



Summary of PGRO R&D project activities

Crop year 2021

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Summary of PGRO R&D project activities

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Outputs from projects are reported in the PGRO journals and on the PGRO web site as and when appropriate. They are further disseminated through various means including presentations, reports industry conferences, trade meetings and seminars throughout their duration and after their conclusion.

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

Full **Pulse Descriptive List (DL)** tables for 2022 were launched on 24 November 2021 and are available at <https://www.pgro.org/pgro-pulse-descriptive-lists/>. The move to Descriptive Lists for pulses is still in transition from the legacy ridged Recommended Lists. Varieties that can provide growers with agronomic performance and still serve the market requirements will gradually come to the fore and be grown in sufficient quantities to serve those markets. The benefits of pulses to the overall farm rotation should not be underestimated also.

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 yield control uses a robust basket of varieties that have been in the trial series for 4 or 5 years and applies across all types.

Five year control means for peas at 4.05t/ha were slightly up on the five year mean compared to 2020. Spring and winter beans showed little difference. Single year control means in 2021 for peas were up by 1.21t/ha, for spring beans up by 1.59t/ha and for winter beans up by 2.41t/ha compared to 2020. The effect of seasonal variation is clearly seen.

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.

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 - 2021, 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. A final report was presented to AHDB and a summary of results can be found in the Winter vegetable magazine <https://www.graphicgeneweb.co.uk/veg/mobile/index.html>

Descriptive Lists for vining peas can be downloaded from <https://www.pgro.org/downloads/PGROViningPeaDescriptiveLists2022.xlsx>

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.

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-nine pea crop entries and 51 bean crop entries were monitored throughout the 2021 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 for pea YEN on 12 November 2021 and for bean YEN on 10 December 2021 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.

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

Improvement of soil health using cover crops in peas – co-funded by EIP-Agri (via the Rural Payments Agency), the Green Pea Company, Birds Eye, HMC Peas 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/research-publications/>. 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, 2020 and 2021. Results showed improvements in soil structure following inclusion of cover and catch crops, and no detrimental effects following the inclusion of vetches or Berseem clover in the cover crops.

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

Varietal susceptibility of combining peas to downy mildew – funded by PGRO levy (L2020-10)

As part of the series of trials to assess the relative susceptibility of combining peas to downy mildew, two disease observation trials are carried out by PGRO in conjunction with those carried out by NIAB. Ratings are reported in the DL.

Addresses strategic priorities 1, 4, 5 and 6.

Downy mildew control using foliar sprays in 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 peas, including the screening of new and existing foliar active ingredients. In 2021, Soriale, a product containing potassium phosphonates, significantly reduced infection levels with downy mildew after the first application. Revus slightly reduced infection levels in comparison to the control after the first application, but in this trial, control was not significant. None of the products showed any downy mildew control after the second application.

Addresses strategic priorities 1, 5 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. In 2021, Soriale, a product containing potassium phosphonates, provided good downy mildew control. Phorce, a fertiliser containing phosphites, also reduced levels of spring bean downy mildew, a result which PGRO had also observed in a different trial in 2019. SL 567A also controlled bean downy mildew, although, in this trial, not significantly.

Addresses strategic priorities 1, 3, 5 and 6.

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 <https://www.pgro.org/downloads/pulse-mag-winter-201911.pdf>. The work was repeated in 2021 using the white pea, Karpate. Results showed that gross margins increased with population density for the variety Karpate, tailing off above 100 seeds/ m². For all scenarios (certified seed for HC/ certified seed for feed/ home saved seed for HC/ home saved seed for feed) the optimum economic plant density was 100-110 plants/ m².

Addresses strategic priorities 1, 4 and 6.

Intercropping peas and beans – funded by PGRO levy (L2020-12 and L2020-13)

In 2018 to 2021 PGRO evaluated peas with varying rates of spring oats and spring beans with virtually no inputs. In 2020 and 2021 peas, beans and oats were sown as sole crops and as various intercrop mixtures. One very similar treatment across the two years of SO 70 plants/m² plus SB 50 plants/m² in 2020 and SO 80 plants/m² plus SB 50 plants/m² in 2021 was sown. The number of oats was a little different in each year, but close enough to make a valid comparison. The yield of the mixtures was greater in all cases than the yield of sole crops, giving Land Equivalent Ratio's (LER) more than 1 in both years. A summary of 2020 results can be found at:

<https://www.pgro.org/downloads/pulse-mag-spring-2021.pdf>. 2021 results were reported in the spring 2022 edition of Pulse Magazine.

Addresses strategic priorities 1, 4 and 6.

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

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 very 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. In 2019, 2020 and 2021, PGRO evaluated cultivation techniques that may help to manage BSF attacks in legumes, including timing of spring cultivations compared to drilling date, and degree of tillage (including min-till and no-till). We also evaluated the effects of cultivation techniques and BSF damage on plant infection with soil-borne diseases. Trials were carried out using farm-scale machinery with the assistance of grower groups. Results indicated that the period between cultivation and drilling may be more important than either drill type or whether rolling had been undertaken. The data also suggested that the traps gave a good indication of periods when attack would be the greatest, and when drilling took place before highest numbers of bean seed fly adults were recorded in traps, damage to seedlings was much lower. This would be expected, as better-established plants are less at risk of damage than imbibing seed and emerging seedlings.

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

Investigation of the effect of cultivation timing on damage caused to vining peas (*Pisum sativum*) by bean seed fly larvae (*Delia platura*) (Becky Howard) AHDB FV462/ PGRO L2020-33

A small plot trial was established in 2020 and 2021 at Stubton in Lincolnshire to evaluate the effect of cultivations made at weekly intervals up to one month before drilling. Significant reductions in damage were achieved if a period of at least 7 days was left between cultivation and drilling, and the longer the period, the lower the level of damage. This trial is co-funded by the AHDB FV462 Horticulture Strategic Centre for Vegetables.

In addition, as part of AHDB FV462 Horticulture Strategic Centre for Vegetables, PGRO maintains a page in the PGRO App to allow incidence of bean seed fly damage to be recorded by growers and advisors across the country. Instructions for use are available and the PGRO App can be downloaded at Google or Apple stores.

Addresses strategic priorities 1, 4, 5 and 6.

The use of entomopathogenic nematodes (*Steinernema feltiae*) to control bean seed fly larvae in vining peas (Becky Howard PGRO/ Stemgold Peas/ Richard Binks Koppert UK) PGRO L2021-3

A large-scale strip-design trial was carried out at a site in Lincolnshire to assess the efficacy of different timings of entomopathogenic nematodes applied using a dribble bar against bean seed fly larvae in vining peas. Timing of treatment was 2, 4 and 6 days after drilling. In a non-replicated large plot trial, although there were no statistically significant differences between treatments, bean seed fly larval damage was lower in all the treated strips compared to the untreated area, with the lowest level recorded in the strip that was treated six days after drilling.

Addresses strategic priorities 1, 4, 5 and 6.

Improved management of virus diseases: Production of a recommended approach to study virus diseases in horticultural crops and its application to example crops (peas) (Becky Howard/ Shona Duffy) – AHDB FV459/ PGRO G2020-11/ FERA Science Ltd./ DEFRA

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 2021, twenty pea crops were sampled to provide virus incidence data and to identify fields for focused further study of virus yield reduction/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. In 2019, the project uncovered a well characterised virus, turnip yellows virus (TuYV).

TuYV was found in 2021 at 13 of the 20 sites, pea enation mosaic virus (PEMV) at 10 sites, pea seed-borne mosaic virus (PSbMV) at 4 sites, soya bean dwarf virus (SbDV) at 2 sites, and a newly recorded virus, pea necrotic yellow dwarf virus (PNYDV) at one site in Kent. Preliminary results have shown 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, although it was postponed in 2020 due to uncertainty about availability of reagents for molecular testing, and safety considerations arising due to Covid-19 regarding site selection and travelling distances. It will continue for a final year in 2022.

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Addresses strategic priorities 1, 4, 5 and 6.

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)

An approach to pest management is to use perimeter trap crops to attract insect pests and prevent infestation of the main crop. Bruchid beetles may be more attracted into earlier developing host crops as they emerge from overwintering sites, where they are able to feed and oviposit, sparing later sown crops from the highest levels of infestation and damage. Pea and bean weevils are also known to have other plant hosts, which in trap crop mixtures, may lead to reduction of migration into bean crops. In conjunction with the semio-chemical attractants already developed, we are evaluating the effectiveness of trap crops to help manage both beetle pests. We will also evaluate the impact of these measures on aphid and beneficial insect species. Preliminary results from 2021 are encouraging and the first annual report will be available by the end of February 2022. Work will be carried out in 2022 and 2023.

Addresses strategic priorities 1, 4, 5 and 6.

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

A replicated, small-plot experiment was conducted in 2020 and 2021 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. Varying levels were tested. Prior to stem extension, there were significant differences in the early growth of the plants. The more infested seeds led to plants with slightly delayed maturity and smaller leaves, although these differences disappeared as the canopy developed. There were no variations in standing ability or haulm length between the plots. In both years there were no significant differences in yield between any of the various levels of seed infestation, although there was a slight trend towards lower yields as the higher infestation levels. Seed costs were calculated by using the TSW and % Germ for both years with prices from the John Nix pocketbook. The seed cost was only slightly higher for the more infested seed, as the requirement for a greater number of seeds to compensate for the poor germination is offset slightly by the smaller seed size. An income per hectare was generated by multiplying the yield at 15% moisture by £198 £/t (Average of 2020 and 2021 from John Nix). The seed cost was then subtracted from the income calculation to give a margin for each ratio of bruchid in the seed. Spraying and labour costs etc weren't factored into this but would have no reason to vary between treatments. The margins created by this calculation don't differ significantly from each other but do trend towards a decreased margin for the lower quality seed. This trendline corresponds to a drop of £22.93 per tonne between clean seed and fully infested. Results were published in the spring edition of Pulse Magazine.

Addresses strategic priorities 1, 4, 5 and 6.

Fertiliser Manual (RB209), PLANET and MANNER-NPK updates – funded by AHDB, PGRO and BBRO Peas and beans (L2020-21)

In January 2021, all sections of The AHDB Nutrient Management Guide (RB209) were updated. A list of updates can be found at <https://ahdb.org.uk/knowledge-library/2021-update-of-rb209>. 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.

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

Legume disease management in vining peas, combining peas and faba beans – funded by PGRO levy (L2020-1)

The project aims to test a variety of biostimulants, biocontrol agents and nutritional products in field conditions in vining peas, field beans and combining peas. The work continued in 2021. There were no treatment effects on crop emergence. Bean rust was observed to be lower when Multimax GPA and Take-off ST were used. This may have been due to decreased foot rot severity or improved crop nutrition which then had an indirect effect on foliar disease. Downy mildew was also decreased (not significantly) by Phorce in beans. Take-off ST and Serenade reduced foot rot infection compared to the control. There were no statistically significant treatment effects on yield in any crop. However, Take-off ST and Phorce generally performed best across the board. Reports are available at <https://www.pgro.org/research-publications/>.

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

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

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. Data sources are a combination of direct field and remotely sensed measurements from grower group field sites, and preliminary data analysis and modelling was carried out using historic trial data for the Nocton vining pea site. In 2021 the harvest date model showed a slight overestimation of harvest dates in the first half of the season. These earlier harvest dates were generally earlier sown crops, with drillings beginning on the 22nd of March 2021. This may indicate that there were factors accounting for early-year conditions which are not yet included in the model. Soil conditions from February to March, or periods of low temperatures for example, may affect the earlier sown crops. 2021 results of the yield model also showed a reduction in accuracy when compared to the training data.

A more detailed report can be found in the 2021 winter edition of Vegetable Magazine <https://www.graphicgeneweb.co.uk/veg/mobile/index.html>.

Addresses strategic priorities 1, 4, 5 and 6.

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. PGRO did not carry out a trial in 2020 due to the risk of loss of genetic material if work was not completed because of Covid-19. The trial continued in 2021. This is the final year of trials.

There was a meeting for stakeholders on 17th November 2021, to discuss the latest developments within genetic research on UK pulse crops. For further information about PCGIN go to <https://www.jic.ac.uk/pulse-crop-genetic-improvement-network-pcgin/>.

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

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 are being 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. PGRO did not carry out multiplication or evaluation of agronomic characteristics in 2020 due to the risk of loss of genetic material if work was not completed because of Covid-19. Due to lack of seed the multiplication was not carried out by PGRO in 2021.

Addresses strategic priorities 1, 3, 5 and 6.

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 was to develop routes to sustainable and competitive legume-based farming systems and agri-feed and food chains in the EU. The project assessed economic and environmental benefits from more widely and sustainably producing and using legumes. PGRO was a work package manager for knowledge transfer, as well as a partner to develop farm networks and supply chain case studies. A report was collated to describe typical cropping systems for different regions in Europe, and a review of ecosystem services provided by legumes was undertaken. The case studies were used to provide technical information to underpin the project, including production improvements, technological advances, and development of new supply chains. More information is available at <http://www.legvalue.eu/>. The project ended in 2021.

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

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

The main aim of TRUE was to identify and enable pathways to successful legume-supported production systems and agri-feed and -food chains. PGRO was a partner for dissemination and stakeholder engagement. More information is available at <https://www.true-project.eu/>. The project ended in 2021.

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

Variety evaluation of lentils (L2020-20) – funded by PGRO levy

24 lentil varieties were evaluated in duplicate in a small plot trial in 2020. 18 promising varieties were trialled in slightly larger plots in 2021 and number of replicates increased to three. The weed burden in 2021 was very high, impacting on yields. In 2020, the trial demonstrated that lentils could potentially yield over 4 t/ha and produce a good quality sample, but only in a low weed pressure situation. In 2021, achieved yields were mostly lower than 2 t/ha.

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

Pea powdery mildew screening (L2020-34) – funded by PGRO levy with chemical companies

A trial was carried out in 2021 following preliminary results in 2020. After the first application in 2021, only Caramba 90 reduced powdery mildew levels significantly. After the second application, all products reduced powdery mildew levels significantly. Arizona was the weakest product, Caramba 90 the strongest. The lower disease pressure translated into faster senescence of the crop, although not significantly.

Addresses strategic priorities 1, 3, 4 and 6.

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

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.

BBSRC-LINK pea and bean downy mildew pathosystem: deploying disease resistance, pathogenomics and microbial biocontrol (G2020-13). Lead partner University of Worcester – funded by BBSRC and industrial partners.

The disease is managed through the deployment of resistant varieties and a limited number of chemical controls; a lack of information on prevalent isolates can lead to serious yield losses in crops grown on contaminated sites with incorrect variety selection. Although a differential set of plant cultivars is available to identify the virulence genes in pathotypes of downy mildew, the test is too time consuming to be of immediate use to the commercial growers. Use of appropriate molecular tools will enable breeders, epidemiologists, modellers and growers to: a) identify the prevailing virulent isolates; b) investigate the epidemics of disease; c) monitor pathogen movement; d) select and deploy the appropriate cultivar(s) resistant to the prevailing isolate rapidly and thus control the disease in an environmentally friendly and sustainable manner; and e) provide a medium to long-term strategy to minimize increases of infective oospores on land allocated to pulse production.

This project focuses on the identification of new R-genes for breeding purposes and the development of tools for accurate detection and diagnostics of downy mildew isolates. We will also explore smart biologics, especially biological control agents, to control downy mildew. The project consortium consists of 16 academic and industrial partners. PGRO has an advisory role.

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

Scaled-up Production and validation of pea midge and pea and bean weevil pheromones for pest management (peas and beans) (G2021-2/ UKRI 10004414). Funded by UKRI and co-funded by PheroSyn Ltd with PGRO as partner.

Midges and weevils are significant pests of legumes in the UK. There is a growing global trend to move away from reliance on chemical pesticides in favour of integrated pest management (IPM) strategies.

Pheromones form an important component of IPM strategies. In this project, PheroSyn are developing routes for commercial-scale production of the pea midge sex pheromone and pea & bean weevil aggregation pheromone. PGRO have validated the efficacy of the midge pheromone in 2021 and found that it is highly effective. Data from 2021 show that midge emergence was prolonged, high numbers of midge being recorded in traps from 18th June to 14th July leading to vulnerability of more pea crops to damage as flower buds were forming. Koppert Biological Systems will market the pheromones for use in legume production systems. Although less of a problem in the less determinate combining pea crops, the pest can occasionally affect combining peas. The pea and bean weevil pheromone will be evaluated in early 2022 and the midge validation will continue from May 2022. The project ends in September 2022.

Addresses strategic priorities 1, 4, 5 and 6.

The use of entomopathogenic nematodes (*Steinernema feltiae*) to control pea moth in combining peas (L2021-04), funded by PGRO levy with Koppert UK and farmer co-operation.

Two products containing the entomopathogenic nematodes *Steinernema feltiae* were tested at field-scale in strips compared to an untreated area and conventional insecticides, to evaluate their effectiveness for control of pea moth larvae. All operations were carried out on-farm. Simple analysis of pea samples taken at harvest showed a beneficial effect when using the nematodes compared to the untreated area, although the insecticide performed better in this trial. Due to the nature of the trial, it was not possible to carry out statistical analysis.

Addresses strategic priorities 1, 4, 5 and 6.

Evaluation of automatic trap for monitoring pea moth activity (L2021-05) – funded by PGRO levy with Metos UK and farmer co-operation.

During May, June and July an iScout automatic camera trap was placed in a crop of peas near Sawtry in Cambridgeshire in conjunction with a field scale strip trial. The camera trap was used to monitor adult pea moth activity without visiting the field regularly. The trap worked well for pea moth and the trial described above was treated using the recommendation generated from this trap with the PGRO pea moth forecasting model. Visit requirement in 2021 was reduced from three weekly visits using a normal system to one visit every two to three weeks. This may vary each year depending on numbers of moths caught on the sticky card. The trap was used in conjunction with the PGRO Field Climate account (Metos UK/ Pessl Instruments).

Addresses strategic priorities 1, 4, 5 and 6.

Herbicide options – vining peas and green beans (Jim Scrimshaw/ Lea Herold) AHDB SCEPTRE plus/ PGRO G2020-7

A trial funded by AHDB (SCEPTREplus, P1901288) was carried out in 2019 and, due to late arrival of products, repeated in 2021. The cool temperatures in mid-April 2021 meant that green beans were slow to emerge after drilling. Later in their development cool temperatures returned and crop progress slowed again. Irrigating the area encouraged weed growth and provided the best conditions to allow accurate assessment of efficacy and phytotoxicity of all the pre-emergence applications. However, the wetter than usual conditions may well have highlighted an issue of brittle stems that is encountered occasionally when using pendimethalin and can be devastating for mechanically harvested beans. Rates of use of Stomp Aqua in green beans are well below the EAMU maximum individual rate of 2.9 l/ha not only because of the potential to cause brittle stems but higher rates can reduce vigour unacceptably, slow emergence and cause swelling of the hypocotyl. Cool and wet

conditions can increase the likelihood of herbicide absorption because of prolonged exposure. The better long term weed control was seen on those plots which had pendimethalin as a component of the treatment. These treatments also tended to exhibit the greater long-term losses in crop vigour. Single rate applications of commercially used Stomp Aqua (pendimethalin) + Centium (clomazone) caused an acceptable loss of vigour but double applications, simulating spray overlap, caused the greatest reduction in vigour in green beans compared to all other treatments.

Weed pressure at the vining pea site was eventually very high and Nirvana 3.5 l/ha and Wing P 4.0 l/ha were the only two treatments to deliver reasonable long-lasting control. In this situation a pendimethalin component appeared vital to give any level of control. Crop damage with all was minimal, although a coded product early in the work was the most damaging.

Addresses strategic priorities 1, 5 and 6.

PGRO PhD program (<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.

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 and the thesis is due to be submitted in early 2022.

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

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 indicated that some biofumigant mustard crops, such as Indian Mustard, led to potential reductions of nematodes of up to 30% in soils. Laboratory tests indicated that low levels of isothiocyanates lead to immobilisation of the nematodes, preventing plant invasion. The study also showed that some mustard species hosted *Ditylenchus dipsaci* and may be undesirable in rotations that contain this species. The student, Nasamu Musa, submitted his thesis in October 2021.

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

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 explores 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 is 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.

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 is working with PGRO to gather more data from field-scale sites.

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

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.

Remote sensing and machine learning for the field-scale prediction of maturity and yield in vining pea (*Pisum sativum* L.) – Leah Howells University of Nottingham – PGRO P2021-1

Leah Howells started this PhD in April 2021, co-funded by The Morley Agriculture Foundation (TMAF). Leah will expand on and publish work from the KTP project described above (Knowledge transfer partnership No. KTP011104/ PGRO 2020-10).

Knowledge Exchange

- a. Advice and literature are produced throughout the year with technical information made available via the web site at www.pgro.org.
- b. Marketing reports are collated in conjunction with BEPA and distributed monthly throughout the year.
- c. Pulse roadshows/ webinars are held across the country each year during January and February. Details are available at <http://www.pgro.org/pgro-diary-of-events/>.
- d. Technical members of staff contribute to an increasing number of grower/merchant and Ag-chem Meetings.
- e. All issues of PGRO Pulse Magazine are distributed through Crop Protection Magazine (CPM).
- f. The PGRO Descriptive Lists of vining peas and pulses are published annually.
- g. PGRO has developed an Android and Apple application to replace the printed Pulse Agronomy Guide and Vining Pea Guide. All information from the guides are updated in the App.
- h. Monitoring services are carried out for bean seed fly, pea and bean weevil, pea moth, silver Y moth and bruchid beetle.
- i. Field visits are carried out on request.
- j. The PGRO legume crop protection training course is held annually at the beginning of the year.
- k. The plant clinic operates all year.
- l. Crop updates are distributed to inform about topical issues throughout the year.
- m. AHDB Aphid News is distributed to members via the PGRO website amongst others.
- n. Telephone consultations remain a very popular contact route for engagement for technical advice.

ACKNOWLEDGEMENTS

The Organisation remains grateful to the many seedsmen and agrochemical and nutrient manufacturers for the provision of considerable quantities of seed, agrochemicals and plant nutrients throughout the trialling season.

The assistance and co-operation of Dyson Farming who own the arable land at Stubton and Nocton where PGRO home-based trial grounds are sited and the owner, Sir. James Dyson is gratefully acknowledged.

The help of the numerous growers in the provision of additional field trial sites and the many commercial concerns, levy collectors, Industry Panel members, Associates and individuals too numerous to mention by name, is also gratefully acknowledged with sincere thanks.



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