategy to combat this is to directly treat the seed with a concentrated inoculum of rhizobia, which ensures suitably high concentrations of root-nodule bacteria in the rhizosphere of the growing root. Because this technology is suitably advanced, there is the opportunity to optimise this process by combining seed treatments that can simultaneously increase biological nitrogen fixation and induce disease resistance through the addition of plant growth-promoting rhizobacteria (PGPR) and resistance elicitors. The focus of this studentship is to develop novel legume-microbe seed treatments as practical liquid, solid or seed coating formulations, and assess subsequent root nodulation, plant development and disease resistance in peas and faba bean. The PhD started in October 2017.

Addresses strategic priorities 1, 2, 3, 4, 5 and 6.

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**Understanding and mitigating the causes of yield decline in peas – co-funded by PGRO and BBSRC with Warwick University (P2020-3)**

The objectives are to: Understand the components and dynamics of the foot-rot complex as well as associated microbiota in the pea rhizosphere using both conventional and metagenomics approaches; DNA sequence key pathogens and investigate soil microbial communities; Identify green manure / biofumigant crops that can suppress foot-rot. Several pathogens contribute to the foot rot complex and it was identified that least is known about *Didymella pinodella*. The PhD will therefore focus on *Didymella* and its role within the complex. Interactions with the other foot rot pathogens will be investigated. The PhD started in March 2018.

Addresses strategic priorities 1, 2, 4, 5 and 6.

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**Stem nematode (*Ditylenchus gigas* and *D. dipsaci*) in field beans – co-funded by industry with harper Adams University (P2020-4)**

The study aims to better understand the crop pest relationship, to establish a more reliable quantification method and to investigate likely control methods, whether biological treatments (such as catch/ cover/ biofumigation) or cropping techniques, to speed the remediation of infested land and bring it back into economic bean crop production. The PhD started in April 2017 and trials were carried out at sites known to have a high level of stem nematodes. Initial results indicate that some biofumigant mustard crops, such as Indian Mustard, lead to potential reductions of nematodes of up to 30% in soils. Laboratory tests have indicated that low levels of isothiocyanates lead to immobilisation of the nematodes, preventing plant invasion. The study also shows that some mustard species host *Ditylenchus dipsaci* and may be undesirable in rotations that contain this species. The student, Nasamu Musa, is expected to submit his thesis in June 2021.

Addresses strategic priorities 1, 2, 4, 5 and 6.

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**Strategies to optimise pollination of the UK field bean crop** **– funded by PGRO and BBSRC with Cambridge University (P2020-5)**

Beginning in October 2018 the project explores strategies to maximise pollination of the UK field bean crop. Recent reports suggest that pollination service is limiting yields in field beans. The study will explore strategies for optimising field bean flowers to provide maximum reward to pollinators for minimum foraging energy expenditure. This will have the dual benefit of increasing pollinator attraction to current crops, thus increasing yield, while also supporting wild pollinator populations, thus increasing future pollinator population sizes. A combination of analytical, molecular genetic and behavioural ecology techniques are being used. Commercial lines will be screened for variation in pollinator-relevant traits and to identify genetic variation of potential use in breeding programmes.

Addresses strategic priorities 1, 4, 5 and 6.

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**Bean seed fly (*Delia platura*) – Biology and management (supervised by Rosemary Collier and Becky Howard) PGRO/ Warwick University/AHDB (P2020-6)**

PGRO is co-sponsoring with AHDB a PhD student at Warwick Crop Centre (University of Warwick) that will further investigate the lifecycle of the bean seed fly, aim to produce an accurate prediction model to aid forecasting of peak activity, and carry out further investigation of cultural techniques (cultivations and land preparation) for improved management. The PhD started on 01 October 2019 and the student will work with PGRO to gather more data from field-scale sites.

Addresses strategic priorities 1, 2, 4, 5 and 6.

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**The link between N-cycling and the bacterial cytoskeleton in the Rhizobium-legume symbiosis. University of East Anglia/ PGRO/ BBSRC iCASE (P2020-08)**

Species of Rhizobium bacteria form a symbiosis with legume roots where they fix atmospheric nitrogen and provide this to the host plant. Many rhizobia also utilise nitrate/nitrite and must carefully regulate this pathway to control nitric oxide formation, which inactivates nitrogenase. The legume-Rhizobium symbiosis has significant benefits for agricultural sustainability by decreasing the need for synthetic nitrogen fertilisers and associated environmental pollution. Furthermore, legume breakdown returns nitrogen to the surrounding soil and acts as a green fertiliser to enhance soil health. Little is known about the molecular mechanisms of rhizobial growth, its link to nitrogen utilisation and plant colonisation via infection thread structures. Bacterial growth can take place either at lateral or polar locations driven by cytoskeletal proteins. Rhizobiales species exhibit polar growth but very little is understood of the cytoskeletal network that controls this growth in these bacteria. Polar cytoskeletal complexes have been extensively studied in a different group of bacteria, the actinomycetes, where cytoskeletal complexes are not only essential for polar growth but also for cellular organisation of proteins with wide ranging functions. This work will identify the molecular basis for polar growth amongst the Rhizobiales and determine how the rhizobial cytoskeleton controls the cellular localisation of enzymes for N-fixation and N-cycling. The research will study the sequence divergence of both cytoskeletal and N-cycling proteins by analysing field samples from selected UK locations. The work will shed light on how the bacterial cytoskeleton affects the legume-Rhizobium symbiosis and regulates symbiotic nitrogen-fixation in agricultural contexts.