NIAB TAG

Landmark

ISSUE 44
DECEMBER 2020

Designing wheat for the future

IN THIS ISSUE

Tina Barsby, Chief Executive, NIAB

Science for sustainable agriculture

I recently agreed to take part in an 'exchange of letters' in *Farmers Weekly* on the issue of gene editing, opposite Friends of the Earth (FoE) campaigner Kierra Box.

It was quite an eye-opener, and a reminder of how far we must go to get a better, more science-based understanding of modern plant science and its role in improving crop production.

An early challenge in this exchange was to dispel the myth that agriculture is in some way part of the natural ecosystem. Of course, farmers make use of natural biological processes, but farming itself is not, and never has been 'natural'. None of the crops which make up our farmed landscape are native to this country (not even the grass!). Most bear only a passing resemblance to their wild ancestors, and all have been imported from around the globe and adapted to our growing conditions and markets by the most amazing human and scientific ingenuity.

At the same time, farmers spend much of their time trying to sustain their crops in the face of 'natural' intrusion, e.g. in the form of weeds, diseases, insects and other pests. Scientific innovations, such as gene editing, increasingly offer ways to protect harvests, reducing our dependence on agrochemicals, while minimising impacts on unfarmed habitats and environments.

Another suggestion from FoE was that conventional plant breeding to date has been confined to 'sexual reproduction' – in other words simply crossing compatible plants and selecting the most promising offspring.

Again, the reality is somewhat different, as so much of the success of modern plant breeding is based on laboratory-based techniques used to create new sources of genetic variation, e.g. protoplast fusion, embryo rescue, doubled haploidy, somaclonal variation, and chemical and radiation-based mutagenesis. Mutation breeding has been used by plant breeders world-wide since the discovery in the 1920s that heritable mutations could be induced in plants by means of irradiation or chemical treatments. Subsequently, 'mutation breeding' was widely practised all around the world in the 1950s and many varieties of crop plants were derived from these techniques. Indeed, a celebrated example is the barley variety Golden Promise, a mainstay of the organic brewing sector, the development of which involved bombarding seeds with gamma rays to induce random mutations.

Such misunderstandings about agriculture and crop production feed into a common misconception that traditional, old-fashioned farming methods are in some way better for the environment and more sustainable.

Let us not fool ourselves – to feed a global population which is increasing by about 83 million people per year we need to produce food intensively and sustainably. There never was an agricultural idyll and 'the good old days' never really existed – they were always more about extreme poverty, subsistence farming and survival. Remember the agricultural idyll in Ireland in the 1840s – most tenant farmers had about two hectares of land, just about enough to grow potatoes to get them through the winter months. That is, until potato blight devastated the crop – varietal resistance, no fungicides. The result – over 1 million people died from starvation in Ireland alone, with a similar number emigrating.

I was particularly disappointed to see the Soil Association recently describe the human devastation of the Covid pandemic in terms of a wake-up call from Mother Nature to return to more traditional farming practices! Ironically, this came in the same week that humanity was celebrating the ground-breaking achievements of biotech scientists in developing a potential Covid vaccine, using the very same genetic technologies that the organic industry has banned and campaigned against for years.

For me it prompts a different kind of wake-up call.

The UK Government is preparing to consult on plans for potentially the most

significant policy breakthrough in plant breeding for more than two decades.

Post-Brexit, the UK has an opportunity to embrace a more progressive, science-based approach to genetic innovation, beginning with a Defra consultation on proposals to regulate certain precision breeding techniques in the same way as conventional breeding methods, rather than as GMOs.

This could be a hugely significant step forward for genetic research and crop-related innovation in this country, bringing our rules into line with other countries around the world.

I believe it is more important than ever, therefore, to stand up for agricultural innovation, and do more to explain the vital role science and technology have to play in safeguarding our food supply, tackling climate change and protecting the natural environment.

In 2021 NIAB will be launching a new initiative – Science for Sustainable Agriculture (SSA) – to do just that. The new platform will highlight the role of science and innovation in farming, and provide a focal point for an informed conversation around sustainable agriculture and food production. It will provide technical analysis and commentary on issues such as the loss or restriction of crop protection tools and the resulting impact (e.g. on costs of production, food waste, consumer prices etc) where no effective alternatives are readily available. The loss of neonic seed treatments and the devastating impact on this year's sugar beet crop is a case in point.

SSA will champion the contribution of scientific innovation – in all its forms – in agriculture and food production. It will promote a conversation rooted in scientific evidence, rather than doctrine and ideology and be ready to expose, comment on and challenge unscientific positions in relation to sustainable agriculture.

The opportunities ahead are too great to be missed.

Clare Leaman • clare.leaman@niab.com

What's new in cereals?

The new AHDB Recommended Lists bring a selection of new varieties to our attention across a range of cereal crops. Eight new winter wheats, one spring wheat, five winter barleys and two spring barleys have been added to the Lists and in this article we will have a look at what each one offers.

Winter wheat

Before we look at the new entrants to the List it is important to note that the way some of the disease ratings are calculated has been changed and this has had an impact on new and existing varieties. While 2020 did not see any drastic swing in yellow rust races, some varieties have seen some quite large drops in their ratings on the new AHDB Recommended List.

For yellow rust there have been two changes. The first sees a weighting added to the data which gives increased importance to the most recent year of data. With the fast paced changes we have seen in yellow rust races in more recent years this change should help keep the rating as relevant as possible to what is going on in the field. Secondly, the last few years have seen a slight drift in the ratings, again, partly due to the fast-moving race changes in the field, as well as the desire to try and keep ratings stable between years. To keep this drift in check the line that ratings are fitted to has been 'reset' to the 2012 level. This has led to the large drops that we see in the new ratings as the same amount of disease will now lead to a lower rating. Again this change should keep the ratings more reflective of what is seen in the field as well as adding more clarity to the differences between varieties. Brown rust data has also been weighted but has not been 'reset'. Bearing this in mind it would be worth familiarising yourself with the new ratings for familiar varieties, ensuring your evaluation of the new varieties is in the correct context.

With no new breadmaking varieties added to the List this year we jump straight into the nabim Group 3 varieties, where five new entries nearly triple the choice available. **LG Prince** (Limagrain) tops the group in terms of yield, 2% ahead of KWS Firefly and only 2% below the top yielding feed variety LG Skyscraper. LG Prince has performed particularly well in the East, has good resistance to both yellow and brown rust as well as a good Septoria rating of 7.1. It is on the later side to ripen and has a lower specific weight which may not suit everyone. LG Prince has performed very well as a second wheat and when early drilled. From an end use perspective it has the added option of distilling.

LG Illuminate (Limagrain) is just 1% lower yielding and offers similar resistance to both brown rust and Septoria. It is slightly earlier to ripen and has good resistance to sprouting and these characteristics combined with good performance when early

drilled and wide end use options, including distilling and export, may well draw it to the attention of more northern growers. **LG Quasar** (Limagrain) offers the same yield and similar wide end use options. It has good brown rust resistance but only moderate resistance to yellow rust.

LG Astronomer (Limagrain) has a slightly lower treated yield but an improved untreated yield due to its excellent range of disease resistance, which includes excellent resistance to both yellow and brown rust as well as a good 7.4 for Septoria. LG Astronomer also offers a good specific weight, suitability for early drilling and generally looks to be a relatively low risk variety. Finally, in this group we have **Merit** (Elsoms). Merit has a similar yield to LG Astronomer but has yielded particularly well in the East. It has good rust resistance although it is very susceptible to mildew. With a good specific weight, high Hagberg and end uses including export it should find homes within this region easily enough. All these new Group 3 varieties have resistance to orange wheat blossom midge.

One new soft feed variety, **Swallow** (Senova), has been added to this very competitive group. Swallow is 5% behind LG Skyscraper in UK yield but has been more competitive in the northern trials. This combined with excellent distilling qualities, and what looks like suitability for early drilling, is bound to attract attention within this region. It has short, very stiff straw, and a moderate disease profile with limited data suggesting susceptibility to eyespot.

We now have two new hard feed varieties to look at. **KWS Cranium** (KWS) joins the List with a top yield similar to that of SY Insitor, although it has performed less well in the North. It is a later maturing variety with stiff straw and good yellow rust resistance but a lower specific weight. It has yielded very well when late sown and may well be a good contender where beet or potatoes are in the rotation or black-grass is a major issue.

Finally we have **RGT Wolverine** (RAGT). RGT Wolverine is all about BYDV resistance; it is the first UK variety to offer genetic resistance and comes at a time where chemical controls are limited or undesirable and mild autumns are seeing increasing risk. Whilst its disease resistance package can only be described as moderate it is not far off the pace in terms of yield and is undeniably an incredibly useful new addition to the toolbox. However, it should be used wisely and targeted at high risk or difficult to manage areas.

Spring wheat

The spring wheat List sees one new entrant, **WPB Escape** (LSPB) – a very high yielding feed variety that has performed well when both spring and autumn-sown. It is relatively late to mature and has good yellow rust resistance.

Winter barley

Three very high yielding two-row feed varieties join the winter barley List, closing the yield gap between two-rows and six-rows. **KWS Tardis** (KWS) offers stiff straw, good resistance to Rhynchosporium and looks well suited to heavier land. **Bolton** (Elsoms Ackermann) also offers stiff straw and is slightly later to mature. It has been a consistent yielder across a wide range of conditions. **Bordeaux** (Senova) has shown more susceptibility to Rhynchosporium but has an excellent specific weight and low screenings.

SY Kingston (Syngenta) is the first of the new six-row hybrids and was rolled on from last year after a good performance in 2020. Whilst it does not move treated yield on, it has a solid disease package and a high untreated yield making management easier and lowering risk. **SY Thunderbolt** (Syngenta) again offers a similar combination of high treated and untreated yield and a good overall disease package, although in this case the straw will require good management.

Spring barley

Skyway (Agrii) offers a step forward in yield for malting varieties with a 3% advantage over the best current varieties. It is under test for brewing and offers a good combination of agronomic characteristics. Although limited data is available on the disease front a high untreated yield suggests no real holes in the armoury. Of course, as a malting variety, it is still early days with much testing still to be done but Skyway certainly looks like one to keep track of in the next year or two. **Cadiz** (Senova) joins the List as the top feed variety, although it is not as high yielding as Skyway. It has good straw characters and a relatively high untreated yield suggesting adequate disease resistance.

There are no new winter or spring oats to look at this autumn.

In summary we have some excellent new additions adding choice in areas that have been limited and opportunities to manage risk more easily. As chemical options narrow, improved genetics should be welcomed and used to their optimum.

Colin Peters • colin.peters@niab.com

New oilseed varieties

It is an exciting year for new varieties of winter oilseed rape and spring oilseed rape appearing on the AHDB 2021 Recommended and Descriptive Lists with five new varieties appearing on each, all hybrids. We also have one new variety added to the Spring Linseed Descriptive List.

The 2019/20 season was very difficult for oilseed rape trials operators. In recent years, many growers have become more used to drilling earlier to combat the problems of establishment and cabbage stem flea beetle. With oilseed rape variety trials, the seed is rarely available before the last third of August so we can face problems getting even establishment. This is clearly demonstrated by the fact that the most southern trial used in the 2020 harvest results was Framlingham in Suffolk, highlighting the need for long-term datasets so we can evaluate varieties over several growing seasons. Not having data from the more "intense" CSFB regions is a concern; it is fair to say that in our trials that were not even enough to take to yield, the hybrids in general did appear to be coping much better. This should not be taken as fact but has prompted a significant amount of effort in looking at varietal interaction with CSFB mentioned later in this article.

Winter oilseed rape

LG Aviron (Limagrain) has jumped in and straight to the top of the List, matching Ambassador in the East/West region at 109% of control gross output and a good northern result at 105% compared with Ambassador's 102%, making Aviron the second highest yielding variety in the north behind Aurelia. Aviron is a slightly taller variety at 161 cm but has a good score of 7 for resistance to lodging, although this is based on a limited set of data. It flowers very early with a medium early score for maturity. With very good scores for resistance to light leaf spot and stem canker, as well as resistance to turnip yellows virus and pod shatter, it has shown to be a very robust variety which was also third for early vigour in NIAB trials last year. Breeders generally are delivering varieties that grow vigorously in the autumn – a welcome trait for increasingly challenging establishment conditions.

LG Antigua (Limagrain) is recommended for the East/West region and equals the East/West yield of LG Aviron (109%). It is on the taller side, similar to LK Aviron, but with proposed good resistance to lodging. It flowers early and matures medium early with a high oil content at 45.6%. It has resistance to pod shatter and turnip yellows and good resistance to stem canker but a slightly lower level of resistance to light leaf spot than LG Aviron. It performed very well in NIAB trials last year ending up fifth for gross output.

Respect (LSPB) is a new variety for the East/West region, delivering a gross output of 106%. It is another tall variety but with proposed good resistance to lodging. It lacks pod shatter and TuYV resistance but has an excellent score of 8 for resistance to stem canker.

DK Expectation (Bayer CropScience) is the third new variety for the East/West region, slightly shorter than the other new entrants with a good gross output of 107%, excellent resistance to stem canker as well as good light leaf spot resistance. Bayer is actively targeting genes for vigorous establishment, with DK Expectation very vigorous in the early stages of growth. It also has resistance to pod shatter and turnip yellows and a high oil yield of 45.4%.

The final addition to the AHDB List is **DK Imprint CL** (Bayer CropScience). This is a herbicide tolerant variety with a UK-wide recommendation. It has an East/West gross output of 95% and North gross output of 91%. It has very good stem canker resistance as well as pod shatter resistance. The variety has a light leaf spot rating of 6 but does not have TuYV resistance.

All these varieties help raise the platform of the quality on the List. Plus keep an eye out for candidate varieties for the 2021 AHDB Recommended List that members may have seen featured in NIAB variety trials in 2020. A standout one would be **DK Extremus** (Bayer CropScience) which performed very well in our own trials – fourth for

gross output with a high oil yield and only a little way ahead of **DK Exstar** (Bayer CropScience). **Duplo**, from DSV, also performed well and we look forward to seeing more of these varieties in the future.

Flea beetle

The establishment challenges of 2019, and the following winter CSFB larval problems with oilseed rape crops into the spring of 2020, have caused many growers to reconsider their oilseed rape areas. On a positive note, we are all well aware of some very promising looking crops in all regions this autumn. Anecdotally at this stage, the earlier drilled crops (late July or soon after) appear to be those that are most robust. Personally, I am less concerned with over-proud crops in the autumn versus CSFB and pigeon issues as, historically, large autumn crops were the norm. There are ideal scenarios with plant counts, canopy structures and light interception, but we need to look at the crop differently and acknowledge the need to work around the challenges to improve crop safety and increase the rotational margin overall.

Over recent years, many have suggested that the earlier the crop the more CSFB larvae and, hence, we will be causing a bigger problem. Again, this is somewhat anecdotal. ADAS has carried out some great research on the subject over recent years and is starting a further three year AHDB-funded project looking at some of the complexities of how the adults behave in relation to juvenile plants amongst many other things.

NIAB has won funding from Defra to work alongside ADAS in understanding how on-farm interventions work and which are the most successful. This will be complemented by small plot trials aimed at understanding varietal interactions with the pest, using detailed monitoring of adult and larval damage from emergence to final yield relating to different drilling dates. In early 2021 NIAB will be launching a cross-industry and grower initiative, developing and rolling-out agronomy tools, such as simple ways to monitor CSFB activity, to help on-farm pest and crop management decisions. I tend to liken this to the black-grass situation. Not too many years ago if wheat growers, with a black-grass problem, had been told not to drill wheat in September we would have been laughed out of the field. But growers have learnt now how to deal with the grass-weed and the same may well be true with CSFB in the near future.

We want to connect with growers who have tried various interventions, successful or otherwise, with the aim of protecting the future of this break crop that has been so successful for the past 40 years. We hope that many NIAB TAG members will join us to help make the project a success.

Spring oilseed rape

There are five new varieties on the AHDB 2021 Spring Oilseed Rape Descriptive List, all hybrids. The Defra crop planting figures for spring 2020 suggest that there were some 14,000 ha of spring oilseed rape planted. This crop does provide a good break option with a good margin and helps with difficult weed control issues. Just note that all the DL data is from a limited number of trials and should therefore be treated cautiously.

Lakritz (DSV) arrives on the List with a strong yield performance of 109%. It does flower early but has a moderate maturity date similar to the other higher yielding varieties. **Menthal** (DSV) is slightly lower yielding with a moderate oil content but does mature slightly earlier and the breeder claims clubroot resistance.

There are three new spring herbicide tolerant varieties new to this year's DL, presenting an opportunity to control awkward brassica weeds. **Contra CL** (DSV) has a gross output yield of 99% with an oil yield of 43.5%, **Inv110 CL** (BASF) has a gross output of 95% and **Cebra CL** (DSV) has a gross output of 94%.

Spring linseed

There is only one new spring linseed variety this year on the AHDB Descriptive List. **Buffalo** (Elsoms) has a strong yield at 109% of controls with a high oil content at 42.3%. It is fairly short and although it tends to flower late, it has a medium early maturity score.

Aoife O'Driscoll • aoife.odriscoll@niab.com

New pea and bean varieties and a move to a Descriptive List

In the new PGRO Descriptive List for 2021, there are seven new peas, seven new spring beans and two new additions to winter bean varieties.

Moving from a Recommended List to a Descriptive List

For 2021, PGRO has moved to a new Descriptive List from the long-standing Recommended List system. With the more flexible and adaptable approach of the new Descriptive List, varieties coming through from National List will have the chance to be described on the DL, and no judgement will be performed about their market value. The DL will be a point of reference for growers to source variety information; whether they will meet their needs, as well as the needs of the market. This change should encourage innovation from breeders, with the knowledge that their efforts will not be handicapped by not being included on the DL before the market has had a chance to judge these new varieties for use.

Within the new DL system, there will be no changes to the sites and their number, and no change to the rigour and quality of the data collected. DL tables have been updated with some cosmetic changes; varieties are now down the side and agronomic characters across the top. There have been changes to the recommendation categories, with varieties now listed with the year that they appear within the five-year matrix, and the number of years that they have been in trial. In the previous RL system two varieties would have been used as yield controls. This has been updated to include a larger basket of varieties within each of the crops. This should give a much more reliable yield control which stands the test of the time and gives good comparisons year on year. To align things with the international recognition of blue and white peas, these will be renamed as green/blue peas and yellow/white peas. Within the blue category, small and large will be combined together, eliminating any confusion as in the past the division has been a little blurred. The thousand grain weight for each variety will be included alongside the pea type.

By national standards combining peas is a relatively small crop. The largest segment, over 50% based on seed production, is green (blue) peas, followed by marrowfats at close to 40% and then yellow (white) peas. Most experienced pea growers target premium markets and are aware of the difficulties of achieving good quality samples, accepting the yield penalties often associated with the most attractive varieties.

New growers, needing to fill rotational gaps in the coming season, may be best to go straight for high yielding types, targeting feed markets and taking premium quality as a real bonus if they achieve it. Beans are the larger crop and are generally less tricky to grow than peas, with far less lodging risk, although dry conditions at flowering can cause poor seed set and wet weather and disease in the run-up to harvest can cause loss of quality due to staining on the grain. The holes left from emerging bruchid beetle larvae can result in a loss of quality where infestations are severe.

Progress in pea yields

New to the list for Year 3 status are **Stroma** (LS Plant Breeding), **Kaiman** and **Kiravi** (both Senova), **Raider**, **Greenway** and **Mikka** (all IARA). For the second year running, the top yielding yellow (white) pea variety was **Kameleon** (Senova) on 120% of controls, representing a tremendous yield advance. In other respects, it has fairly short plants with moderate standing ability and early maturity. It has a good, bold grain size and may well be suited to the wholegrain packet trade and the split pea market, in addition to its general suitability for animal feed compounding. It is classified as 'moderately susceptible' to downy mildew.

Orchestra (LS Plant Breeding) is another high yielding variety in the yellow seeded peas at 115%. It is medium for plant height, has moderate standing ability and is medium early to mature. The grain size, at 308 g per thousand, is large, which in addition to its value in standard markets may also make the variety attractive to some of the niche, high value markets. The downy mildew resistance, with a 'susceptible' 4 rating, should be noted.

Within the green (blue) seeded peas, **Kaktus** (Senova), **Bluetime** (LS Plant Breeding) and Stroma all vie for the position of top yielding variety at 112% and 111%, respectively.

Most of the pea varieties now have a downy mildew resistance score of 5 or over, with **Blueman** (LS Plant Breeding) scoring 8 (this score has been quite consistent over the years). Blueman has the additional advantage of a high level of resistance to powdery mildew, a new trait considered under the disease resistance category for 2021. It has been an increasing problem, both in trials and for growers, with the 2020 season particularly problematic, thought to have been exacerbated by later sowings combined with ideal conditions for powdery mildew development and spread. **Greenwood** (IARA) and **LG Aviator** (Limagrain) have also been listed as highly resistant to powdery mildew.

Grain appearance is highly important for some of the end uses for peas, to the extent that **Daytona** (Agrii), on 100% of controls for yield, is currently the market leader. Looking at size, Orchestra, Greenwich and Stroma have particularly large thousand seed weights in their yellow and green seeded categories, respectively. **Greenwich** (LS Plant Breeding) has a yield figure of 107% of controls, short-to-medium straw length, moderate standing ability, early maturity and moderate downy mildew resistance. At 324 g per thousand, its grain size is the largest in the group and may be particularly suited to micronising, producing flaked pet foods.

The yield potential in the marrowfat group has been increased with the addition of top-yielder, **Akooma** (LS Plant Breeding) at 97% of controls. Akooma has a much higher yield potential, some 11% higher than Sakura, with a slightly higher downy mildew rating of 5 and a particularly large seed size for a marrowfat. **Sakura** (Dalton), **Octavia** (IARA) and **Banshee** (Senova) are just behind, on 85% to 86% yield of the controls. Both Banshee and Octavia have short-to-medium straw, better standing ability than most marrowfats and late maturity. All four varieties have the typically large grain size

associated with this group. The downy mildew resistance rating of 3 for Octavia will be a concern.

There were no additions to the maple pea group.

New variety choices in spring beans

With the addition in 2020 of the low vicine/convicine beans with their superior nutritional properties, seven new names have been added to the DL.

Stella, **Capri** and **Daisy**, all Saaten Union varieties, and **LG Viper** and **LG Sphinx** (Limagrain) are new for 2021 with **Bolivia** and **Allison** (LS Plant Breeding) entering as new varieties in the low vicine/convicine category. Both Stella and LG Viper are showing early indications of exceptionally high yields. LG Viper has some additional interesting characteristics in that it is a very late maturing variety but has good resistance to both downy mildew and rust. The seed size is also large for this category and it has a high protein content. Stella has moderately tall straw, moderate standing ability and medium late maturity, but its susceptibility to downy mildew should be noted. Capri, Daisy and LG Sphinx also performed well in terms of yield at 105%, 104% and 103%, respectively.

Looking at downy mildew resistance, both Lynx and Yukon have exceptionally good levels of resistance. **Lynx** (LS Plant Breeding) is also a high yielding variety, on 106% of controls with very good standing ability. Though not a particularly high yielding variety, **Yukon** (LS Plant Breeding) is rather unique in having exceptionally early maturity. This should be of particular interest to northern growers, who can produce very good quality grain, because of reduced bruchid beetle pressure, but may run into late harvesting. It is a short variety, with moderate standing ability and large grain size.

LG Raptor (Limagrain) is also on 105% for yield. It is moderately tall, with good standing ability and medium-early maturity. It has an average grain size but has susceptibility to downy mildew. **Ghengis** (LS Plant Breeding) has a yield figure of 105% of controls. It is tall, with moderate standing ability, medium-early maturity and medium-to-large grain size. Once again, the potential flaw is susceptibility to downy mildew.

Victus and **Tiffany**, both LS Plant Breeding varieties are both low vicine and convicine types with Victus having a slightly better yield and downy mildew resistance score. **Allison** (LS Plant Breeding) is a new variety for 2021, it has the largest seed size of the low vicine/convicine types and exceptionally early maturity. However, its downy mildew score of 3 should be noted.

Looking at particular traits from an industry perspective when it comes to seed size – 'the bigger the better', with **Macho** (LS Plant Breeding) showing the largest seed size. Macho, on 105%, is moderately tall, with reasonable standing ability and late maturity. The exceptionally large grain size should be attractive for the developing de-hulling end-use for farmed fish food, as well splitting to produce falafel in North Africa and the Middle-East. The downside is its susceptibility to downy mildew. Protein is also important, with **LG Cartouche** (Limagrain) consistently producing the highest protein levels, although quite a number of varieties now have a protein content in the high 20s.

Maris Beard (WA Church), in limited trialling for the last two years, is also now on the DL, being introduced back into trialling for the 2021 season.

Winter beans

Vincent (Senova) moves to the top of the yield rankings, on 110% of controls, ahead of **Vespa** (Senova), on 109%, **Norton** (Senova) on 107% and **Bumble** (Senova) on 104%.

Ellie Sweetman • ellie.sweetman@niab.com

Exploring opportunities for herbal leys

Mixed swards, whilst relatively novel in today's farming systems, are not new. A much wider range of forage crops and multiple species swards were grown across the UK prior to World War II. With increased pressure to reduce environmental impacts and greenhouse gas emissions through increased nitrogen efficiency and improved soil health, there is a renewed interest in these high potential leys. This may be for use within the arable rotation for improving soil conditions as a long term green manure, as a haylage crop or to bring livestock back onto the farm; or for livestock systems as a nutrient dense, productive grazing sward with increased livestock health benefits.

A herbal ley is a multi-year, diverse sward composed of legumes, grasses and herbs. It provides nutrient rich forage, with the potential for high dry matter yields without reliance on artificial nitrogen inputs and with the bonus, from some species, of anthelmintic effects and improved mineral profile. The different species present will have varying root properties, rooting depths, accessing more moisture and nutrients in the soil profile, conveying drought tolerance and the potential for improving soil health and structure through increased biological activity. These multi-species swards work especially well in areas where ryegrass leys are at risk of burning off in high summer on dry, lighter land. Improved drought tolerance has been particularly noticeable during recent prolonged dry spells, with these leys remaining green whilst other forage crops are seen to suffer and grass to burn off, giving a longer, productive growing season.

Ongoing NIAB projects suggest that

herbal leys can give higher dry matter yields than the shallower rooted grass-clover leys in dry weather. The work has also shown that where there are high levels of biomass above ground, there are high levels of biomass below ground, accessing moisture and minerals from greater depth. Other livestock-focused project work by organisations such as Rothamsted Research, University of Reading, Agri-Tech Cornwall, the Soil Association and Agricology, has also found that complex mixtures can outyield grass-clover mixtures and monocultures that have received an artificial nitrogen application. The diversity within these swards also has wider environmental benefits supporting a wide range of pollinators and other invertebrates and wider ecological food chains.

Herbal leys also fit nicely into arable rotations, as they scavenge residual soil N and through their high root biomass and increased root zone biological activity, build soil carbon, as well as mobilising soil phosphorus and fixing nitrogen to increase N supply for the following crop. They also provide a great opportunity to bring grazing livestock back into the rotation. These mixed swards were traditionally used as a minimal input, four-year break crop to build soil fertility and improve soil structure and drainage, whilst providing high quality livestock fodder with associated health benefits of dietary minerals and reduced gastro-intestinal

worm burdens. A current NIAB research project is looking into restoring soil quality through reintegration of leys and sheep into arable rotations, trialling both herbal and simple leys, which will be followed with a wheat crop to look at their value as an arable break crop.

Species

There are a range of different grass, legume and herb species that can be used in mixtures, with some species preferring a higher pH and some not coping well in wetter soils. Choice will also vary depending on whether the sward is to be grazed or cut and the preferred ley lifespan. Care must be taken to monitor species composition which will vary over time, with some species tolerating certain growth conditions and management approaches better than others but there is increasing advice and guidance available from current growers and organisations to aid farms to find and establish the best mixtures for their conditions.

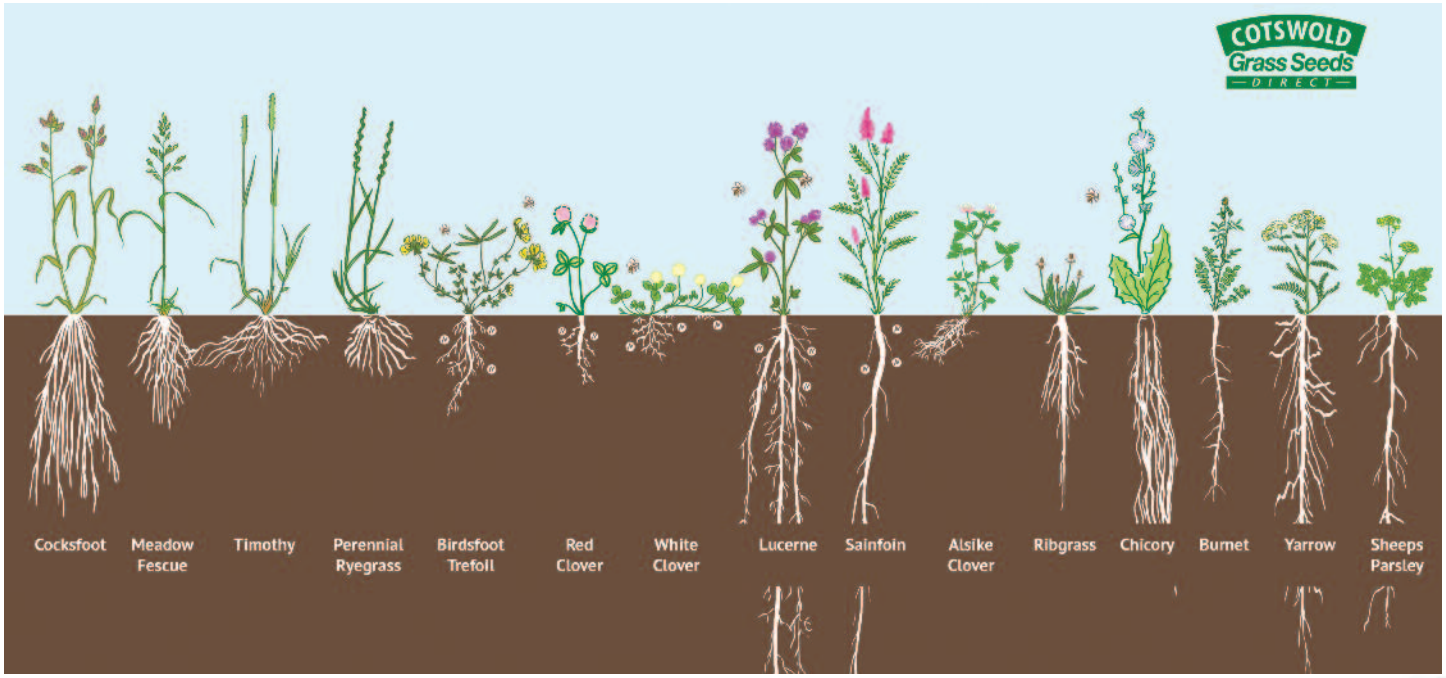
Legumes

The nitrogen-fixing legumes in the sward provide a source of available nitrogen to surrounding plants, minimise GHG emissions by reducing the need for applied nitrogen and increase livestock food conversion efficiency, which also reduces methane production. By being able to fix their own nitrogen, these legumes provide high levels of protein to the mix and subsequently good animal growth rates.

Clovers are not the only nitrogen-fixing legumes available. Sainfoin is a currently under-utilised deep rooting, mineral-rich, highly palatable perennial species that contains condensed tannins which have anthelmintic (worming) action in the gut. It is particularly helpful for late season grazing and useful in a dry summer when high temperatures can lead to dormancy in grasses. Lucerne is another perennial legume, grown extensively on the continent, providing high quality protein, minerals and resilience in dry seasons.

Grasses

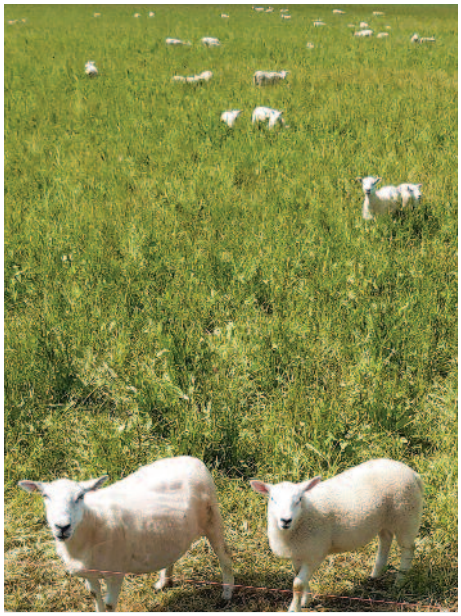
Grasses provide bulk and highly digestible carbohydrates in the mixture and are usually included – though some farms are



finding success without grasses, experimenting with different mixtures for different fields and situations. Perennial ryegrass is used in many medium to long-term leys for relatively fast-growing dry matter bulk which can provide a good soil cover whilst allowing the herbs to establish. Italian ryegrass and Westerwolds are not suitable for inclusion due to their relatively short-term production and risk outcompeting the slower growing herbs. As a hybrid of fescue and perennial ryegrass, the relatively new Festuloliums combine the stress resistance of fescue with the growth and tillering characteristics of perennial ryegrass. Cocksfoot is deep-rooting and grows over a slightly longer season, allowing for extending grazing. Timothy will grow at lower temperatures than many other species. It is also very palatable, which encourages high overall feed intake.

Herbs

Chicory, ribwort plantain, yarrow and the legumes birdsfoot trefoil, black medic (aka yellow trefoil) and alsike clover contain high concentrations of the minerals that livestock are most likely to be deficient in. The deep rooting chicory and ribwort plantain (ribgrass) have also been found to withstand dry conditions whilst



promoting good lamb growth rates and chicory and birdsfoot trefoil also have anthelmintic properties.

Establishment

Herbal leys can be slow to establish. Legumes prefer a warm soil for the development of the nodule inhabiting rhizobial bacteria so mixtures are best sown by mid-August with plenty of light and warmth in order to develop in time for productive spring growth. They prefer a soil pH of 6 or above, with as high as pH7 if sainfoin is included. Care must be taken to ensure the right soil conditions for establishment with sufficient soil moisture within the top 2.5 cm and a fine, firm tilth to provide good seed to soil contact. An inoculum of the right strain of rhizobium may also be needed to ensure good legume development. Leys should ideally be grazed lightly in the first year to encourage plant development, tillering and avoid plant damage.

Management

When grazing these leys, whilst management may vary depending on species present, the best approach has been found to be to 'mob graze'; put high stocking rates on for short periods of one or two days and aim to graze off a maximum of half the plant biomass at one time, then leave swards 28-35 days to allow for recovery and regrowth. This approach also prevents selective grazing by livestock of the most palatable species. Whilst this may seem counter intuitive for efficient production, better overall dry matter yields across the season have been achieved by not overstressing the plants.

If you are interested in learning more about herbal leys/mixed swards, sharing your experiences, or if you would like to be involved in any future project work in this area, please contact me at ellie.sweetman@niab.com or on 07734 567597.

Richard Harrison • richard.harrison@niab.com

How policy can help

In the fourth and final article in his series for *Landmark*, NIAB's Dr Richard Harrison covers his conclusions and recommendations from his Nuffield Farming Scholarship *Where next for soft fruit in the UK?*

My previous articles covered how genetics must be integrated into system design and the evaluation of future food production systems must take into account, and mitigate, externality costs across a basket of measures. In this, my final article, I will explore my final two conclusions which investigate some ways in which policy may help and the role we all must play in the transformation of our food system.

Conclusion 4

In a new UK agricultural policy landscape there could be further direct incentives to lower fossil fuel energy and transfer to renewable usage through a 'produce or reduce' energy incentivisation scheme for green energy.

When I wrote my report, in 2019, I remember my sense of frustration at the lost decade of the 2010s. This led me to writing my recommendation:

Recommendation 4

Policy instruments, further to the carbon tax should be developed; any 'polluter pays' scheme should be coupled with funds for investment and the playing field should be levelled for UK growers, perhaps through a border tax on

carbon, internalising externality costs for food imports, or alternatively through greater efforts for multilateral decarbonisation coupled to domestic green growth. Greenhouse gas emissions should not be considered in isolation, but as part of a wider basket of sustainability metrics.

The speed at which the government is reacting to the climate crisis is clearly gathering pace and part of my recommendation is already well underway. The recent ten-point plan for a green industrial revolution, notable for the absence of agriculture but the inclusion of carbon capture and nature restoration, sets a partial path for how 'green' growth can be achieved. Although it leaves much unanswered, it is clear that the ambition to mobilise £48 billion of public-private investment over the next ten years is a positive step forward. Coupled with this there are the recent announcements of a National Infrastructure Bank, focused squarely on securing a green recovery through investment in low-carbon capital projects around the nation and the rumours that the chancellor is considering a UK-wide carbon tax, which includes agriculture to potentially replace the current EU-wide emissions trading scheme, potentially set at £75/t, by 2030.

So what of agriculture? As the principal land user it is clear that agriculture will be affected by all of these major shifts in policy to a net-zero economy, alongside the existing changes proposed in agriculture from the shift in subsidy regime, the removal of red diesel subsidies and the focus on delivery of environmental service alongside food production. Throw in a dollop of Brexit and farming is set for a bumpy ride, which some will enjoy and others will not.

My recommendation also speaks of an incentivisation scheme. While in California I learned about a scheme, run by the state energy commission, which incentivises through funding farmers to make the transition to renewables. Their Pigovian taxation system of 'polluter pays' is matched by an incentivisation scheme that funds growers to decarbonise and directly funds private-public research and development initiatives to innovate in the area of renewable energy use on farm. Above and beyond any replacement of the Common Agricultural Policy and change in taxation, I think that this idea should be explored to its fullest extent. In California, the mechanism through which the state government invested in this R&D was twofold. First, to equip established players in the sector with funding to help their research base co-design solutions with the industry and, second, to provide co-funding to venture capital in order to accelerate the growth of green business start-ups. As I state in my report, this scheme is not perfect, but is in my view better than the system that we have at the moment in the UK where we seem to be obsessed with setting up new initiatives and centres, rather than investing in the ones we have already and then failing to provide sufficient operational funds to make centres a success, which then just leads to ever more brutal competition between organisations that should be working together.

Conclusion 5

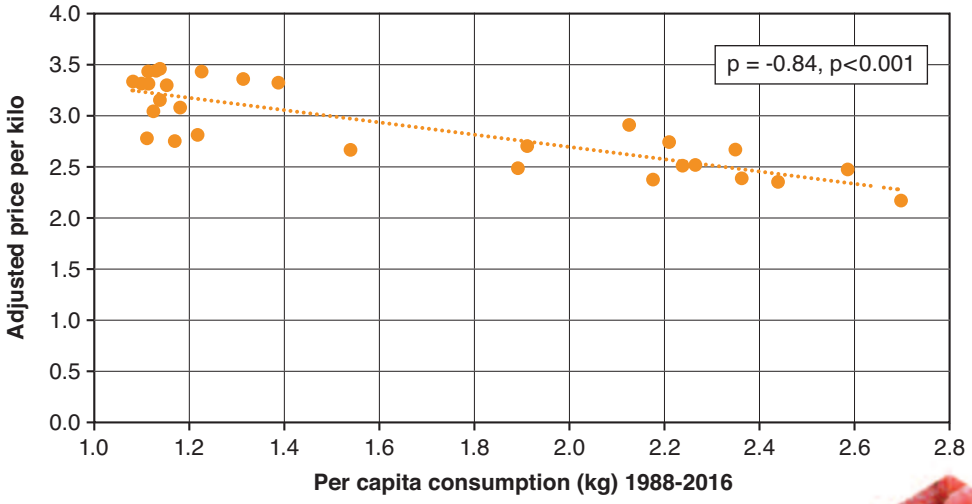
Every consumer is responsible, but largely unaware of our actions. Technology could help raise awareness of sustainably produced fresh produce and help shift consumer behaviour.

My final conclusion was one that was aimed at all of us; put succinctly, 'we talk a good game' when it comes to our values around food. The data however suggests that on the whole we shop on price and little else. Moreover, my cursory analysis of strawberries showed that consumption of nutritious foods, such as strawberries, was highly correlated to price (Figure 1). This means that if we allow the price (note I am not referring to the cost of production) of our nutritious food to increase, people will eat less of it. This in turn leads to the observation that if we do not act in a holistic way to ensure access to nutritious food is protected then we will simply exacerbate other problems in society, which clearly are of great personal and social cost. We have all brutally seen through the Covid-19 crisis how obesity, diabetes and likely 'hidden hunger' worsen the likelihood of a positive outcome from coronavirus infection.

The question of how we deal with a rise in the cost of production and a shift to sustainable production must take into account how the market will respond to the action and consider the consequences of this market response. This question is at the heart of the National Food Strategy, yet another thing that did not exist when I was writing my original report!

One observation that I would add is that sometimes, small nudges can make a difference (think for example of the carrier bag tax). Far more work is needed on the social acceptability of any move to change consumer behaviour (especially when it comes to food labelling) but it is definitely an area that merits consideration. Furthermore, if supermarkets carry on as they are trying to fully work out the scope 3 (supply chain) emissions of their supply chains, there could be win-win situations where sustainably produced food could be preferred by consumers. I, for one,

Figure 1. Strawberry per capita consumption (kg) versus inflation adjusted per kilo cost (1988-2016)



look forward to seeing the full report of the food strategy.

Recommendation 5

Nudge policies, such as printing food miles on food, having small 'token' charges, or colour coding emissions levels on products, could help raise awareness and shift consumer behaviour.

As with the original Nuffield scholar, Henry Morris, who travelled to Detroit to see Henry Ford's pioneering production plant for the Model T Ford and then returned home and set up Morris Garages, I too am now working to take the best that I have seen from around the world and implement and expand upon it here in the UK. My Nuffield experience changed many things, including some of the research and development that I now do. If anyone reading this series of articles is considering carrying out a scholarship, I would be happy to offer a perspective and hopefully some helpful advice. I will end this series with thanking two people (in addition to my ever patient family) that supported me throughout my study, Tina Barsby (who originally suggested I carry out a Nuffield scholarship) and Richard Harnden who acted as my sponsor and occasional travel comparison on some of my trips.

Jane Thomas • jane.thomas@niab.com

Lucy James • lucy.james@niab.com

Amelia Hubbard • amelia.hubbard@niab.com

Sarah Wilderspin • sarah.wilderspin@niab.com

Tom Wood • tom.wood@niab.com

Rusts and downy mildews update

UKCPVS

INTERNATIONAL YEAR OF PLANT HEALTH 2020

Plant rusts and downy mildews are two very different groups of obligate pathogens that cause damage to the yield potential of many crops nationally and internationally. At NIAB, we continue our research on the cereal rusts and this year sees the start of a new project on pulse crop downy mildews.

Rusts

The UK Cereal Pathogen Virulence Survey (UKCPVS) project forms the core of rust work and, after a relatively quiet year for yellow rust in 2018, some new pathotypes erupted in 2019 which have threatened the adult plant resistance of some previously highly resistant varieties. The detailed results can be found in the 2020 UKCPVS Annual Report, available on the NIAB and AHDB websites, but the differential effects of isolates on some varieties can be clearly seen as examples in Table 1, extracted from the report. Though only five isolates can be tested at the adult plant stage, they reflect both a combination of the dominant variety of origin and novel seedling pathotypes in 2019. There is no certain way of predicting which of the isolates will persist in the future; experience in recent years has shown that the selections do remain a part of the highly heterogeneous population that is now typical of yellow rust, and the isolates go on to be part of the Recommended and National List testing programmes.

It is clear that KWS Firefly was susceptible to all of the isolates (Table 1), and indeed a large number of samples from that variety were received in 2020. KWS Extase was only susceptible to one pathotype, and a few samples from this variety were received relatively late in the 2020 season. LG Skyscraper was slightly

UKCPVS disease nurseries test individual isolates on adult plants

Table 1. Variable adult plant reactions to five isolates of yellow rust, 2020 UKCPVS tests

Yellow rust isolate	Adult plant (% plot area infected)				
	19/010	19/038	19/119	19/165	19/215
Source variety	KWS Zyatt	Shabras	KWS Firefly	KWS Zyatt	KWS Extase
Test varieties					
KWS Siskin	0.1	0.1	0.8	0.1	0.1
KWS Extase	0.1	0.7	0.0	0.0	14.9
LG Skyscraper	0.6	11.0	0.1	0.9	7.5
KWS Firefly	10.8	14.1	12.6	12.0	18.1
KWS Zyatt	26.0	19.5	27.2	24.8	39.8

susceptible to two of the isolates, and highly resistant to three, and just four samples were received from this variety in 2020 from a restricted number of sites. As expected KWS Zyatt was susceptible to all five isolates, and many samples were still received from this variety. Meanwhile, KWS Siskin remains highly resistant to all isolates, as do many other varieties.

We still cannot predict which varieties will become infected at specific localities, but AHDB will be launching a watch list of varieties which may be prone to higher levels of yellow rust early in the new year. UKCPVS provides vital ongoing information to underpin this new variety management tool which will indicate those varieties where careful monitoring is necessary.

The situation with brown rust is more straightforward, though new seedlings virulences on Theodore and RGT Saki were detected for the first time in 2019. Levels in adult plant tests in 2020 were low, but KWS Firefly was susceptible to one of the isolates used, and further samples from this variety were received in 2020.

Though not part of the UKCPVS, two severe outbreaks of oat stem rust were seen in 2020, both on winter oats. This form of stem rust does not infect wheat, but its presence indicates that at least the southern parts of the UK have the very warm conditions in some years that allow stem rust to infect. In southern Ireland this year, there were reports of stem rust in untreated winter wheat trial plots, and several reports in central France. While early maturity and robust fungicide programmes are likely to protect UK winter wheat, the steady progression northwards of this disease in recent years demonstrates that shifts in weather patterns will favour the emergence of forgotten diseases.

Downy mildews

Like rusts, downy mildew pathogens can exist as many different pathotypes capable of interacting with host resistance and leading to its breakdown. The UK's major pulse crops, pea and faba (field) bean, can both be infected by separate, though closely related, forms of the disease. Within the pea infecting form, there are a large number of pathotypes which have been described using differential lines, while in the bean infecting form, the structure of the population in the UK remains unknown.

The two diseases are increasingly problematic to control, with constraints on seed treatment and relatively expensive sprays, so host resistance is a vital element for their management. A new project, funded by BBSRC, aims to identify stable resistance in both crops, and develop diagnostic assays to predict which pathotypes are present in production fields, thus guiding variety selection. The project is led by the University of Worcester, with partners at NIAB and the John Innes Centre.

2020 was the International Year of Plant Health and though many events were curtailed, many still went ahead in one form or another to emphasise the vital role that plant health research plays in food security. Some events will continue in 2021 to maintain the momentum generated. Projects like UKCPVS, and the new programme on downy mildews, are dependent on industry stakeholders providing samples. We are extremely grateful to everyone for taking the time and trouble during 2020 to send NIAB material under difficult circumstances. We received over 300 samples of yellow rust and 40 of brown rust.

Acknowledgements

UKCPVS is funded by AHDB and APHA. *Pulse downy mildew pathosystems* is funded by BBSRC-LINK, project number BB/T016043/1.

Bean downy mildew

John Cussans • john.cussans@niab.com

Control of wild oats – common and winter

Over the past few years there has been an increase in the number of wild oats popping up across UK cereal fields. It has been over twenty years since the significant research project on wild oats so an updated picture of UK wild oat populations and herbicide resistance is well overdue. NIAB and Life Scientific teamed up over summer 2020 to offer UK growers and advisors free wild oat resistance testing on submitted samples in exchange for answering a detailed questionnaire on wild oat control and crop management.

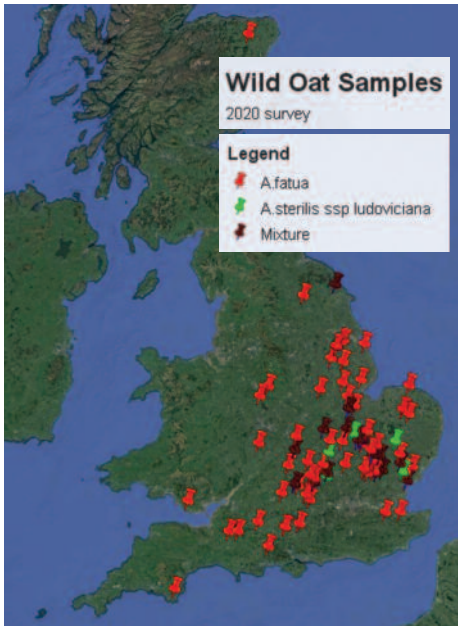
There are two species of wild oats that are weeds in the UK – the common, or spring, wild oat and the winter wild oat. The common wild oat (*Avena fatua*) is an important weed in all parts of the UK and grows in most soil types, causing problems in winter and spring crops. A second species, the winter wild oat (*Avena sterilis* ssp. *ludoviciana*), is becoming more widespread and increasing in number.

Wild oats are our most competitive grass weed, on a potential yield loss/plant basis. Just one wild oat plant/m^2 can reduce yields by as much as 1 t/ha in winter cereal crops, and 0.6 t/ha in spring cereals. Wild oats also act as hosts for pests and diseases, such as barley yellow dwarf virus.

Wild oats have become much easier to spot than in previous years which could be due to several factors. Min tillage or direct drilling fails to bury wild oat seed, burial increases dormancy so seeds left on the soil surface are more likely to germinate and thrive. There has also been a reduction in the use of ALS chemistry, traditionally used to control black-grass. Growers worried about the reliance for black-grass control have forgotten that these herbicides can be very effective at wild oat control.

The survey

Over summer 2020, 105 samples, plus questionnaires, were submitted by UK growers concerned about the status of their wild oat populations. 97 of these were viable for resistance screening to pinoxaden (e.g. Axial Pro) and iodosulfuron/mesosulfuron (e.g. Niantic). Thank you to all growers and agronomists who took the time to collect the samples and complete the detailed questionnaire.



Around 30% of the samples received contained winter wild oats (*A. sterilis*) making this species much more common than we had previously thought. The questionnaire responses suggest that the wild oat problem is increasing at the highest rate where winter wild oats are present, making understanding the contrast between the two species more urgent.

The immediate concern is that the prevalence of herbicide resistance might be higher in winter wild oats than in common wild oats (*A. fatua*) and that this may be behind the former's increased abundance. The initial findings point to cases of resistance in both species to both pinoxaden and iodosulfuron/mesosulfuron, with the study confirming that the occurrence of resistance is indeed higher in the winter wild oat.

Priorities

The results point to several priorities for farmers:

- Identifying and understanding more about the two differing wild oat species on their own farm.
- Making better use of existing products to maximise their potential in-field – getting the application timings right relative to growth stages and conditions.
- Herbicides and rotating active ingredients – there is relatively low-level of cross-resistance between herbicides in both species, so this approach will become increasingly important.
- Adopting some element of cultural control in order to supplement and sustain the control achieved by herbicides.

Common wild oat (Avena fatua) (left) and winter wild oat (Avena sterilis) (right)

Fiona Leigh • fiona.leigh@niab.com

Designing wheat for the future

DFW

The pre-breeding team at NIAB was established in 2005 by former NIAB Director and CEO Professor Wayne Powell and former Director of Genetics and Breeding Professor Andy Greenland. It was ahead of its time, filling a niche in translational science between academic research and the cereal stakeholders, including plant breeders, in the UK. Since then, pre-breeding at NIAB and elsewhere, has become a significant feature of the cereal research landscape.

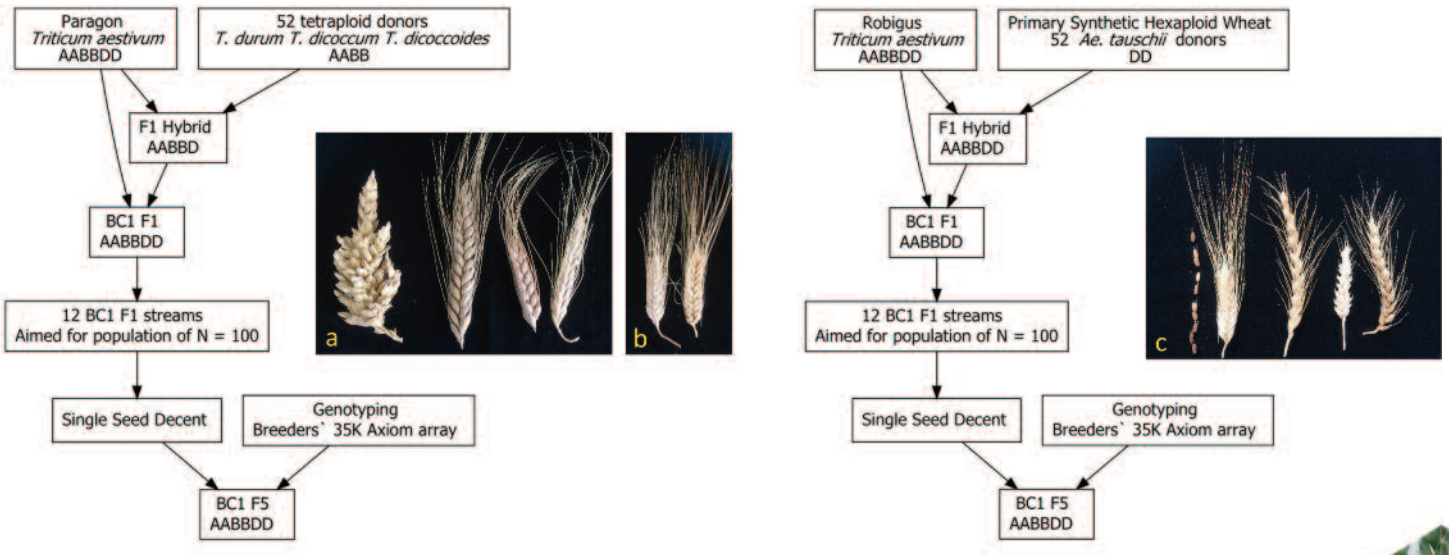
Pre-breeding is a term that we use to refer to the creation of material that could go into a breeding programme and is not just restricted to wheat. For example, in the *Smart Carbohydrate Centre*, funded by the BBSRC, NIAB provided the link between colleagues at the John Innes Centre, who were characterising barley lines that had unusual starch properties such as waxiness or low digestibility, and industry end users including barley breeders and maltsters. These genes were often in barley material that was unsuited to cultivation in the UK so NIAB created a collection of lines in an elite barley background that contained the novel starch genes, and made them available to the barley community along with a suite of molecular markers to facilitate their use in breeding programmes.

For the past eight years, NIAB's pre-breeding team has been part of the Wheat Improvement Strategic Programme (WISP) and its successor Designing Future Wheat (DFW). These programmes are large, multi-partner BBSRC-funded collaborations and encompass all aspects of research in wheat – from developing novel phenotyping capabilities through to characterising the control of novel starch and cell wall traits for end users whilst also creating new genotyping platforms for the wheat community. At NIAB, the DFW pre-breeding team has created a unique genetic resource focused on capturing diversity from wheat progenitor species.

Wheat is a hexaploid species that arose from a chance hybridisation, that naturally occurred around 10,000 years ago, between a tetraploid wheat, such as emmer or durum wheat, and a diploid wild goatgrass (*Aegilops tauschii*). Domestication, adaption and plant breeding have created high yielding, highly adapted modern wheat varieties. However, wild relatives and landraces of wheat are recognised to be an untapped reserve of diversity that could be employed in crop improvement. This diversity can be captured by crossing tetraploid wheat, with AABB genomes, with modern, or elite, wheat varieties which have the genomes AABBDD). For the D genome donor, instead of crossing *Ae. tauschii* directly to elite wheat we recreate the original hexaploidisation event. We do this by making a 're-synthesised' or synthetic wheat, crossing a durum wheat with the *Ae. tauschii* then

The DFW (Designing Future Wheat) pre-breeding team at NIAB is Richard Horsnell, Tally Wright, Fiona Leigh, Robert Jackson and Keith Gardner.

Figure 1. Capturing diversity. The pipeline used to create the diverse populations with three rounds of single seed descent (SSD) performed in each stream to generate BC1F5 seed. Examples of emmer and durum wheat are shown in panel a and b respectively; The components of the SHW family are shown in panel c – from left *Ae. tauschii* (DD), durum wheat (AABB) – these lines are crossed to make the SHW, fourth from left is Paragon (the recurrent parent) which is crossed with the SWH then backcrossed to create the BC1, right of photo.



using a chemical called colchicine to double the chromosomes to make a stable hexaploid wheat. These novel lines are known as Synthetic Hexaploid Wheats (SHW).

As part of DFW, NIAB created 50 SHW, each containing a novel D genome from *Ae. tauschii* accessions sampled from across the geographic range of the species. The 50 NIAB SHW have been backcrossed into two elite UK wheats, Paragon (spring wheat) and Robigus (winter wheat), to create a panel of introgression populations.

To introduce diversity to the A and B genomes of modern wheat, a parallel population stream was created by directly crossing and backcrossing 50 tetraploid *T. turgidum* spp wheat accessions into Paragon and Robigus. The 50 are a mix of wild emmers – *T. turgidum ssp. dicoccoides*, cultivated emmers – *T. turgidum ssp. dicoccum* and durum wheats – *T. turgidum ssp. durum*. The resulting progeny contain diversity on the A and B or D genomes that is readily accessible pre-breeding material in populations known as Nested Association Mapping (NAM) populations (Figure 1).

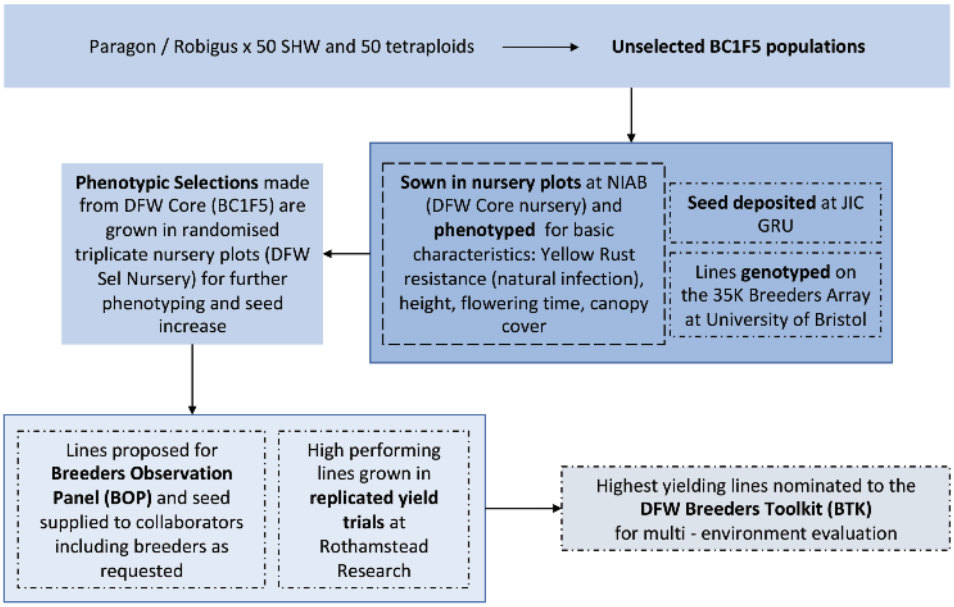
Diversity

The resulting BC1F5 populations are very diverse, with variation in traits including flowering time, height, presence of awns, biomass, ear size, grain size and disease resistance observed in NIAB's pre-breeding nursery plots in the field. Figure 2 shows an example of the variation in ear characteristics in one cross between an emmer wheat (*T. dicoccum*) and Robigus.

The next challenge is to tease out of this diverse collection combinations of traits that are desirable; along with the beneficial traits less useful traits, such as ear shattering and lodging, have also been captured. To offer a sense of scale to this effort 1,250 lines were evaluated in the winter nursery and 1,170 in the spring nursery during the summer 2020. NIAB primarily selects lines that offer potential yield improvements and encourage collaborators from commercial plant breeders and universities to come and look at our material and select lines that they would like to include in their wheat breeding or research programmes. The material is available free of charge under a standard Material Transfer Agreement; this year, 12 collaborators requested a total of 664 lines.

Figure 2. Robigus, Emmer (left and second left) and resulting BC1F5 ears from 2020 field evaluation (four ears on the right)

Figure 3. Evaluation of NIAB DFW material within the DFW project



And that is just the start. NIAB works with DFW partners to help characterise a subset of the most interesting lines (Figure 3). The BC1F5 lines are genotyped and ultimately deposited in the Germplasm Resource Unit at the John Innes Centre. The Breeders' Observation Panel includes lines that may offer new, often high-risk traits such as novel disease resistance. The highest yielding lines enter the Breeder's Toolkit trials, a network of multi-site yield trials at plant breeding companies around the UK and Europe. Early data shows that NIAB's most advanced material offers yields that can exceed the elite wheat parent used to make the backcross.

The lockdown of 2020 failed to stop the wheat growing in NIAB trials, our field evaluations or our outreach events. The DFW team normally engages with NIAB TAG members, industry stakeholders and other interested parties at conferences, on training

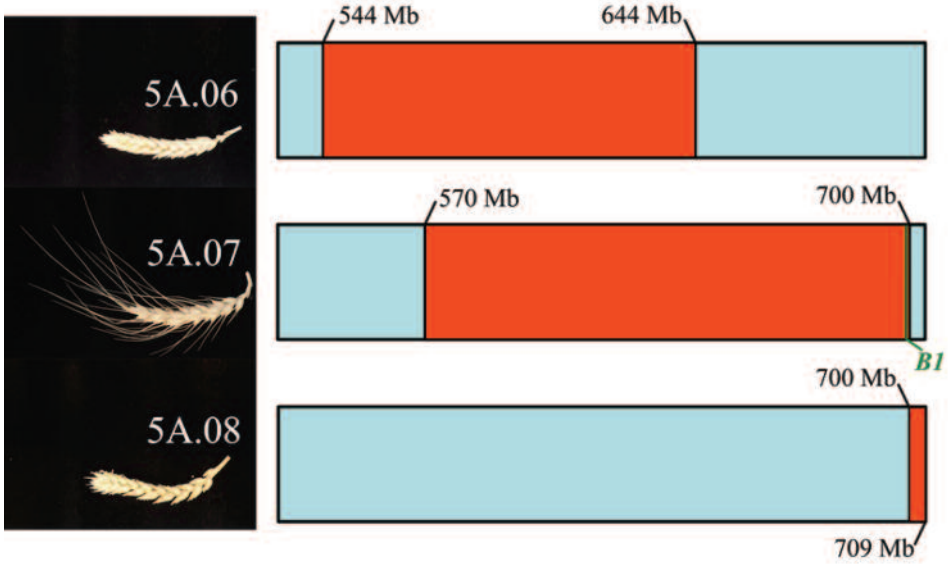
courses and at events such as the DFW and NIAB open days and the Cereals Event. This year we had to adapt and embrace new ways of communicating, including a range of videos hosted on NIAB's Virtual Event Hub and social media platforms (Figure 4).

The DFW project is entering an exciting phase. Now that NIAB has captured this plethora of wheat diversity, how do we explore, characterise and deploy it? Using a combination of bioinformatics, statistical analysis and bespoke populations alongside the diverse NAM populations, we are working to identify and dissect traits of interest. For example, two Chromosome Segment Substitution Line (CSSL) populations have been created, in which the entire genomes of Ttd140 (*T. dicoccoides*, AB genomes) and SHW041 (D genome) have been crossed into Paragon as a series of discrete, tessellated introgressions. The final population was genotyped using the Axiom 35k Breeders SNP Array by the University of Bristol and grown over the summer of 2020. Each introgression is defined by molecular markers, allowing the match of phenotypes to introgressions. In Figure 5, the introgression carrying an awn allele from Ttd140 is present in line 5A.07, but not in the lines containing the neighbouring regions of the Ttd140 genome.

The diverse DFW populations offer a really exciting opportunity to identify traits for climate resilience and disease resistance in wheat. This is a truly collaborative project, and we welcome enquiries from anyone who is interested in working with us. It is also a huge team effort, from the DFW Genetics and Pre-breeding team at NIAB Cambridge, to the DFW partners and collaborators and the NIAB family who manage our trials, publicise our work and support our science.

Figure 4. Richard Horsnell in action; filming a demonstration of the DFW material in the field

Figure 5. AB-CSSL lines containing introgressions from the 5A chromosome from the Ttd140 genome. The segment in line 5A.07 codes for the awned phenotype



Acknowledgements

Fiona Leigh, Richard Horsnell, Tally Wright, Robert Jackson, Alek Ligeza, Keith Gardner and Alison Bentley* are (*were) funded by the BBSRC Cross-Institute Strategic Programme "Designing Future Wheat" BB/P016855/1. The Smart Carbohydrate Centre (BB/E007031/1) was delivered by Fiona Leigh, Ruth Bates and Phil Howell.

Bill Clark • bill.clark@niab.com

The challenges and opportunities of climate change

Putting climate change into perspective for UK farmers and the environment they protect was the focus for the 2020 BCPC Seminar, an annual event organised jointly with The Farmers Club in September, and this year held live online. The specialist panel of speakers explained some of the challenges and, more importantly, detailed the opportunities for UK agriculture in the face of climate change.

2020 BCPC Seminar speakers

- Rebecca Pow MP, Parliamentary Under Secretary of State at Defra,
- Dr Ceris Jones, Climate Change Advisor, NFU
- Professor Steven Penfield, Group Leader, Genes in the Environment, John Innes Centre
- Mark Tucker, Business Development Manager and Head of Agronomy, Yara UK
- Ross Newham, Operations Director, NIAB EMR

Recent Met Office statistics for the UK reveal that the past decade holds eight high-temperature records – and only one low-temperature record. They also confirmed that 2019 was the fifth wettest year on record. As many of us experienced, first-hand, that pattern of high rainfall continued well into the spring of this year. UK agriculture is in the front line of climate change impacts. Unpredictable weather patterns pose big challenges – but climate change can also present some opportunities for some sectors. Defra Minister Rebecca Pow told the audience that the government stands ready to help farmers reduce greenhouse gas emissions and mitigate the impact of climate change. The Government's Agriculture Bill will work alongside its 25-year environment plan and clean growth strategy to continue guiding emissions reductions in the sector, she said.

In June 2019, the UK became the first major economy in the world to set a legally binding target to achieve Net Zero emissions in all sectors by 2050. Although emissions have fallen over the past 30 years, there was still much more to do for the UK to meet its goal, said Ms Pow. "Agriculture is a key sector for both adaptation and mitigation given that farms are on the front line of climate change. Farming livelihoods are especially vulnerable to the increasing variability of temperature and rainfall – as well as to the impact of increasingly frequent extreme weather events."

Ms Pow said that the Government's forthcoming Environmental Land Management scheme (ELMs) would pay farmers to reduce emissions of greenhouse gases and sequester carbon. Land management activities that could be funded included creating and enhancing habitats for wildlife species threatened by climate change. "It is clear that farm businesses, supported by Government, must be proactive about forward planning and future-proofing for a changing climate," highlighted Ms Pow.

Dr Ceris Jones, NFU's Climate Change Advisor was confident that UK agriculture could reach Net Zero by 2040, a full decade ahead of the government's target for the country to end its contribution to global warming. She said the goal would be achieved by balancing a reduction in emissions from farming with agriculture's ability to take carbon out of the atmosphere. It was a national aspiration for the agricultural industry as a whole, not an expectation that each individual farm will reach Net Zero, she explained. The government's forthcoming Environmental Land Management scheme (ELMs) would help farmers deliver the goal, but it was equally important to address productivity.

Three pillars

"Achieving the goal will be based on three pillars – boosting productivity and reducing emissions; carbon sequestration; and a focus on renewable energy and the bioeconomy. Boosting productivity and reducing greenhouse gas emissions is good for farm businesses as well as the environment. When it comes to carbon sequestration, agriculture has a unique ability to store carbon on land – whether in soil, hedges or trees. In addition to planting new woodland, it could be about allowing hedges to grow bigger or bringing back old farm woodland into active management. And some 40% of farmers have already invested in renewable energy projects on their farms – including anaerobic digesters, solar panels and wind power," explained Dr Jones.

Professor Steven Penfield, from the John Innes Centre in Norwich, spoke about the increasingly variable weather patterns posing a big challenge for UK farmers, perhaps much more so than warmer temperatures. This includes important changes in rainfall patterns, with more rain in winter and less in summer. Climate models also predict a decline in autumn and winter frosts.

"Under some emission scenarios, the UK could be looking at winter warming of between 4°C and 7°C, with increases in precipitation of up to 50% in some areas," warned Professor Penfield. "The implications are great but include opportunities as well as threats. A longer growing season could create substantial opportunities especially in the horticultural and soft fruit sectors,

reducing reliance on imports. It also means opportunities for some broad-acre crops like sugar beet. But an expected reduction in overall rainfall in the south of England is a threat, resulting in lower crop yields, including in wheat, in some areas."

That said, Professor Penfield believed the overall outlook for wheat production in the UK is expected to remain favourable throughout this century, even under the most pessimistic scenarios. "But be aware that crop yields are becoming more unpredictable, heightening the need for plant varieties that are more robust and resilient to variable weather," he finished.

Mark Tucker, Business Development Manager and Head of Agronomy at Yara UK, explained how fertiliser manufacturers are investing heavily in carbon-neutral production processes to reduce greenhouse gas emissions and help reach climate change targets.

Abatement technology

The widely-used Haber-Bosch process involves taking nitrogen from the air and combining it with hydrogen to create ammonia, which is subsequently turned into fertiliser. The process is energy intensive, involving high temperatures and pressures and contributes to climate change. But abatement technology can reduce the amount of nitrous oxide emitted, reducing the carbon footprint of the production process by as much as 90%.

"Growers should consider sourcing abated nitrogen fertiliser to help reduce the carbon footprint of their farm businesses. And check the country of origin as the carbon footprint is much lower for ammonia nitrate and urea produced in Europe than the same fertiliser produced using coal-based systems in China and Russia," advised Mr Tucker.

He finished by explaining that Yara's ultimate goal is to achieve carbon neutrality by 2050, largely by producing zero-carbon nitrogen using 'green ammonia'. "Green ammonia is produced by the electrolysis of water and is a carbon-free process that can help meet climate change targets, but will take huge financial investment."

Ross Newham, Operations Director at NIAB EMR, outlined how the horticultural sector is well-placed to help the UK meet climate change targets by ramping up productivity – producing more food using fewer resources. The sustainable intensification of some crops on a smaller land area would have major benefits, freeing up land that could then be used to lock up carbon as well as creating habitats to maintain and increase wildlife.

"Horticulture currently accounts for some 25% of the value of plant-based agriculture in the UK but utilises just 3% of the country's land. The sector has already made great strides in terms of productivity – and this is likely to increase as diets and consumer-demand changes. Science has a key role to play in increasing productivity sustainably too – and increasing the efficiency of 'closed systems' for food production. This includes the breeding of pest and disease resistant varieties, enabling growers to produce food with fewer plant protection products," said Mr Newham.

Last word

The BCPC Seminar highlighted the challenges posed by climate change and the contribution that farmers and researchers can play in the process of climate change reduction and mitigation. Climate change is at the forefront of much of the research carried out at NIAB. We use the knowledge of how genetics, environment and management interact to increase both production and quality, and cope with a more variable and changing climate. Biodiversity protection and enhancement are also key goals, alongside increasing the efficiency of resources, resulting in less waste across the food system. We believe that sustainable and efficient crop production can go hand in hand with action to reduce greenhouse gas emissions, to sequester carbon, and to adapt crop varieties and cropping systems to a changing climate.

Farming occupies a unique position as both a significant contributor to climate change and a major source of solutions to mitigate and reduce its impact. A major driving force in agriculture is the globally increasing demand for food, driven largely by a growing world population and a wealthier population with a higher proportion of meat in their diet. As a consequence of this global food production system, greenhouse gas emissions are increasing at around 1% per annum. The challenge of reducing agricultural emissions is acute because the reductions achievable by changing farming practices are limited and are often in conflict with the increasing demand for food. However, agriculture, more so than any other industry, is uniquely placed to be a part of the solution to climate change as it acts as both a source and a sink for greenhouse gases (GHGs). The UK's agricultural sector is in a position to become the global leader in low-carbon farming technologies.

Videos of all the presentations are available at www.bcpc.org.

Julian Westaway • md@bcpc.org

Online Green Book relaunch

BCPC has relaunched its Online UK Pesticide Guide platform with a host of new features including an easy-to-use product search and comparison tool.

The new-look online version of the widely-used UK Pesticide Guide, affectionally referred to as the 'Green Book', is the practical guide to all pesticides, plant growth regulators and adjuvants that can be legally and effectively used in the UK. The resource is used throughout the agriculture, horticulture, forestry, amenity and pest control sectors and is an essential reference manual for sprayer operators, farmers, park and green-keepers, advisors, agronomists and industry professionals.

Having access to the latest pesticide information is vital for all those involved in their use and application. The UK Pesticide Guide, in both its online and print version, is the one-stop database for all pesticide products approved in the UK, including the latest active ingredient profiles, new products and formulations. The online version has undergone modifications to its look and feel as well as improved functionality to support crop protection decisions, giving users access to in-depth product data, clearly presented for easy reference.

The new comprehensive, flexible, easy-to-use product comparison tool allows users to tailor their search by multiple attributes, which can be filtered and sorted.

For a grower it is a particularly useful tool when buying pesticides, allowing comparison between similar products which, for example, may have different aquatic or arthropod buffer requirements or maximum rates/ha. Users are also able to select products with simpler buffer zone requirements to reduce the complexity of recent pesticide regulations and aid compliance. For others it may save time when planning pesticide use, in accessing product information and safety data sheets or just comparing products.

An annual subscription to the Online UK Pesticide Guide costs only £70 + VAT and is available at www.ukpesticideguide.co.uk. The new platform is optimised for PC and tablet use and regularly updated.

The 2021 UK Pesticide Guide print version, now in its 34th edition, goes on sale in January 2021, and includes a crop-pest index, pesticide profiles, suppliers and distributor contact information, and key information on pesticide use and legislation. The print version is available for £59.50 + P&P, with 50% discount for users with an online subscription. Up to three BASIS points and two NRoSO points are available depending on the purchase option.

Charles Mear, Wood Farm, Waresley

Full circle growing

Charles Mear is a fourth-generation farmer on the Cambridgeshire/Bedfordshire border. Here he keeps almost 28,000 free-range chickens on his 100-hectare farm, with the hens taking up under 30 ha, with and arable cropping the majority of the rest. But on Charles' farm he is continually looking to make the farm more efficient, more sustainable and more environmentally-friendly.

The whole philosophy at Wood Farm is trying to create the first carbon neutral egg. And as part of that, Charles is constantly pushing the boundaries of what is possible on his farm.

Choosing chickens

During the mid-90s, Charles' father was farming the land by himself, so Charles' joined in with a new initiative and the first chickens arrived on the farm in 1996. Back then, free-range eggs made up only 17% of the UK's egg market.

Fast forward to 2009, and Charles, with his wife Jo, started Wood Farm Free Range Eggs to sell direct into the supermarkets. In those days being free-range was almost enough on its own to get into the supermarkets. Nowadays, Charles wants to not only maintain their position in the market, but also do something that sets his eggs, and farm, apart.

As a company they are committed to reducing their impact on the environment. They started with power, so in 2013 installed a 50 kWh solar system. Then in 2014 along came a feed mill, where Charles mills his own as well as locally grown wheat and barley, adds some vitamins, probiotics and enriched natural yeasts to produce food for his chickens. While many farmers run their mill at night when electricity is cheapest, Charles waits for the sunniest days to run his.

By 2016, an Anaerobic Digester was added as well. This is fed by maize and rye grown on the farm and locally. The farm uses about 10% of the electricity generated with the rest being sufficient to run around 340 local houses.

The Wood Farm Free packing unit is on the farm too, meaning that eggs are packed and produced in the same place. But it's the latest installation that's a bit different, as Wood Farm is the first to have its own fully automated insect mini-farm on site.

The first of its kind

Created by start-up company Better Origin, the AI-powered mini-farm was installed in early 2020. The aim is to produce black soldier fly larvae onsite, which can be fed to the chickens. The insect farm is a converted shipping container where trays of the larvae are fed by-products and waste wheat, before they themselves are then fed to the chickens.

Initially a trial, the idea was to offset around 5% of the soy used in Wood Farm's feed, while seeing how the birds reacted.

Trial success

Charles' hens seem to like their new feed. Now they're feeding an entire hen shed with the black soldier fly larvae alongside continual data collection for Better Origin. Who, of course, hope to roll out more of these insect farms to chicken farmers across the country.

But the best thing about the new food source is the improvements in the chickens' gut-health. This is something taken very seriously at Wood Farm: "We're trying to create the perfect environment for gut bacteria to thrive. The insect larvae feed is very much part of that." says Charles. During the trial, the gut biome was measured as incredibly healthy and there are now plans to feed some of larvae with good bacteria.

Wood Farm has been medicine-free for four years, which Charles puts down to using different natural yeast probiotics in the feed.

Next steps?

The chickens are not the only ones who can benefit from the insect larvae. Having just received a LEADER grant (an EU programme aimed at providing grants for rural development in local areas), Charles is now using the heat from the Combined Heat and Power on the Anaerobic Digester plant to dry chicken manure and turn it into pellets for use in gardens and growing medium. This led to the latest venture from the farm: Full Circle Growing, creating bio-mulch, soil conditioner, liquid bio-plant feed and soil conditioner/chicken manure

blended pellets. These peat- and chemical-free products are available to gardeners to buy.

Of course there is a risk in everything Charles does at Wood Farm in his efforts to diversify, become more sustainable and adopt new technology. Before we even talk of the effects of Covid-19 and now bird flu restrictions, he's had to deal with a lot of changing goal posts. His advice for anyone thinking of going down the same route is do your homework: "When looking to invest in new technology companies make sure the companies you work with are sound. Check out previous projects, are they financially viable? Don't just jump straight in. Check out the other payments too, such as digressions of tariffs etc – are they about to change?".

Anaerobic digester

New digestate products

Black soldier fly larvae

SME support at NIAB

Better Origin started out on its commercial life at the Eastern Agritech Innovation Hub near Soham in Cambridgeshire. Led by NIAB, working with a network of farming businesses, the Hub enables SME producers, researchers and waste users to collaborate in developing commercial approaches to waste reduction and management; linking small-scale research to business operations.

Better Origin was one of the first start-ups to benefit from NIAB's expertise at the Hub. Founder and CEO Fotis Fotiadis explains that:

"The Innovation Hub was the perfect place to start and develop the business. In fact, the site has been excellent for agribusinesses to kick start their journey with laboratory and prototyping space readily available. The wealth of knowledge and support from experienced NIAB staff was very useful for guidance and training in those early days. The site has become a popular venue for networking and events within the local agricultural community, and offers the chance for startups and SMEs to connect with influential growers, retailers and academics."

Along with the Eastern Agritech Innovation Hub, NIAB is opening a similar initiative at its Park Farm sire in early 2021. Barn4 opens its doors to SMEs next year supporting agritech innovation, start-up companies and new thinking on solutions to food and farming challenges. If you, or someone you know would benefit from this, please contact the Barn4 team at contact@barn4.com.

For more info see: innovationhub.co.uk or barn4.com

For more on Better Origin visit betterorigin.co.uk.

ARTIS NIAB Technical training courses

2021 Classroom Courses

11 February	**Advanced nutrient management for combinable crops** • Trained by Stuart Knight • NIAB Park Farm, Cambridge
16 February	**Developing your strategy to manage healthy soils for sustainable production** Trained by Elizabeth Stockdale • Reaseheath College, Cheshire
17 February	**Best practice in water management and irrigation** • Trained by Mark Stalham • NIAB Park Farm, Cambridge
3 March	**Optimising crop management of leafy salads** • Trained by Liz Johnson • Mulberry Room, NIAB HQ, Cambridge
3 March	**Understanding potato growth stages and scheduling irrigation to optimise yield and quality in potatoes** Trained by Mark Stalham • NIAB Park Farm, Cambridge
4 March	**Understanding and optimising potato nutrition and improving potato yields and profitability by measuring and monitoring performance** • Trained by Marc Allison • NIAB Park Farm, Cambridge

To see how we are keeping you safe on our courses and our flexible booking policies visit www.artistraining.com and click the Covid-19 button.

2021 Virtual Courses

19 January	**Advanced crop management of bulb onions** • Trained by Andy Richardson
4 February	**Essentials of good soil management** • Trained by Elizabeth Stockdale
9 & 10 February	**Benefits of cover crops in arable systems** • Trained by Nathan Morris Course split over two 3 hour morning sessions
10 February	**Advanced crop management of vegetable brassicas** • Trained by Andy Richardson
23 February	**Using an integrated approach to weed management in arable crops** • Trained by John Cussans
25 February	**Better control and avoidance of disease in wheat** • Trained by Bill Clark and Aoife O'Driscoll

e-learning

Nematicide Stewardship Programme (NSP) • The NSP Protocol is now an audited part of the Red Tractor Standard for potatoes, carrots, parsnips and sugar beet. Complete the FREE online training modules to obtain your certificate and prove your compliance.

Register your interest

We are still in the process of organising some of our courses. Please visit www.artistraining.com to register your interest for a course or join our mailing list for regular updates.

01223 342444 info@artistraining.com @ARTIStraining artistraining.com

NIAB TAG

Lawrence Weaver Road
Cambridge CB3 0LE

T: 01223 342495
E: info@niab.com
www.niab.com
@niabgroup

NIAB TAG Contacts

Andrew Watson (East)
07768 143730

Patrick Stephenson (North)
07973 537427

Richard Overthrow (West)
07974 391724

Poppy de Pass (West)
07900 166784

Syed Shah (South)
07714 081662

Steve Cook (South)
07775 923025

Keith Truett (South-east)
07818 522763

Cambridge • 01223 342200
Hannah Parish and Sue Mann

Morley • 01953 713200
Christopher (Chris) Whyles

East Malling • 01732 843833
Lorenzo Borleanu

Sutton Scotney • 01962 761166
Katie Simmonds

Cirencester • 07900 166784
Poppy de Pass

Wimborne • 07850 511449
Ivan Brain

Newton Abbot • 01626 833399
Mark Wavish

Hereford • 07866 448933
Mike Perry

Telford • 07725 544331
Cathy Johnson

Headley Hall • 01937 832798
Jake Wild

Benniworth • 01507 313960
Hayley Rhodes

Kirton • 01205 724472
Shaun Coleman

When contacting by email, please use **forename.surname@niab.com**

FSC

Printed on 100% recycled, totally chlorine free fibre. This paper is totally recyclable and bio-degradable. NAPM recycled certification.

Edited and published by NIAB TAG. Designed and produced by Cambridge Marketing Limited, 01638 724100