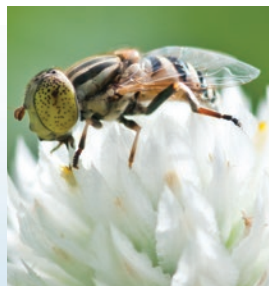


# NIAB InnovationFarm VISITOR GUIDE 2019



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# INTRODUCTION

NIAB Innovation Farm is a unique physical showcase of agricultural and horticultural activity, with particular focus on plant genetic improvement, working with academics and industry to utilise, develop or produce plant-derived or plant-based materials.

Our central objective is to show how plant resources and crop genetic improvement can help address the major global challenges of sustainable use of resources, climate change, food security and provision of high quality food to enhance health and nutrition.

## THE CHALLENGES

Agriculture and food production face enormous challenges in the years ahead. NIAB Innovation Farm demonstrates how crop genetic improvements can address the issues of:



### Food security

The need to increase global food supplies through sustainable management of resources to keep pace with the demands of a growing world population; to provide food that is affordable, nutritious and safe.



### Sustainable resources

Agriculture and food production face enormous challenges in the years ahead. Solutions must be achieved using less land and fewer or less expensive resources; including for example water, nutrient and crop protection amendments, agronomic management (such as soil preparation) and pre or post-harvest crop processing.



### Climate change

Unknown changes in weather patterns and seasonal temperatures will impact on both crops and organisms that interact with them, such as new or altered levels of pests and diseases. Growers will have to understand and deal with these biotic and abiotic factors to maintain production of existing crops or perhaps to switch to new ones.



### Health and nutrition

Concerns over food safety and the need for more variety and more healthy nutritious food have driven innovation in quality standards. The demands of both consumers and the food and drink processors have led to many changes in recent years. Innovation is needed to provide nutritional security on top of food security; through for example, higher or more balanced nutrient content, reduced toxins and improved digestibility.



### Biodiversity and Aesthetics

A beautiful and diverse environment is vital to maintain ecosystem services at landscape-scale and to maintain an appealing environment for both human and other species.

# PROMOTING THE POWER OF GENETIC INNOVATION

In the context of these Key Challenges, our exhibits and events consider progress in improving:

- Crop or final product yield
- Crop, food product quality
- Disease susceptibility or resistance
- Importance or impact of seasonality
- Diversity and biodiversity
- Aspects of performance
- Resource use efficiency
- Ecosystem services

Why get involved with NIAB Innovation Farm?

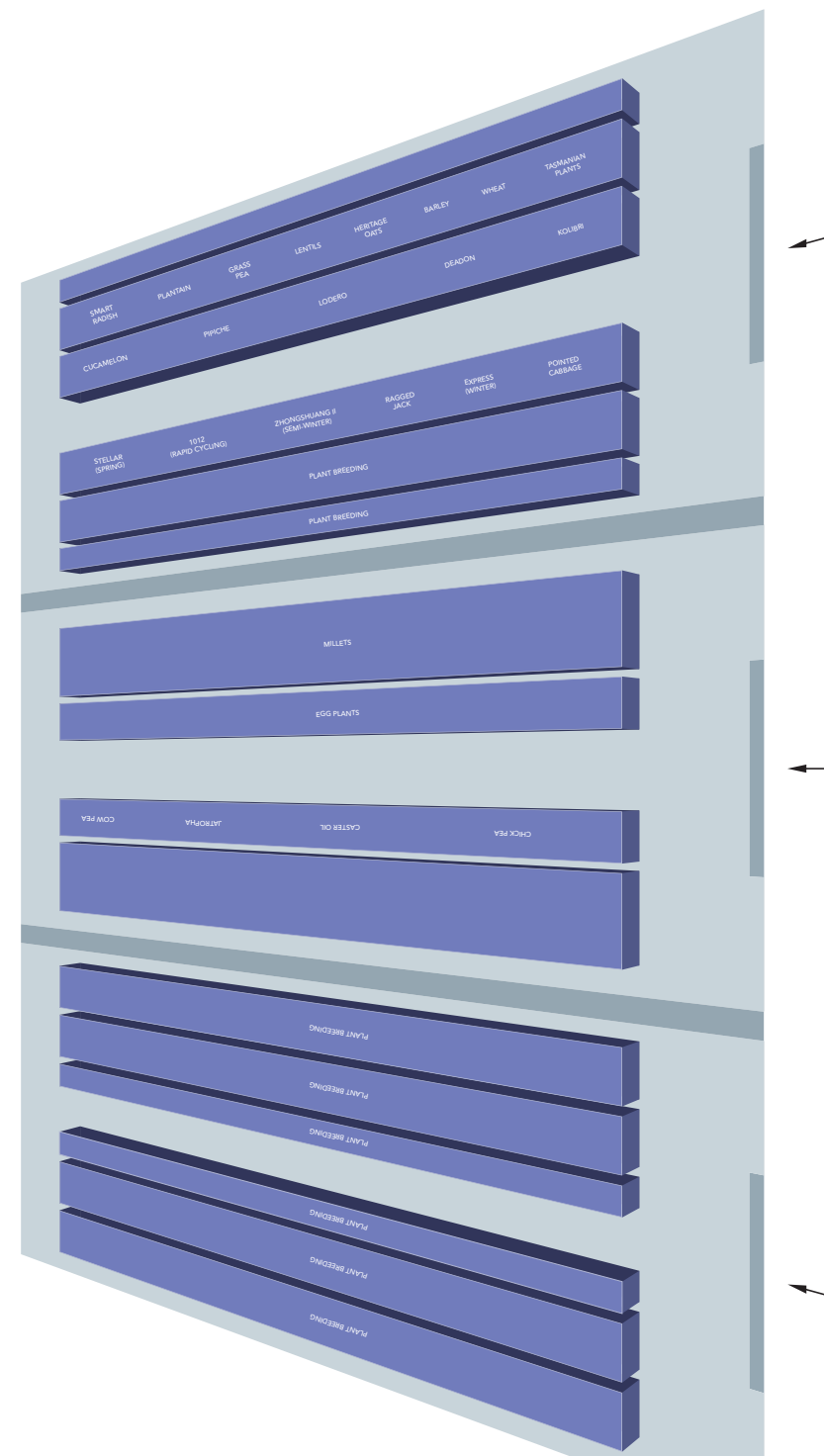
- Genetic innovation, and translation into practice, is key to addressing societal challenges
- One-stop-shop for understanding and demonstrating innovation
- Proven platform with wide engagement
- Industry, policy maker and grower audiences
- Easy access to experts (research to industry)
- Source of collaborators

How to get involved with NIAB Innovation Farm

- Provide a plant genetic innovation for a field or glasshouse exhibit
- Sponsor a specialist themed event
- Register as a delegate to attend an event
- Use our facilities to host an event

To discuss these opportunities or research and innovation e-mail Dr Lydia Smith ([lydia.smith@niab.com](mailto:lydia.smith@niab.com))

## IN THE GLASSHOUSE



## TEMPERATE CROPS

### TASMANIAN NATIVE SPECIES ●●

Supplier: Wildseed tasmania

#### **BOWER SPINACH** (*Tetragonia implexicoma*)

From the Aizoaceae family, Bower spinach is a mat-forming perennial. It is a bush tucker plant with leaves that can be eaten raw or cooked. In the wild it can be found on coastal exposures, beach frontages, dunes or cliffs. Grown in gardens it can be used for fast growing ground coverage or as a climber.

#### **ROCK LILY** (*Bulbine glauca*)

A clump-forming lily from the Asphodelaceae family, this is a fast-growing herbaceous perennial which dies down in the winter. Its distribution is mostly associated with elevated areas, cliffs, crevices and summits. It has edible seeds and roots. Grown in gardens it is used for mass plantings, rockeries, pots and ponds.

#### **PIG FACE** (*Carpobrotus rossii*)

Another member of the Aizoaceae family, Pig Face is a succulent plant with bright pink flowers. It is a pioneer species, found growing in coastal dunes or on cliffs. Fruit and leaves are edible raw or cooked.

#### **GREY SALTBUSH** (*Atriplex cinerea*)

A pioneer species indigenous to Tasmania, New Zealand and South Australia, Grey Saltbush is a member of the Chenopodiaceae family. It is a drought tolerant plant, found in coastal areas, around salt lakes, dunes and cliffs. It provides very nutritious animal fodder and many parts of the plant are edible for humans, particularly the leaves, which have a salty flavour due to salt being drawn in through the deep roots.

## WHEAT GENETIC DIVERSITY

The NIAB MAGIC Elite population is based on eight UK commercial wheat varieties. NIAB is developing heterogeneous inbred families (HIFs) from selected individuals, to support projects on disease resistance, photosynthesis and yield traits. The HIFs will allow study of their genetic control with even greater precision. This builds on previous results from field and glasshouse experiments.

The NIAB MAGIC Diverse population was similarly developed by inter-crossing 16 UK wheat varieties, and samples genetic diversity from each decade of breeding from 1930s to 2000s. 'Catch-up' generations are being grown to expand the population size, which will increase the precision of future experiments using this community resource.

The Cambridge-India Network for Translational Research in Nitrogen (CINTRIN) project aims to better understand nitrogen use efficiency in cereal crops. Here, NIAB is growing wheat and barley mutants with altered grain quality characters such as starch biosynthesis and/or embryo size at different soil nitrogen levels. This allows an investigation into how changing the sink (different grain properties) and the source (nitrogen levels) impacts on nitrogen flow and grain quality.

## BRASSICA RAPESEED AND VEGETABLE OPTIMISATION (BRAVO) ●●●●

Supplier: Wildseed tasmania

Partners: John Innes Centre, BBSRC, Syngenta, Rothamsted Research, Aberystwyth University, University of Bath, University of Nottingham, Warwick University, University of York

#### **OILSEED RAPE** (*Brassica napus*)

Varieties: **STELLAR, ZHONGSHUANG II, EXPRESS** and **RAGGED JACK**

#### **CABBAGE** (*Brassica oleracea*)

Varieties: **1012** (rapid cycling) and **POINTED CABBAGE**

Plants have evolved signal-processing machineries to adapt to their environment. The timing of key developmental transitions, including germination, flowering and fruit and seed development is determined by seasonal progression.

Elements of the gene pathways, which were first described as controlling the time to flowering, have now been revealed as regulating many of these transitions in plant development. However, much of the genetic architecture that controls the timing of these transitions remains unknown.

Understanding the environmental sensitivity of the underlying regulatory pathways is of central importance for optimising crop performance in new climates. In Europe, predicted climate change will demand mitigation strategies including changes in crop sowing and harvesting dates, the introduction of cultivars with different relationships between developmental transitions and seasonal progression, and breeding for robust performance under stressful conditions.

Brassica species encompass a diverse range of economically important crop species worth in excess of \$20 billion worldwide. The Biotechnology and Biological Sciences Research Council (BBSRC) BRAVO project brings together UK plant scientists and industries representing horticultural and oilseed Brassica crops to increase robustness in crop performance, combating environmental change. The goal of BRAVO is to understand seasonal and environmental effects on developmental transitions in Brassica crops, and to use this information to improve reliability, yield and quality. Brassica species contain a wealth of natural variation that can be exploited to improve crops. BRAVO will use this variation to understand the gene networks controlling flowering time and study how these networks affect all developmental stages, from vegetative growth to seed production. Determining relationships between genes, traits and the environment will aid targeted crop improvement to secure future yields.

## BIOBOOST ●●

**Funder:** European Union, European Regional Development Fund (ERDF)  
**Partners:** NIAB, Municipality of Westland (Netherlands, Lead), Catholic University College, Inagro, Transportbedrijf Van Vliet B.V., Institute for Agricultural and Fisheries Research and Epping Forest District Council

Anthocyanins are flavonoid plant compounds. They occur in plants as pigments (ranging from red to deep purple-black). They are also increasingly thought to be highly beneficial for human health, as they are antioxidants. NIAB Innovation Farm is demonstrating a wide range of varieties that contain high levels of anti-oxidants to show the sourcing high value phytochemicals from a range of fresh produce. For more details about the BIOBOOST Project, please see the 'In The Field' section.

### CABBAGE (*Brassica oleracea*)

**Varieties:** LODERO and DEADON

Lodero is a red-leaved cabbage. This variety shows high resistance to one or more races of the clubroot fungus. Deadon is a hybrid variety. It has dark green outer leaves with a red tinge. Colour may be increased in stressed growing conditions.

### KOHL RABI

**Variety:** KOLIBRI (*Brassica oleracea* (Gongylodes group))

Kolibi is a mid-early variety, with purple skinned and white flesh. This variety can be eaten raw.

## LENTILS (*Lens culinaris*) ●●

**Supplier:** Hodmedods

**Varieties:** ANICIA and FLORA

These varieties are also demonstrated in the field. Please see the 'In The Field' section for information.

## GRASS PEA (*Lathyrus sativus*) ●

**Partners:** NIAB, John Innes Centre, Bidhan Chandra Krishi Viswavidyalaya, BenchBio

Grass pea (also demonstrated in the field) offers an excellent opportunity for sustainable agriculture and food security; it is a legume and performs well in marginal soils or under harsh climatic conditions. It is grown for seed and fodder production in many countries, including large parts of India, Europe and China. It is a low input crop, a cheap source of protein and is particularly tolerant to drought, water logging, and moderate alkalinity. However, grass pea can cause a devastating disease called neurolathyrism, believed to be due to its content of beta-N-oxalyl-L-alpha,betadaminopropionic acid (ODAP). This neurological disorder is irreversible and occurs when people are dependent on the crop as a major food source. Grass pea can also inhibit growth in some animals when used as feed.

This project is using germplasm and existing mutant populations as novel resources for the rapid identification of mutations offering improved crop characteristics via a non-GM route. The objective is to develop modern genomics tools and resources for rapid domestication of grass pea to remove ODAP and provide a non-toxic, stress tolerant

legume for food and fodder. It is also investigating why grass pea has improved stress tolerance compared to other legumes, with the objective of using this fundamental insight to improve stress tolerance in UK legumes, such as pea.

## UNLOCKING THE TRANSFORMATION POTENTIAL OF BARLEY ●●

**Varieties:** M1460, MINERVA and GOLDEN PROMISE

Genetic transformation is used to create genetically manipulated (GM) plants. Although controversial, most scientists agree that this technology could help us to respond to the challenges of climate change and famine on our over-populated planet. Transgenic barley is usually obtained from the germ of developing grains after co-cultivation with the bacterium *Agrobacterium tumefaciens*. It is a problem that most barley varieties are not transformable. The variety commonly used for transformation, Golden Promise, is an old variety, not widely grown due to its poor yield and susceptibility to disease.

NIAB searched a collection of barley mutant lines and found one called M1460 that was transformable, and had a transformation efficiency equivalent to that of Golden Promise. The parent of M1460, Minerva is not transformable. NIAB is attempting to identify the gene in M1460 that is responsible for high transformation efficiency so that we can transfer it to elite barley varieties and thus make them transformable.

## BARLEY (*Hordeum vulgare*) ●

**Breeder:** Bangor University

**Varieties:** SEIRIOL and BODFAN

These lines are also demonstrated in the field. See the 'In The Field' section for information.

## CUCAMELON (*Melothria scabra*) ●

**Supplier:** Chiltern Seeds

Cucamelon is a vigorous climber which bears large numbers of grape-sized fruits that look like mini-watermelons. Also known as mouse melon or Mexican sour gherkin, it is a member of the cucumber family (Cucurbitaceae) and is like a cross between a cucumber and a watermelon. The flavour is more that of a cucumber, but with a hint of lime. Cucamelon is also demonstrated outside in the Sophi Taylor Building garden.

## PIPICHE (*Porophyllum tagetoides*) ●

**Supplier:** Chiltern Seeds

A member of the Daisy family (Asteraceae), Pipiche is also known as Mexican Coriander. It has a fresh citrus-coriander flavour with overtones of anise. Also used as a medicinal herb, the leaves secrete the essential oils which give the plant its unique flavour. It is very fast growing and has very unusual blue flowers without petals. Pipiche is also demonstrated outside in the Sophi Taylor Building garden.

## ASSOCIATION MAPPING IN OAT (*Avena sativa*) ●●●

**Partners:** Aberystwyth University – Institute of Biology, Environmental and Rural Sciences, BBSRC, Senova

**Varieties:** **BANQUO**, **MILFORD**, **MELYS**, **DYFED** and **S75** (spring oats – Heritage lines)

These varieties are also demonstrated in the field, see In The Field section for more information.

## PLANTAIN (*Plantago lanceolata*) ●

**Partners:** Norwest Seeds Ltd, NIAB

**Variety:** **BOSTON**

The narrow leaf forage plantain is a rapid establishing perennial pasture herb. It is deep rooted with good drought, heat and cold tolerance. Boston Plantain is mineral rich which elevates: copper, selenium, cobalt, calcium, magnesium, sodium and zinc levels in farmed animals. It can be planted as a 'plantain pasture' alone or in a seed mix, but needs to be at least 30% of any pasture content to get these full benefits. In New Zealand, plantain has been found to help reduce cow urine nitrogen and methane emissions. Boston Plantain is a late flowering variety and consideration is needed in managing a plantain pasture with rotational grazing of about 21 days as stock prefer the younger leaves but will also eat flower heads. This crop is also demonstrated in the field.

## RADISH (*Rhaphanus sativum*) ●

**Partners:** Norwest Seeds Ltd, NIAB

Radishes are the fastest growing of all the brassica family. Smart Radish® has a pull-down tap root with greatly increased fibrous side roots, and larger leaves. It can be used as a green manure crop or for grazing. It has been bred to optimise soil nutrients uptake time and to break up soil compaction while feeding the soil biology at the same time. After terminating it slowly recycles nutrients for the next crop to take up. It is a 90-day cover crop radish which should be planted in late summer in a cover crop mix with cereals. This crop is also demonstrated in the field.

## SALAD MUSTARD (*Eruca sativa*) ●

**Partners:** Norwest Seeds Ltd

**Variety:** **Xtender**

Salad Mustard (or *Brassica aruluga*) is the fastest growing brassica. It is being developed as a component for cover crop mixes, or for green manure/forage. It is autumn planted, and is very cold tolerant with bio-fumigant properties.

## TROPICAL CROPS

NIAB Innovation Farm provides a venue for demonstrating research and innovation in tropical crops, especially crops from parts of Asia and Africa that are subject to heat, drought and concomitant food shortages. The sustainable utilisation of resources, including soils, is a theme of particular importance.

## COWPEA (*Vigna unguiculata* subsp. *unguiculata*) ●●

**Supplier:** International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Cowpea is a member of the Leguminosae family. It is a multi-use crop, grown particularly in semi-arid areas, primarily as a pulse, although the leaves and green peas are eaten as a vegetable and it is suitable for use as fodder for livestock.

Significant research by organisations such as CGIAR, the International Institute of Tropical Agriculture (IITA) and ICRISAT is underway, including surveys of the current plant genetic resources for cowpea and their conservation, and research into potential intercropping with other crops such as sorghum, to improve yield and reduce soil erosion.

## CHICKPEA (*Cicer arietinum*) ●●

The chickpea is the third most important food legume and one of the earliest to be cultivated. It is grown on 11.5 million ha worldwide with 96% in developing countries. New varieties that combine early maturity and resistance to Fusarium wilt have been widely adopted in eastern Africa.

## SOIL NUTRIENT CYCLING ●

**Partners:** NIAB, Alborada Trust, Michael Okpara University of Agriculture Umudike (MOUAI)

**Species:** Neem (*Azadirachta indica*), Jatropha (*Jatropha curcas*) and Castor Oil (*Ricinus communis*, ex Dominican Republic)

Soil nutrient cycling from organic (farmyard manure) can be too rapid under the warm moist conditions in parts of Nigeria. This project will consider ways to control mineralisation rates so that nutrients are not lost from the system before they can be utilised by crop plants. The partners are investigating the use of symbiotic mycorrhizal fungi inoculation alongside the use of combinations of microbial and products of plant decomposition to control this process. These phytochemicals are sometimes known as 'compost teas' and their composition varies depending on the plant used and the conditions experienced during the composting process.

Three plant species that have shown positive results in preliminary work will be trialled in Nigeria and the protocol optimised in this collaboration with NIAB, funded by the Alborada Fund.

## AFRICAN EGGPLANT (*Solanum eschscholzii*) ●●

**Partners:** NIAB, World Vegetable Centre (Tanzania), Uganda Christian University (Uganda), World Agroforestry Centre (Kenya) and Tanzania Agricultural Research Institute- Mikocheni (Tanzania)

**Varieties:** **GILO GROUP: DB3 AND TENGERU WHIT; SHUM GROUP: ELL, E15 AND E16; KUMBA GROUP: 934750034;** and **ACULEATUM GROUP: 914750093**

African eggplant is an important indigenous crop in Sub-Saharan Africa. It is widely consumed across both west and east Africa as a leafy vegetable and also as a fruit. It is closely related to aubergine/eggplant (*Solanum melongena*), tomato (*S. lycopersicum*) and potato (*S. tuberosum*). Similar to these *Solanum* species, the availability of soil water and the health of the soil, as defined by the presence or absence of diseases, will greatly affect productivity and nutritive content.

There is an immense potential to improve the production of African eggplant through improved water management strategies, improving soil health and growing varieties that are more resilient to water stress. Sustainable Agriculture for Sub-Saharan Africa – *S. aethiopicum* Improvement (SASSA-SAI) is a project aimed at improving the production of African eggplant; the project aims to adopt two major approaches to maximise African eggplant production: 1) developing new plant and crop management strategies to improve production; and 2) characterisation of the genetic diversity towards identifying more drought resilient accessions.

## MILLET (*Panicum miliaceum*) ●

**Supplier:** Soya UK

**Variety:** **MAMMOTH**

Widely grown for game cover, rather than a general cover crop, millets are also increasingly being developed for human consumption in the UK as a high value niche end-market product. Mammoth is a white millet variety grown commercially (for food rather than cover) in the UK since 2003. It is an early maturing variety with good standing ability.

## ALOE VERA ●

Aloe vera plants use Crassulacean Acid Metabolism (CAM), which is an adaptation to high temperature and low water levels. The CAM pathway allows the plant to close its stomata during the day (when at the highest risk from excessive water loss). Carbon dioxide is taken up by leaves during the night, stored as Crassulacean Acid, and then fed into the photosynthesis reaction in the day when it is light. This crop has been the subject of research at the University of Cambridge Plant Sciences Department. It is used in many cosmetic and skin care products due to its beneficial properties.

# IN THE FIELD

A plan of the field exhibits and demonstration plots is shown on pages 18 and 19

## HERITAGE WHEAT

**Varieties:** **SQUAREHEADS MASTER, LITTLE JOSS, YEOMAN, HOLDFAST, CAPELLE DESPREZ, MARIS HUNTSMAN, SLEJPNER, RIBAND, CLAIRE, KWS SANTIAGO**

This demonstration shows a variety of winter wheat from each decade of the past century. Grown next to one another, the changes that plant breeding has made can be seen in the size, shape, yield, quality and agronomy of wheat varieties, as well as possible developments in the future.

## UK CEREAL PATHOGEN VIRULENCE SURVEY (UKCPVS)

**Varieties:** **REFLECTION, INVICTA, KRANICH, WARRIOR, SOLSTICE, ROBIGUS, MADRIGAL, BRIGADIER, HORNET, SLEJPNER**

These plots trace the development of yellow rust in the UK over the past 35 years, across a range of wheat varieties. UKCPVS was set up in 1967 to alert growers, breeders and agronomists to any important changes in the populations of important cereal pathogens. Initially, this covered the pathogens behind the cereal diseases oat crown rust, oat leaf spot, wheat, barley and oat powdery mildew, barley leaf scald (*Rhynchosporium*) and wheat and barley yellow rust.

Today, UKCPVS monitors the pathogens behind wheat yellow rust, wheat brown rust and wheat and barley powdery mildew. With the current diverse population of the wheat yellow rust pathogen (*Puccinia striiformis* f.sp. *tritici*), developing new resistant varieties is now a high priority for wheat breeders. Recent developments in field pathogenomics are aiding the fight against new races. Looking through historical Recommended Lists, it is clear that there are many varieties that were resistant when they were removed from the list and these represent untapped resources of resistance that could be exploited. NIAB trials at three locations, as part of project *Yellowhammer*, showed that, whilst some of the varieties no longer had effective resistance, such as Aquila, Hunter and Deben, others could prove to be useful sources of resistance, such as Flanders, Mercia and Parade. Further work is now ongoing to identify the genomic regions that encode these resistance genes and help breeders to select for these regions in their current breeding programmes. By incorporating lots of different sources of resistance varieties can be produced that are resistant to future changes in pathogen populations.

## WHEAT GENETIC DIVERSITY

### BLESS-T ●

Funder: BBSRC

The endosperm, rich in starch and storage proteins, makes up over 80% of the weight of modern wheat grains. The starch is packaged into large A-granules and smaller, but much more numerous, B-granules. These B-granules can be problematic in some food, drink and industrial processes, and starches with greatly reduced B-granules might have novel valuable characteristics. Most *Triticeae*, including all wheat and barley varieties, produce grains which contain both A and B-granules. Through smart conventional breeding, NIAB has produced BlessT: a wheat line which contains the larger A-granules only.

Early work funded by the BBSRC Crop Improvement Research Club has now been taken forwards with a BBSRC Follow-On Fund project, in which NIAB is multiplying up BlessT. Together with breeders and end-users, NIAB will evaluate its field performance and, most importantly, its market potential in terms of functionality and physico-chemical properties. These miniplots include pairs of lines  $\pm$  the BlessT trait.

### WIDE CROSSING AND WHEAT RESYNTHESIS ●●●●

Funder: BBSRC, NIAB

Since 2005, NIAB has invested heavily in wheat pre-breeding, notably assisted by BBSRC's Wheat Improvement Strategic Programme (WISP) and Designing Future Wheat (DFW) projects. These have generated thousands of new experimental pre-breeding lines, which capture novel genetic diversity through crosses between exotic sources and more typical UK varieties. The best of these are then characterised more fully in conjunction with commercial breeders.

This demonstration highlights NIAB's flagship wheat resynthesis programme, which recreates a rare hybridisation event which led to the formation of hexaploid wheat (genome AABBDD) as we now know it. NIAB has pollinated tetraploid wheat – in this case durum wheat (*Triticum turgidum durum*; genome AABB) – with the wild goatgrass (*Aegilops tauschii*; genome DD). After a tissue culture step NIAB has regenerated fertile plants, called SHW (synthetic hexaploid wheat), from this cross. Because NIAB is able to then make crosses between SHWs and modern varieties, the technique can be used to increase the genetic diversity available to commercial breeders, especially for the D-genome which is otherwise rather conserved in current wheat breeding programmes. This plot highlights some of NIAB's SHW-derived lines which are being further studied in the DFW Project.

In a similar fashion, NIAB have crossed a number of wild and cultivated tetraploids (including wild emmer, cultivated emmer and durum wheats) directly with modern hexaploid wheat to increase AB-genome diversity. These 'THEX' derivatives are also being studied in DFW.

The demonstration also includes eight SHW- and THEX-derivatives which have been selected across multiple seasons by NIAB as showing promising field characteristics, especially for yield and biomass.

### MAGIC POPULATIONS (Multi-parent Advanced Generation Inter Cross) ●●●●

Funders: BBSRC and National Institute of Agricultural Botany Trust

NIAB has been at the forefront of developing MAGIC (Multi-parent Advanced Generation Inter Cross) populations in wheat. With funding from BBSRC and the National Institute of Agricultural Botany Trust, two populations have been initiated:

- NIAB Elite MAGIC – the intercrossing of eight UK winter wheat varieties
- NIAB Diverse MAGIC – the intercrossing of sixteen historic and current European winter wheat varieties selected to maximise the genetic variation captured.

Since completion in 2011, the 'NIAB Elite MAGIC' population, has formed the basis for many studies investigating the genetic control of agronomic traits, often in partnership with industrial collaborators. These have included a wide range of targets: disease resistance (*Fusarium* head blight, yellow rust, *Septoria tritici*, *Septoria nodorum*, tan spot); aspects of photosynthesis (photosynthetic rate, stomatal conductance, canopy architecture); phenology (paired spikelets, height, heading date) and yield/ yield components. An example of the latter is the MAGIC YIELD project, in which the population was used to investigate genetics of yield and yield components within a BBSRC LINK project in conjunction with AHDB Cereals & Oilseeds and five commercial plant breeding companies.

These miniplots contain contrasting lines identified within the NIAB Elite MAGIC population, to showcase how different components such as grain size, grain number and tiller number contribute to yield.

### CINTRIN (Cambridge-India Network for Translational Research in Nitrogen) ●

Funders: Newton-Bhabha Fund (BBSRC, NERC and the Department of Biotechnology India (DBT))

Partners: NIAB, ICRISAT, University of Cambridge (Plant Sciences, Sainsbury Laboratory), ADAS, Punjab Agricultural University, the National Institute of Plant Genome Research (NIPGR) and KisanHub

The CINTRIN partnership represents a powerful alliance of academia, research institutes and business, with a primary goal of reducing the use of agricultural nitrogen through exploiting plant genetics. CINTRIN is led by NIAB in the UK and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India. The demonstration plots, contain the same material grown with standard N application (CINTRIN +N) and with no N applied (CINTRIN -N). Each plot contains lines with contrasting root architecture, as identified through previous experiments. These lines are also in field trials which will help to determine how differences in root architecture can affect N-uptake and yield in different environments.

### F1 HYBRID PARENTS ●●●●

Many wheat breeders are keen to develop F1 hybrid varieties. As well as the characteristics of the F1 hybrid itself, the commercial success of hybrid wheat will depend on the ease, reliability and cost of field-scale F1 seed production. Potential parents would be screened for suitable male and female characteristics, including height, flower structure and flowering time. Males tend to be relatively tall, with good anther extrusion and a long duration of pollen shed. Females are generally shorter, with an open flowering habit. Both parents must overlap in terms of flowering time, with females slightly earlier than males. This plot has examples of lines from the NIAB Elite MAGIC population which appeared to have good male and female characters in 2018 field tests.



## HYBRID WHEATS ●●

Breeder: Saaten Union

Varieties: **HYKING** and **HYBIZA**

A high yielding variety that requires nitrogen fertilisation to be split to ensure good protein content, Hyking has resistance to Orange Wheat Blossom Midge, and has been bred for good winter hardiness and lodging resistance. Hybiza is a very early hybrid which is potentially suitable for cultivation in hot and drought prone areas.

## SPRING WHEAT – DESIGNING FUTURE WHEAT (DFW) ●●●●

Funder: BBSRC

Line: **NIAB 1749**

This is an advanced NIAB pre-breeding spring wheat line developed as part of the BBSRC Wheat Improvement Strategic Programme (WISP), selected from a cross between Paragon (a UK breadmaking variety) and a durum wheat. This selection forms part of the BBSRC Designing Future Wheat (DFW) 'Breeders Toolkit' and has yielded well in trials. This demonstration shows treatments at the full rate of nitrogen and no nitrogen.

## FORAGE AND HERBAGE

These exhibits are in adjacent Field 43.

Several of the mixtures here are currently being considered in a multi-partner project, funded by the BBSRC, as part of the Sustainable Agriculture Research and Innovation Club (SARIC). In particular, the four-year herbal ley mixture supplied by Cotswold Seeds is being considered in this project.

SARIC recognises the urgent requirement to determine how best to restore soil quality, and achieve good livestock production and economic returns through a comprehensive evaluation of the costs and benefits of such systems. The goal is to provide the first comprehensive industry-informed, farmer-participatory assessment of soil quality, environmental and economic cost-benefits, farmer motivations and barriers to reintroducing sheep into arable rotations, focused on our most intensively cultivated areas of eastern England. This project is led by Sheffield University and includes NIAB, Bangor University, Birmingham University, CEH, Rothamsted and Harper Adams University College.

The approach is to compare traditional grazed grass-clover leys and conventional crop cultivation, with innovative management systems that hold the promise of better returns involving combining novel species-rich herbal leys, mowing and no-tillage direct drilling of the crops.

## SAINFOIN (*Onobrychis viciifolia*) ●●●

Partners: NIAB, Cotswolds Seeds, Aberystwyth University – IBERS

Sainfoin is a high protein, low-input forage crop that grows well on dry, poor quality, neutral to alkaline land. It has a long history of cultivation in temperate zones for forage use, particularly for heavy horses, but its use has declined since mechanisation.

Sainfoin is generally not as productive as other forage legumes and is more difficult to establish, but has very valuable characteristics such as high palatability and drought tolerance. Furthermore, anthelmintic and non-bloat digestive properties, due to its unique tannin and polyphenol composition provide a potential alternative to synthetic pharmaceuticals. It can be fed fresh as hay or silage; as a perennial long-term ley, it is

seen as a high quality alternative to grass and clover mixes. The complex tannins also reduce greenhouse-gas emissions from ruminant livestock when used in their feed, and improve wildlife biodiversity in the field.

NIAB and IBERS have undertaken research to sequence the genome and find markers for future breeding and improving variety selection. NIAB has also developed husbandry guides with Cotswold Seeds, and investigated response to new agronomic strategies, such as companion cropping and herbicide use.

## RED CLOVER (*Trifolium pratense*) ●

Supplier: Cotswolds Seeds

Widely grown for forage and silage, red clover is also included in many cover crop mixes for its ability to fix nitrogen and to establish quickly, providing soil cover and weed suppression.

## FESTULOLIUM ●

Supplier: DLF

Variety: **LOFA**, **HIPAST** and **PERSEUS**

Lofa was developed in the Czech Republic by crossing Italian Ryegrass with tall fescue. Selection was then made for ryegrass type plants showing high yield and forage quality and fast growth. A strong root system, allows Lofa to maintain growth into the summer better than straight ryegrass. It also has good winter cold survival. Lofa is grown for both grazing and machine harvesting. It may be companion planted with alfalfa or overseeded into winter damaged stands.

A late variety, Hipast is a persistent festulolium forage grass which is grown for comprehensive ground cover, density and softness. It is suitable for grazing and silage making, and may be grown in warm, humid areas affected by drought periods and diseases.

A forage variety for silage or pasture, with good palate and digestibility, Perseus has a strong root system, increasing summer performance and drought resistance over a straight ryegrass. It recovers quickly from stress and can be mixed with legumes or used as a pure stand. It can be used as a nurse crop when establishing alfalfa, or interseeded into weak winter damaged stands.

## GWCT FORAGE ACRE MIX

Partner: Game and Wildlife Conservation Trust (GWCT)

Supplier: Oakbank Game and Conservation Seeds

This mixture was designed to favour game, with a particular emphasis on partridge numbers. It contains a mixture of legumes and herbs to give a complex sward structure with seed and other resources.

## RYEGRASS LEGUME MIX

Supplier: Kings Crops

Designed to meet the AB15 option within Countryside Stewardship, this mix (KLeg) is designed to help manage black-grass populations by putting land into fallow for two years. The mix contains a number of species which are beneficial to pollinators including late perennial ryegrass, red clover, common vetch, birdsfoot trefoil and common knapweed.

## HERB RICH SWARD MIX

Supplier: Kings Crops

A general purpose grass and herbal ley which can be used in grassland or arable situations, the mix (Kherb) provides a sward that can be grazed by cattle and sheep. It is designed to improve soil structure and creates a beneficial habitat for pollinators. The mix contains: red clover, late and intermediate perennial ryegrass, timothy, meadow fescue, smooth stalked meadow grass, rough stalked meadow grass, birdsfoot trefoil, alsike clover, yarrow, ribwort plantain, sheep's burnet, ox-eye daisy and chicory.

## HERBAL GRAZING LEYS MIX 20

Supplier: Cotswold Seeds

Herbal grazing leys provide grazing for early turnout and continue to produce forage through the summer and autumn. Containing deep-rooting species, these four-year leys (one particularly designed for heavier soils) aim to improve soil structure and draw up essential vitamins and minerals for the ruminant animal. The Standard Herbal Grazing Ley (Mix20) mixture contains festuolium, cocksfoot, perennial ryegrass, timothy, meadow fescue, tall fescue, late flowering red clover, white clover, alsike clover, bird's-foot trefoil, sainfoin, sweet clover, chicory, ribgrass, burnet forage herb, yarrow forage herb and sheep's parsley forage herb. This resource is being tested in a BBSRC-funded Sustainable Agriculture Research and Innovation Club (SARIC) 3 Project from 2018-22.

The mix for heavier soils contains tetraploid hybrid ryegrass, tetraploid perennial ryegrass, timothy, meadow fescue, tall fescue, late flowering red clover, alsike clover, lucerne, sweet clover, white clover, chicory, ribgrass forage herb and burnet forage herb.

The Simple Herbal Ley contains a more diverse grass seed mixture that is more complex than just ryegrass and clover. It contains ryegrass, cocksfoot, timothy, meadow fescue and legumes, red clover, white clover, and mineral rich forage herbs including chicory and ribgrass.

The Chicory Grazing Ley is a high-protein, mineral-rich and drought resistant mix combining chicory, clover and some ryegrass. It will last for three to four years. This mix was formerly known as the 'Lamb Finisher' mixture.

## LEGUME FOOD AND FEED

### SOYA

Partner: Premium Crops

Varieties: AMAROK and TOUTATIS

Originally from East Asia, with early evidence of domestication in China dating to around 9,000 years ago, soya is now widely cultivated, particularly in Brazil and the United States. Locally adapted soya varieties are collected by gene banks for use in breeding new soya varieties; collected for physical characteristics and potential for disease resistance. Breeding by this supplier focused on development of a variety that is better adapted to the cool UK climate, one of the key issues with potential cultivation of soya in the UK.

### SOYA WITH MYCORRHIZAL FUNGI AND BACTERIAL INOCULANT

Partners: NIAB, Soya UK, Legume Technology Ltd and PlantWorks Ltd

Varieties: SIVERKA and ARNICA

The commercial use of rhizobium bacterial inoculants is commonplace when planting legumes such as soya. Trials by PlantWorks Ltd in 2017-2018 demonstrated additional potential benefits to the crop through the application mycorrhizal fungi inoculants both alone and in combination with rhizobia.

In 2018 the scope of the trials was extended to explore the effects of adding an additional group of beneficial microbes, the Plant Growth Promoting Rhizobacteria (PGPR) from the PlantWorks' commercial library. The objective in undertaking these trials is to define a practical, and commercially viable, understanding of the optimal microbial communities that can be applied to maximise the crop's efficiency at fixing, releasing and metabolising applied and environmental available nutrients.

### GRASS PEA (*Lathyrus sativus*)

Partners: NIAB, John Innes Centre, Bidhan Chandra Krishi Viswavidyalaya and BenchBio

This crop is also demonstrated in the glasshouse (page 7).

### PEA (*Pisum sativum*)

Supplier: Chiltern Seeds

Varieties: ALDERMAN, PETIT PROVENÇAL and SERGE

Alderman is a variety which has sustained cropping over a long period. It has long, large pods and may grow to over two metres in height. Petit Provençal is a traditional French petit pois variety that produces small sweet tasting peas. Serge is a vining pea which has been bred specifically for its edible shoots and tendrils.

### RUNNER BEAN AND PLANT GROWTH PROMOTING RHIZOBACTERIA

(*Phaseolus coccineus*)

Supplier: Suttons Seeds

Varieties: SCARLET EMPEROR, ENORMA and MOONLIGHT

The runner bean is a legume species from Mesoamerica closely related to common bean (*Phaseolus vulgaris*). It is a perennial species, but it is usually cultivated in small-scale agriculture as an annual crop for its dry seeds and edible immature pods. One of its main characteristics is an ability to tolerate cooler climates than other *Phaseolus*. Despite the cultural value, economic importance, and agronomic potential of *P. coccineus*, little is known about its domestication history and the genetic variability of its wild and cultivated forms.

A heritage seed variety, Scarlet Emperor produces a profuse crop of large pods, both in hot and dry, and also in cold and wet seasons. With bright orange flowers, it is high yielding and very early, and can be grown on supports or as a ground bean. It attracts long tongued bumble bees. Enorma produces short-jointed plants with a crop of very long, smooth, slender beans. Moonlight produces large numbers of self-pollinated, white flowers, and stringless pods.

Supplier: Legume Technology Ltd

Inoculant: LegumeFix

Legume Fix is a bacterial inoculant which introduces nitrogen-fixing bacteria into the soil rhizosphere. These bacteria encourage the plant to form nodules which allow it to take nitrogen from the atmosphere and convert it to a form useable by the plant, to support growth.



## SPRING BEAN (*Vicia faba*) ●

**Supplier:** LS Plant Breeding

**Varieties:** LYNX, VICTUS and TIFFANY

Tiffany and Victus are spring beans with low vicine (VC) and convicine (CV) content. The Innovate UK Optibeans project demonstrated the value of faba beans incorporated into monogastric feed as a partial substitution for soya protein. In poultry, one particular characteristic, low VC/CV, was critical for maintaining egg laying and weight gain, and is the key trait allowing use of faba bean for poultry feed. Tiffany and Victus combine the trait with other good agronomic characters, making this a significant advance for the crop.

NIAB has developed an accurate biochemical test for these compounds so that breeding material can be evaluated and the trait verified in bulks destined for feed. NIAB is continuing to establish a calibration enabling a rapid NIRS test to be offered to the industry.

## PULSE CROP GENETIC IMPROVEMENT NETWORK (PCGIN) ●

**Partners:** NIAB, John Innes Centre, Defra, PGRO, University of Reading and Aberystwyth University

**Varieties:** KASZTELAN, MARIS BEAD and FUEGO

The Pulse Crop Genetic Improvement Network (PCGIN) is a platform for the process of legume crop improvement in the UK. It establishes the route by which scientific resources, results and knowledge are delivered to breeders, producers and end users, providing a link between these groups and the research base to achieve added value for pulse crops as well as providing resources, expertise and understanding that are drawn upon by both public and commercial sectors in breeding, analysis, and in the definition and improvement of product quality relating to both commercial and public goods. PCGIN promotes and executes the translation of genomic research tools to crop improvement. One of the main strands of PCGIN activity is the improvement of crop performance and reliability by establishing the genetic basis for agronomic traits such as standing ability, yield and disease. Included in this is work on the spring bean (*Vicia faba*) disease Chocolate Spot, a fungal disease (*Botrytis fabae*) that causes dark, chocolate covered spots on all parts of the plant.

## SOIL AMENDMENTS ●

A number of studies are ongoing to consider a range of alternative soil amendments; the outcomes can include potential improvements in soil structure and function, weed, pest and disease control and nutrient supply.

Ongoing projects contributing to this work include EU Interreg2Seas project BioBoost, and the AHDB-funded GREATsoils Project and Soil Biology and Soil Health Partnership.

**Partners:** NIAB, Innovative Farmers Field Lab, Agri-grub, BioBoost

**Suppliers:** Milton Brewery Ltd (spent hops and brewer's waste), Agri-grub (frass), AllPress Farms Ltd (solid AD)

Six treatments were undertaken with fractions of commercial rates of nitrogen added, and the plots sown with Mulika spring wheat.

## Treatments:

1. Chicken manure, no nitrogen applied
2. Solid waste from an AD plant. The liquid digestate contains less than 15% dry matter (DM) content, while the solid digestate contains more than 15% DM. One third rate nitrogen applied.
3. Chopped straw is routinely used by farmers to improve soil structure and function; it improves organic matter (OM) content and adds cation exchange capacity and soil biodiversity. It does not supply significant nutrients. One third rate nitrogen applied.
4. Sawdust waste, obtained from a local forestry works, is used for similar applications to straw, but has a longer decomposition cycle and is used with caution because it can lead to nutrients being temporarily 'locked up'. One third rate nitrogen applied.
5. Frass (made of black soldier fly insect droppings (see Peas section below), skin casings and organic carbon). One third rate nitrogen applied.
6. Spent hops, supplied by Milton Brewery, used to improve soil structure, improve organic matter content and soil biodiversity and low level of slow release nutrients and reduce pH. One third rate nitrogen applied.

To compare all amendment treatments to different nitrogen treatments, four plots were drilled with Mulika and treated with either a full rate of nitrogen (179 kg/ha); one third the full rate; two thirds or no nitrogen.

## PEAS TREATED WITH FRASS ●

**Suppliers:** Agri-Grub (frass) and LS Plant Breeding (pea seed)

**Variety:** BLUETIME

Finding alternatives to petrochemical pesticides is critical now more than ever, with recent restrictions on neonicotinoid usage affecting many growers. AgriGrub is a commercial producer of Black Soldier Fly larvae, growing this insect at large scale using only food and agricultural waste as inputs. The virtuous by-product of this process is Frass, the insects' excrement and skin casings. AgriGrub's frass is 14% chitin, a compound from the skin of the grubs.

In soils, chitin breaks down into the shorter chain chitosan, which activates receptors in plant roots. These in turn activate parts of the jasmonic and salicylic acid pathways eliciting Systemic Induced Resistance and the upregulation of a number of plant defences against pests and pathogens. The resulting effects vary between crop species, but may include increased lesion formation and increased production of defence compounds and structures, as well as increased water use efficiency.

Frass acts like a vaccination, fooling plants into thinking they are under attack by insects, and plants bolster their defences accordingly. This new method of action, eliciting existing plant defences, gives growers a better option for pest control which benefits the local and global environment. There is significant body of evidence showing the efficacy of chitosan in crop protection, though sourcing chitosan from crustacean shell proved too costly and energy intensive. Frass represents a concentrated source of chitosan which requires little processing, has a suite of other micronutrients and is produced from a process which saves two tonnes of CO<sub>2</sub> emissions for each tonne of agricultural waste processed. Recent trials at AgriGrub showed a 9.4 fold reduction in the number of aphids on cabbages treated with frass, and a 25% reduction in slug and snail damage after seven weeks.

Current trials at AgriGrub, NIAB and with commercial partners are looking at pest and pathogen reduction in a variety of crops including potato, brassicas, legumes, glasshouse crops, soft fruit and ornamentals. Frass is approved by the Soil Association as an input for organic food production.

## BARLEY, OATS AND RYE

### SPRING BARLEY

#### Specialist naked barley for food use ●

Lines: **NEWBAR-04** and **NEWBAR-12**

Wholegrain naked barley, in which the hull threshes freely away from the grain, is an excellent food source rich in soluble fibre. NIAB has been developing specialist naked barley which combines high levels of beta-glucan and resistant starch, which trials suggest can confer health benefits. These two varieties have shown promising performance in multi-location yield trials and are being multiplied for quality evaluation by end-users.

#### Naked barley ●

Breeder: Bangor University

Varieties: **SEIRIOL** and **BODFAN**

Seiriol and Bodfan are two-row naked (hulless) spring barley lines bred at Henfaes Research Centre. Seiriol has a predicted yield is 4.8 t/ha and Bodfan 5.6 t/ha. The naked grain trait originates from Pakistan and their pedigrees contain two UK varieties (Static and Westminster). The varieties have been selected for high beta-glucan and good field performance in Wales. The intended use is in wholegrain foods and could be marketed as having the following health benefits: lower cholesterol, reduced risk of coronary heart disease and reduction of post-prandial glycaemic responses.

These lines are also demonstrated in the glasshouses.

#### Barley seeds with enlarged germ for nutritionally-enhances food and feed ●

Lines: **RISØ 1508** and **BOMI**

NIAB is investigating a variant form of barley that has seeds with germ that is twice as large as that in normal barley. The germ is the part of the seed that will grow into the seedling upon germination. It contains higher concentrations of nutritionally-valuable components (oil, protein, vitamins and minerals) than the rest of the seed which consists mainly of starch. Unfortunately, the starch content of this variant form of barley is lower than normal and the seeds are smaller and slightly shrivelled. This undesirable trait limits the usefulness of the large-germ barley. NIAB is aiming to identify and separate the factors responsible for the desirable (large germ) and undesirable (low starch) traits in order to produce a barley variety with enhanced nutritional properties.

#### Bere barley ●●

Partner: Orkney College University of the Highlands and Islands (Agronomy Institute)

Bere is an ancient type of Scottish barley and is probably the oldest continuously cultivated crop in Britain. Today, it is only grown on a small scale in Scotland's Northern and Western Isles. The University of the Highlands and Islands' Agronomy Institute started working on bere in 2002. One of the aims of the project was to develop new markets for the crop as a means of helping its *in situ* conservation. With Orkney's Barony Mill already supplying a market for beremeal, most of the efforts have been in developing beverage markets. The first collaborations were with Isle of Arran Distillers and Valhalla Brewery (in Unst, Shetland) and these initial projects demonstrated between 2004 and 2006 that modern equipment/facilities could successfully deal with malting, distilling and brewing with Bere and that it produced very acceptable beverages. Out of these collaborations, Valhalla Brewery produced a beer (Island Bere) and Isle of Arran Distillers released two (limited edition) single malt Orkney Bere whiskies.

From 2005, a particularly successful and long-lasting collaboration developed with Bruichladdich Distillery on Islay because of the distillery's particular interest in the effect which barley type and growing condition have on whisky. To meet the demand from Bruichladdich, the Institute formed a supply chain of four Orkney growers in 2007 and this has produced over 60 tonnes of grain annually for the past 12 years. Although most has been supplied to Bruichladdich, surpluses enabled continued production of Island Bere by Valhalla Brewery and the development of new beers by Swannay Brewery.

The Agronomy Institute has also carried out studies on nutritional aspects of bere grains and beremeal in collaboration with the British Nutrition Foundation and Rowett Institute. It is involved in a five-year Scottish Government-funded project on the agronomic traits of bere which has discovered a remarkable ability of some accessions to tolerate high pH soils which are deficient in manganese and other trace elements. Another interesting line of investigation NIAB is involved in is collaborating with archaeologists at the Universities of Sheffield and Manchester to see if any evidence for bere can be found amongst grain samples from Scottish archaeological sites. This is aimed at trying to find out how long it has been grown in Scotland and whether it was introduced before the Norse occupation.

#### ASSOCIATION MAPPING IN OATS ●

Partners: Aberystwyth University – Institute of Biology, Environmental and Rural Sciences, BBSRC, Senova

Varieties: **SPURTLE, LENNON** and **CONWAY** (spring oats); **BANQUO, MILFORD, MELYS, DYFED** and **S75** (spring oat heritage lines); **IBERS 14355** (spring oat elite line); and **GRAFTON, BLACK/BRISTLE OATS, MASCANI, GALLOWAY, PELOTON, FUSION, BALADO** and **PENROSE** (winter oats).

The demand for high quality, food grade oats is increasing annually, driven by its proven health benefits and by product development by the milling and cereals industries. This project is applying genetic tools and resources, including genomic selection, to improve key traits that will increase the production and utilisation of oats, and to enhance grain yield, quality and composition.

The project is using a range of unique genetic material to dissect the genetic and environmental factors contributing to yield variation and is using that information in an innovative oat breeding programme. Breeding programme populations will be used to extend the range of available marker-trait assays to improve selection efficiency in early generations and ensure uniformity in late generations. Phenotyping of key traits concerned with yield, milling quality and with human health and nutrition will be conducted and the impact of changing grain quality characters (beta-glucan or starch content/type) determined.

The project is applying state-of-the-art high throughput breeding and phenotyping, including association mapping (AM), genomic selection, genomic sequencing, Single Nucleotide Polymorphisms (SNPs), metabolic profiling and micro-scale analytical methods. Chip-based high throughput genotyping will be used to predict breeding values; genotype and phenotype data will be incorporated into a pedigree database to further facilitate 'intelligent' breeding design.

This project is of relevance specifically in enhancing crop productivity and quality, enhanced nutritional composition, increasing sustainability of crop production and understanding and exploiting genomics and the genetic diversity in plants. It will also investigate the potential of novel nutrient supplies from plants (healthy and safe food).

## HYBRID RYE ●

Breeder: KWS

Varieties: **KWS PROPOWER, KWS ETERNO** and **KWS BONO**

Hybrid ryes are valued for their high yield, ergot resistance and general aggression in competing to suppress black-grass populations. KWS Propower is a hybrid rye variety which has been bred for use in anaerobic digestion (AD). KWS Eterno and KWS Bono have been bred for AD, grain (feed/flour) or distilling.

Supplier: Cotswold Seeds

Variety: **DANKOWSKIE**

This old variety is often used in winter cover crop mixtures and is a reliable variety for good over winter biomass production.

## ALTERNATIVE CROPPING

### MILLET (*Panicum miliaceum*) ●

Supplier: Soya UK

Variety: **MAMMOTH**

Widely grown for game cover, rather than a general cover crop, millets are also increasingly being developed for human consumption in the UK as a high value niche end-market product. Mammoth is a white millet variety grown commercially (for food rather than cover) in the UK since 2003. It is an early maturing variety with good standing ability.

Supplier: Boston Seeds

Variety: **RED MILLET**

Red Millet is often sown as a game cover crop. It is sown alongside other crops to provide a source of small seeds for birds. Red Millet is susceptible to frost and is earlier maturing than white millet.

### BUCKWHEAT (*Fagopyrum esculentum*) ●

Supplier: Cotswolds Seeds and commercial seller

Buckwheat is a fast-growing summer annual that prefers well drained, low-fertility or acidic soils. It is not frost hardy, but it can act as a weed suppressor. Research has shown that buckwheat could be an ideal break crop as it has good phosphate sequestration properties, improving soil fertility and making nutrients available to the following crop.

### CRAMBE (*Crambe Abyssinica*) ●

Supplier: Natures Crops International

Crambe is a member of the mustard family. It is native to the Mediterranean region and has become naturalised in many other parts of the world. Crambe oil is sourced from the plant seed, and contains up to 60% erucic acid, which is used in the production of a wide range of high-value oleochemical (oil) derivatives including polymers, polymer additives, surfactants, personal care products and pharmaceuticals.

### AHI FLOWER (*Buglossoides arvensis*) ●

Breeder: Natures Crops International

Varieties: **SPRING, WINTER 1128, WINTER 1123** and **WINTER 1133**

*Buglossoides arvensis* grows as both an annual and a biennial and is a member of the Boraginaceae family. It is planted in early spring or in the autumn and takes from 100–150 days to reach maturity. It has multiple flowering points and each flower can produce four seeds which are held tightly in the plant until harvest. Seeds contain approximately 20% oil, of which approximately 20% is stearidonic acid (SDA) and 5% is gamma-linolenic acid (GLA). SDA is a nutritionally-important fatty acid in the omega-3 family, and has a wide range of potential uses including nutritional supplements, foods and personal care products.

### LINSEED (*Linum usitatissimum*) ●●

Supplier: Premium Crops

Varieties: **ALPAGA** and **SIDERAL**

Winter linseed can be grown anywhere in the UK. Alpaga and Sideral are high yielding brown linseed varieties, which are winter hardy; the plant remains an annual and does not require vernalisation. Linseed may be grown to reduce the build-up of oilseed rape volunteers, as well as contributions towards control of runch, charlock and cranesbill. It also has the advantage of not being a target for cabbage stem flea beetle as it is not a brassica.

### LENTILS (*Lens culinaris*) ●●

Supplier: Hodmedods

Varieties: **ANICIA** and **FLORA**

Lentils come in different colours and sizes; from red split lentils, to speciality puy lentils. Lentils are a difficult crop to harvest and have never been grown widely in the UK. They are low-growing and not especially vigorous; they need a warm, dry autumn to ripen for harvest and, even if all that goes well, are not very high yielding. Yet, they may be a useful low-input crop for less intensive farming systems; they fix their own nitrogen and suffer few pests and diseases and require less water than many other crops.

Hodmedods has been working with Professor Martin Wolfe of Wakelyns Agroforestry, in North Suffolk, to increase diversity, yield and resilience in farming systems. The first lentils released from the trials were an experimental mixture of varieties – a mottled green lentil (the same variety as is grown in Le Puy-en-Velay, in France) and a gun-metal grey lentil (also widely grown in France). The mottled green variety, Anicia, is demonstrated at NIAB Innovation Farm. Anicia is a characteristic variety. It has a yellow cotyledon and green seed coats with very specific anthocyanic marbling. Also demonstrated is Flora, which has light green cotyledons and ochre brown seed coat. These varieties are also demonstrated in the glasshouse.

## COVER CROPS AND ECOSYSTEMS SERVICES

### PLANTAIN (*Plantago lanceolata*) ●

Breeder: Norwest Seeds Ltd

Variety: **BOSTON**

The narrow leaf forage plantain is a rapid establishing perennial pasture herb. It is deep rooted with good drought, heat and cold tolerance. Boston Plantain is mineral rich which elevates: copper, selenium, cobalt, calcium, magnesium, sodium and zinc levels in farmed animals. It can be planted as a 'plantain pasture' alone or in a seed mix, but needs to be at least 30% of any pasture content to get these full benefits. In New Zealand, plantain has been found to help reduce cow urine nitrogen and methane emissions. Boston Plantain is a late flowering variety and consideration is needed in managing a plantain pasture with rotational grazing of about 21 days as stock prefer the younger leaves but will also eat flower heads. This crop is also demonstrated in the glasshouse.

### RADISH (*Rhaphanus sativum*) ●

Breeder: Norwest Seeds Ltd

Variety: **SMART RADISH®**

Radish is the fastest growing of all the brassica family. Smart Radish® has a pull-down tap root with greatly increased fibrous side roots, and larger leaves. It can be used as a green manure crop or for grazing. It has been bred to optimise soil nutrients uptake time and to break up soil compaction while feeding the soil biology at the same time. After terminating it slowly recycles nutrients for the next crop to take up. It is a 90-day cover crop radish which should be planted in late summer in a cover crop mix with cereals. This crop is also demonstrated in the glasshouse.

### SUMMER AND COVER POLLINATOR MIX ●

Supplier: Cotswolds Seeds

A bespoke mix designed to be both a short green manure mix providing ground cover and nitrogen fixation in the soil. Due to the variety of legumes in the mixture it will also provide pollen and nectar for a variety of insects and pollinators. The mix contains: crimson clover (Kardinal), persian clover (Laser and Lightning), alsike clover (Dawn), berseem/Egyptian clover (Akenaton), phacelia (Balo), yellow trefoil (Ekola), and birdsfoot trefoil (Leo).

## BIOBOOST ●●●●

Funder: European Union, European Regional Development Fund (ERDF)

Partners: Municipality of Westland (Netherlands, Lead), Catholic University College, Inagro, Transportbedrijf Van Vliet B.V., Institute for Agricultural and Fisheries Research, NIAB and Epping Forest District Council

The BioBoost project addresses the need for an environmentally friendly and resource-efficient economy focusing on horticulture, using plant resources in a more sustainable, efficient and integrated manner. Development, testing and uptake of green innovations are often slow due to suboptimal interaction between researchers and SMEs, problematic financing and lack of cross disciplinary working and effective support strategies. The overall objective is to accelerate the transition to a bioeconomy by implementing regional test and pilot projects for development of new techniques, methods and products in the horticultural sector and supporting their development towards market uptake. This includes strengthening the supportive role of public authorities to better facilitate and support SMEs to develop more innovations and bring them to the market encouraging support from SMEs for the bio-economy; understanding the opportunities, including in projects dealing with horticultural waste streams and by-products for use for food, feed, green pesticides, materials, pharmaceuticals and cosmetics; and valorising by-products by extracting valuable plant compounds.

## BIOPESTICIDES

### ROSE REPLANT DISEASE SUPPRESSION ●

Partners: Microbiotech Ltd and Agri-Grub

After planting into soil that was previously used for roses, new rose plants show reduced growth and flowering. The exact cause of the problem is unknown but it can persist for several years and is known to be biological in nature. For rose growers, this affects both the production of roses in the field, and the market for rose plants where gardeners may opt for alternative species. As part of an EU-funded project BioBoost, NIAB and Microbiotech Ltd are working with several commercial partners on suppressing replant disease by beneficially manipulating the micro-organisms in the root zone. The demonstration shows dog roses (*Rosa canina*), which are commonly used as a rootstock for hybrid tea varieties, potted in growing media amended with organic amendments and microbial inocula. Similar potted roses have been planted into clean 'virgin' and replant diseased soils and will be assessed for growth and flowering later in 2019.

### HEUCHERA – BLACK VINE WEEVIL CONTROL ●●

Partners: Microbiotech Ltd and Agri-Grub

Vine weevil is a significant pest of ornamental and fruit crops where larval feeding on roots can stunt or kill plants. Effective insecticides have gradually been withdrawn due to environmental concerns. Biological control products using fungi that attack insects (entomopathogens) are available but expensive. Biological approaches to vine weevil control are being investigated in the EU-funded BioBoost project involving the use of chitinous by-products from insect production and spent mushroom compost. They provide a source of chitin similar to an insect host, and are being used to sustain populations of entomopathogens in growing media. The chitin, which mimics the presence of a pest attack, also stimulates the natural defences of the plant, for example in producing thicker leaves and roots. The by-products are also being used as pot topping materials, to repel the egg laying activity of adult weevils. The demonstration shows *Heuchera* plants, which are particularly susceptible to vine weevil attack.

## BENEFICIAL PLANT COMPOUNDS

### BEETROOT (*Beta vulgaris* subsp. *vulgaris*) ●

Supplier: Elsoms

Varieties: **BOLDOR, AVALANCHE, BETTOLLO** and **CHOGGIA**

The colour of beetroot comes from the red-yellow coloured pigments in the betalain group, rather than anthocyanins, and the colour of the root depends on the type of betalain present: betacyanins give the 'traditional' red-purple colour and betaxanthins give a yellow-orange colour. The contrasting colours are demonstrated in the field. The variety Boldor has round roots and produces a distinctive orange flesh with yellow internal colour; Avalanche produces distinct, pure-white roots with a round, uniform shape; and Bettollo has an intense purple colour; and is a red root with a white stripey centre.

## SOFT AND TOP FRUIT

NIAB EMR focuses on exploring novel crops suited to the UK and introducing new varieties conveying desirable characteristics for both growers and consumers. Plant breeding at NIAB EMR combines century-old plant breeding excellence with the latest genetic science. The current crop breeding and genetics staff are principally focussed on commercial breeding programmes of Rosaceous crops (strawberry, raspberry, cherry, apple and pear) with research projects aligned to underpin these programmes and address and understand the inheritance of key commercial traits and mechanisms. The expansion of current breeding programmes to include blackberry, blueberry and lonicera is underway.

### APPLE (*Malus domestica*) ●

Breeder: NIAB EMR

Varieties: **MALLING SUNBURST** and **RED FALSTAFF**

Malling Sunburst was launched in 2017, having been bred at East Malling over 14 years, from heritage which includes Gala, Falstaff, Pearl Pink and the wild Niedzwetzky's apple. A sweet apple with yellow skin and pink flesh through to the core, sunburst fruits in October. Red Falstaff is a red sport of 'Falstaff'. The original Falstaff variety was bred as in the late 20th century from a cross of James Grieve and Golden Delicious at East Malling Research. It is a heavy cropping self-fertile variety. It fruits late (mid-October) and is frost resistant.

Breeder: William Barnett

Variety: **SURPRIZE**

Surprise is an orange-skinned variety with pink marbled flesh that is self-sterile. Surprise ripens in early September, has a crisp flavour and is suitable for juicing.

### RASPBERRIES (*Rubus idaeus*) ●

Breeders: NIAB EMR and RW Walpole

Varieties: **AUTUMN TREASURE, OCTAVIA, MALLING MINERVA, MALLING JUNO, VALENTINA, M26 6886/91** and **T29 6969/11**

Now in its third year, this demonstration shows the wide variety of physical characteristics and flowering/fruitleting timings and available in raspberries. NIAB EMR has a long-running raspberry breeding programme, which is working to improve raspberry crops including breeding for extended season, fruit quality, disease resistance and poor weather. For example, Autumn Treasure is resistant to *Verticillium* wilt and powdery mildew, has good tolerance to raspberry root rot and withstands adverse weather conditions. Octavia has been bred to produce a combination of a very late season and high quality and flavour fruit.

## SUSTAINABLE WEED CONTROL ●●

### COURGETTES AND BIODEGRADABLE WEED SUPPRESSION LINER

Developer and Supplier: Novamont Ltd.

Plastic sheeting may be used to suppress weeds in crops such as courgette. However, the removal of the liner at the end of the season can be problematic. Here, the mulching film (MATER-BI), as a bio-based plastic, is able to biodegrade into the soil, and can both contribute to the better development of horticultural crops, and then simplify the management and reduce the amount of plastic waste at the end of its life. MATER-BI is obtained by means of proprietary technologies using starches, cellulose, vegetable oils and their combinations, made by an integrated industry involving three Italian production facilities.

Breeder: Tozer Seeds

Supplier: Kings Seeds

Varieties: **SUNSTRIPE** and **PICCOLO**

Sunstripe F1 has yellow and white striped cylindrical fruits which are produced from spineless bush habit plants. It has been bred for uniformity in shape and a high yield with good flavour. Piccolo F1 is a dual-purpose variety, with a spine-free bush habit, which produces an abundance of nearly round green striped courgettes. These fruits can also be left to rapidly mature into small round marrows.



## MISCANTHUS AND WILLOW ●

The following crops are located outside of the main demonstration field, near to the Park Farm entrance gate.

### MISCANTHUS (*Miscanthus giganteus*)

Partner: Aberystwyth University – IBERS

Miscanthus, or elephant grass, has been grown in the UK for a number of years as an energy crop. A perennial C4 grass commercially grown, Miscanthus consists almost exclusively of the sterile triploid hybrid *M. x giganteus*, a naturally occurring sterile hybrid of diploid *M. sinensis* and tetraploid *M. sacchariflorus*. Since it is sterile, the crop is propagated by rhizome splitting. This leads to narrow genetic diversity within the germplasm and thus a disease risk when grown on a large scale; it also fails to provide a base for the development of new varieties. Fortunately there is extensive genetic diversity available within the Miscanthus genus allowing for the development of new hybrids tailored to different environments and end uses, such as liquid biofuels for transport or replacements for platform chemicals, and combustion for heat and power.

Alternative Miscanthus species include:

- *M. sacchariflorus* (tetraploid): extremely thick and tall stems with good biomass accumulation. Has a more spreading and prolific rhizome growth once established but generally will not flower in the UK climate;
- *M. sinensis* (diploid): *sinensis*: forms dense clumps with thinner, more prolific stems.
- Flowers readily in temperate climates although flowering times in the UK can extend from June to October;
- *M. sacchariflorus* breeder's line (tetraploid): used in experimental crosses at IBERS with triploid progeny currently in field trials. This accession demonstrates good frost tolerant traits, although it does not flower under UK conditions but can be induced under controlled environments;
- *M. sinensis* 'Goliath' horticultural line (triploid): an intraspecific hybrid of *M. sinensis* that flowers around August in the UK and has been marketed as a 'large-type' horticultural variety since the 1970s;
- *M. sinensis* breeders line (diploid): the female parent of a mapping family at IBERS that has been used to generate the first high resolution genetic map in Miscanthus and is now being used to identify regions of the genome responsible for traits such as spring emergence, flowering, senescence, yield, and composition. It flowers in July in the UK.

### WILLOW (*Salix* spp.)

Partner: Rothamsted Research

Rothamsted Research is running the only major willow breeding programme in the UK. Advances in understanding the physiology and growth of willow, and the on-going discovery of genes underlying key traits, is being used to improve the efficiency of willow breeding. Rothamsted is focused on developing drought tolerant, as well as water and nitrogen-use efficient varieties, for resource poor land. Variety development is also tailored to specific markets, such as second generation biofuels, chemical intermediates and polymers.

Commercial short rotation coppice (SRC) willow plantations typically consist of a mixture of specially developed elite varieties, grown in dense plantations at rates of 15,000 plants/ha. Planting mixtures of varieties exploits genetic diversity to limit pest and disease development in a crop that is virtually impossible to treat with pesticides due to its physical size. Typically 20 cm long stem cuttings are mechanically planted in a twin row design. This layout allows the woody biomass to be harvested by specially developed machines. After an initial establishment year, where cuttings are planted in the spring and cut back in the following winter, SRC willow plantations are harvested on a two to four year cycle.

Plantations are viable for around 22 years (establishment year plus seven harvest cycles). SRC willow can grow well in environments where the alternative land uses are limited, such as the cooler and wetter areas of north-west Europe and North America and the high clay content soils of those and other areas of the temperate latitudes. In these environments where alternative land uses are limited the production of SRC willow is financially very competitive.

Breeder: Lantmännen SW Seed

Variety: **JORR** (*Salix viminalis* × *S. viminalis*)

Introduced in 1988 this variety is now outclassed and susceptible to *Melampsora* leaf rust.

Breeder: Rothamsted Research

Variety: **ROTH CHEVIOT** (Complex *S. viminalis* × *S. schwerinii* hybrid)

Bred in 2004 by Rothamsted Research's willow breeding programme, the variety offers rust resistance and yields comparable to existing commercial varieties.

Breeder: Rothamsted Research

Variety: **RR09057** (Complex *S. viminalis* × *S. schwerinii* hybrid)

Bred in 2009 this variety was generated using marker assisted selection. Markers linked to yield and rust resistance traits were used to choose parents and in early progeny selection. This selection took place using leaf material collected from two month old seedlings and offers potential large time and space savings when compared to the conventional trialling/selection route. This approach is an example of the advances in understanding the physiology and growth of willow, and how the identification of genes underlying key traits can be used to improve the efficiency of the breeding programme.

# SOPHI TAYLOR BUILDING GARDEN

## ASPARAGUS (*Asparagus officinalis*) ●

Supplier: A Grade Asparagus

Varieties: **GYNLIM** and **BACKLIM**

Gynlim and Backlim are both 100% male hybrid varieties. They are high yielding and can be grown for both white and green spears.

## HERBACEOUS BED ●●●

The raised bed shows a range of herbaceous species, many of which are attractive to pollinators and other beneficial wildlife such as bees and butterflies.

## DYER'S CHAMOMILE (*Anthemis tinctoria*)

Supplier: Crocus

Variety: **SAUCE HOLLANDAISE**

A perennial plant that produces soft yellow daisies that fade to cream as they mature. Flowers appear above feathery, filigree-like dark green leaves from late spring to early summer. They are attractive to bees, moths and butterflies. It can be cut to the ground in autumn and will return the following spring.

## BUTTERFLY LAVENDER (*Lavandula pedunculata* subsp. *pedunculata*)

A borderline hardy variety, this French lavender will need to come indoors for the winter in colder areas of the country. It has round, pale mauve flowerheads with upright petals that emerge to look like butterfly wings and flutter in the breeze. The flower-spikes are also a very attractive to bees and other nectar-loving insects.

## FENNEL (*Foeniculum vulgare*)

Varieties: **FENNEL** and **GIANT BRONZE**

With edible foliage, these varieties have clouds of feathery, bright green (Fennel) or bronze-purple (Giant Bronze) leaves, which are followed by flat-topped, sulphur-yellow flowerheads in mid to late summer and then by aromatic seeds. Fennel produces nectar and pollen which are very attractive to bees, in particular, solitary bee species. These are perennial varieties, which die back to below ground level each year in autumn, then reappear in spring.

## CORIANDER (*Coriandrum sativum*)

Variety: **LEAFY LEISURE**

Coriander is widely grown for its leaves and seeds, although the flowers and roots are also edible. This variety produces a large amount of seed and has been bred to be more resistance to bolting in drier conditions. Beneficial insects such as lacewings and hoverflies are attracted to coriander plants.

## CHIVES (*Allium schoenoprasum*)

Supplier: Marshalls

A member of the Onion family (Alliaceae) chives are grown for the delicate onion flavour of their leaves. The purple flowers are also edible. The flowers also provide food for bumblebees, honeybees, mason bees and leafcutter bees.

## ROSEMARY (*Rosmarinus officinalis*)

Variety: **MISS JESSOPS**

Rosemary is a woody, perennial herb with highly aromatic evergreen leaves, and a wide range of culinary and medicinal uses. Being native to the Mediterranean, rosemary is excellent where reducing water inputs is a priority, and the blue colouring is very attractive to bees and butterflies.

## CUCURBITS ●

### WATERMELON (*Cucumis melo*)

Supplier: Marshalls

Variety: **MINI LOVE**

Mini Love is an Fi hybrid, dwarf watermelon variety that grows well in UK conditions, each plant producing up to six melons in an average year. The fruits weigh on average 3-5 kg, and have green striped skin, red flesh and few seeds. This variety has been bred to have improved resistance to powdery mildew and athracnose.

### CUCAMELON (*Melothria scabra*) ●

Supplier: Chiltern Seeds

More details on Cucamelon can be found in the glasshouse section.

## HYDRANGEA ●

Hydrangea is a broad genus of 70-75 flowering species, originally native to southern and eastern Asia (China, Japan, Taiwan, Korea, the Himalayas, and Indonesia) and the Americas. The name Hydrangea is derived from Greek, meaning water vessel, which is in reference to the shape of its seed capsules.

Hydrangeas are often grown for the ability of their flowers to change colour in response to soil pH, which affects aluminium availability. This is most often seen in the mophead and lacecap cultivars of *Hydrangea macrophylla*, and in *H. involucrata* and *H. serrata*. Those with blue or pink flowers tend to be blue in acid soil conditions (high available aluminium), mauve in acid to neutral soil conditions, and pink in alkaline conditions (low aluminium). White and green-flowered cultivars remain white or green regardless of soil pH.

# PARTNERS AND EXHIBITORS

A Grade Asparagus	<a href="http://www.agradeasparagus.co.uk/">www.agradeasparagus.co.uk/</a>
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ADAS	<a href="http://www.adas.uk/">www.adas.uk/</a>
Agri-grub	<a href="http://www.agrigrub.co.uk/">www.agrigrub.co.uk/</a>
Alborada Trust	<a href="http://www.alboradatrust.com">www.alboradatrust.com</a>
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Boston Seeds	<a href="http://www.bostonseeds.com">www.bostonseeds.com</a>
Catholic University College	<a href="http://www.cug.edu.gh">www.cug.edu.gh</a>
Chiltern Seeds	<a href="http://www.chilternseeds.co.uk">www.chilternseeds.co.uk</a>
Cotswolds Seeds	<a href="http://www.cotswoldseeds.com">www.cotswoldseeds.com</a>
Crocus	<a href="http://www.crocus.co.uk">www.crocus.co.uk</a>
Department of Biotechnology India (DBT)	<a href="http://www.dbtindia.nic.in">www.dbtindia.nic.in</a>
DLF	<a href="http://www.dlf.com/">www.dlf.com/</a>
Elsoms	<a href="http://www.elsoms.com">www.elsoms.com</a>
Epping Forest District Council	<a href="http://www.eppingforestdc.gov.uk">www.eppingforestdc.gov.uk</a>
European Regional Development Fund (ERDF)	<a href="http://ec.europa.eu/regional_policy/en/funding/erdf/">http://ec.europa.eu/regional_policy/en/funding/erdf/</a>
European Union	<a href="https://ec.europa.eu/research/fp7/index_en.cfm">https://ec.europa.eu/research/fp7/index_en.cfm</a>
Game and Wildlife Conservation Trust GWCT	<a href="http://www.gwct.org.uk/contact/">www.gwct.org.uk/contact/</a>
Hodmedods	<a href="http://www.hodmedods.co.uk">www.hodmedods.co.uk</a>
Inagro	<a href="https://leden.inagro.be/inagro_en">https://leden.inagro.be/inagro_en</a>
Innovative Farmers Field Lab	<a href="https://www.innovativefarmers.org/">https://www.innovativefarmers.org/</a>
Institute for Agricultural and Fisheries Research	<a href="http://www.ilvo.vlaanderen.be/default.aspx?tabid=6469&amp;language=en-US">www.ilvo.vlaanderen.be/default.aspx?tabid=6469&amp;language=en-US</a>
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	<a href="http://www.icrisat.org">www.icrisat.org</a>
John Innes Centre	<a href="http://www.jic.ac.uk">www.jic.ac.uk</a>
Kings Crops	<a href="http://www.kingscrops.co.uk">www.kingscrops.co.uk</a>
Kings Seeds	<a href="http://www.kingsseedsdirect.com">www.kingsseedsdirect.com</a>
KisanHub	<a href="http://www.kisanhub.com">www.kisanhub.com</a>
KWS	<a href="http://www.kws.com/corp/en/">www.kws.com/corp/en/</a>
Lantmännen SW Seed	<a href="http://www.swseed.com">www.swseed.com</a>
Legume Technology Ltd	<a href="http://www.legumetechnology.co.uk">www.legumetechnology.co.uk</a>

LS Plant Breeding	<a href="http://www.lspb.eu">www.lspb.eu</a>
Marshall's	<a href="http://www.marshall's-seeds.co.uk">www.marshall's-seeds.co.uk</a>
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Microbiotech Ltd	<a href="http://microbiotech.co.uk/">microbiotech.co.uk/</a>
Milton Brewery Ltd	<a href="http://www.miltonbrewery.co.uk/">www.miltonbrewery.co.uk/</a>
Municipality of Westland (Netherlands, Lead)	<a href="http://www.gemeentewestland.nl/home.html">www.gemeentewestland.nl/home.html</a>
National Institute of Plant Genome Research (NIPGR)	<a href="http://www.nipgr.ac.in">www.nipgr.ac.in</a>
Natures Crops International	<a href="http://naturescrops.com/">http://naturescrops.com/</a>
NERC	<a href="http://www.nerc.ukri.org">www.nerc.ukri.org</a>
Newton-Bhabha Fund	<a href="http://www.newtonfund.ac.uk/about/about-partnering-countries/India/">www.newtonfund.ac.uk/about/about-partnering-countries/India/</a>
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Norwest seeds	<a href="http://www.norwestseed.co.nz/">www.norwestseed.co.nz/</a>
Novamont	<a href="http://www.novamont.com/eng/mater-bi">www.novamont.com/eng/mater-bi</a>
Oakbank Game and Conservation Seeds	<a href="http://www.oakbankgc.co.uk/">www.oakbankgc.co.uk/</a>
Orkney College University of the Highlands and Islands (Agronomy Institute)	<a href="http://www.uhi.ac.uk/en/research-enterprise/centres/agronomy/">www.uhi.ac.uk/en/research-enterprise/centres/agronomy/</a>
PlantWorks Ltd	<a href="http://rootgrow.co.uk">http://rootgrow.co.uk</a>
Premium Crops	<a href="http://www.premiumcrops.com/">www.premiumcrops.com/</a>
Punjab Agricultural University	<a href="http://web.pau.edu">http://web.pau.edu</a>
Rothamsted Research	<a href="http://www.rothamsted.ac.uk">www.rothamsted.ac.uk</a>
RW Walpole	<a href="http://www.rwwalpole.co.uk">www.rwwalpole.co.uk</a>
Senova	<a href="http://www.senova.uk.com">www.senova.uk.com</a>
Soya UK	<a href="http://www.soya-uk.com">www.soya-uk.com</a>
Suttons Seeds	<a href="http://www.suttons.co.uk">www.suttons.co.uk</a>
Syngenta	<a href="http://www.syngenta.co.uk">www.syngenta.co.uk</a>
Tanzania Agricultural Research Institute (TARI)	<a href="http://www.tari.go.tz/">www.tari.go.tz/</a>
Tozer Seeds	<a href="http://www.tozerseeds.com">www.tozerseeds.com</a>
Transportbedrijf Van Vliet B.V.	<a href="http://www.vanvliettransport.nl">www.vanvliettransport.nl</a>
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World Agroforestry Centre (ICRAF)	<a href="http://www.worldagroforestry.org/">www.worldagroforestry.org/</a>
World Vegetable Centre	<a href="https://avrdc.org/">https://avrdc.org/</a>



## LEADING IN CROP INNOVATION

NIAB is at the centre of innovation in crop science. Established in 1919 to assess the merits of varieties and seed quality, NIAB has grown in size, expanding its cropping and research expertise to the extent that it is now a major international research organisation in plant science, crop evaluation and agronomy.

With expertise in genetics and breeding, varieties and seeds and agronomy, NIAB works on a wide range of crops from cereals and oilseeds to potatoes, ornamentals, non-food crops and top and soft fruit. We produce new genetic diversity in pre-breeding material for arable crops, as well as plant breeding services for the fruit sector.

The need for innovation in plant breeding and agronomy has never been greater. With a growing global population, food security issues are a concern. Crop science and technology have a vital role to play in boosting productivity, conserving resources and coping with climate change.

NIAB is unique in being an independent science-based research organisation with a very large farmer and industry-based membership who help to ensure that research outcomes are transferred into practice.

Privatised in 1996 NIAB is a not-for-profit organisation with independent charitable status. We re-invest all of our income into future research in crop science and production.

- **Crop genetic improvement**
- **Efficient agronomy**
- **Translational research**
- **Crop protection**
- **Data and informatics**
- **Commercial partnerships**
- **Membership base**

NIAB's scientific capabilities span the crop improvement pipeline, from the first cross through to the harvested crop. We have the specialist knowledge, skills and facilities required to support the improvement of agricultural and horticultural crops, to evaluate varietal performance and quality and ensure these advances are transferred effectively onto farm through efficient agronomy.

The acquisition of the University of Cambridge Potato Agronomy Unit (now NIAB CUF) in 2014 and East Malling Research (now NIAB EMR) in 2016 has broadened the range of crop expertise that now resides within the NIAB Group.



Crop genetics and plant breeding research  
 Variety evaluation and seed certification  
 Field crops research  
 Laboratory services  
 NIAB Ventures  
 Training and Skills



Arable variety and agronomy research  
 NIAB TAG Membership  
 Field trials  
  
 niab digital



Horticultural crop  
 (top and soft fruit) and  
 environmental research



Group



Plant genetics knowledge  
 transfer platform



Potato agronomy research



Science and technology  
 information platform and events

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