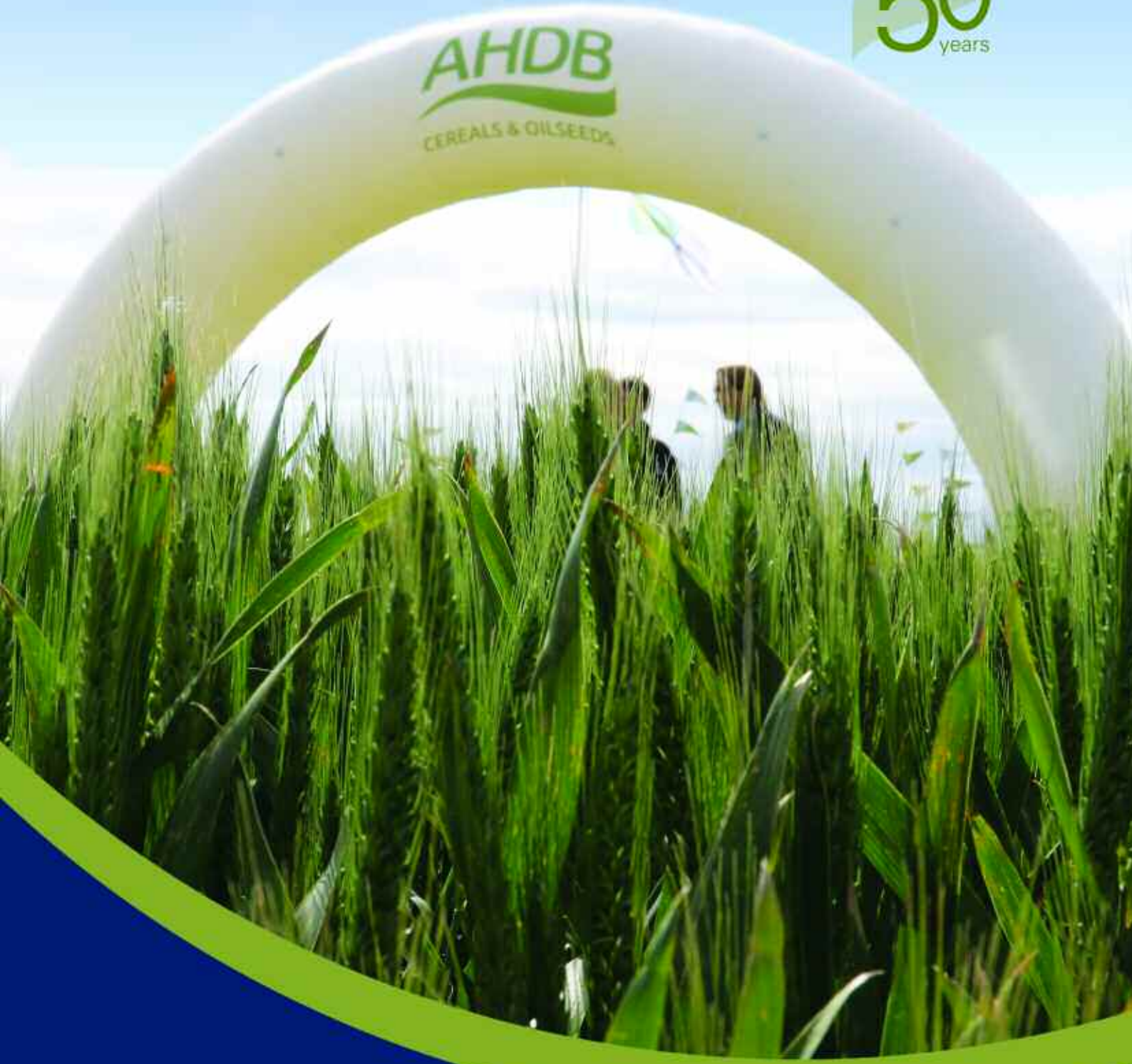
theory to field

a celebration of 50 years of research for growers

Celebrating 50 years



cpm

A *CPM* publication in association with AHDB Cereals and Oilseeds

AHDB
CEREALS & OILSEEDS

cpm theory to field AHDB CEREALS & OILSEEDS

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Has farming really changed?

The 1960s must have been a pretty awesome time to grow crops.

Following the war, there was a huge government-led push to step up production. The fruits of publicly funded advances in technology were making their way on to farms and growers who harnessed them were beginning to realise the immense potential of these crop and crop protection innovations for productivity.

Into that heady mix of innovation and progress, the levy-funded body we now know as AHDB Cereals and Oilseeds was born in 1965. Its focus then, as it is now, according to its recently published Research and Knowledge Exchange Strategy, was to ensure a competitive crop sector through factual, evidence-based advice, information and activity.

For me, that AHDB badge means something, and I reckon I'm not alone. Both as a farmer and a journalist, when I'm told something about a new product, an exciting opportunity or interesting practice, my first instinct is to ask "says who?", and you can't deny that if there's an AHDB moniker sitting behind that claim, your interest is piqued — if it wasn't, you probably wouldn't be reading this now.

So that's why, when AHDB suggested a supplement that captured some of high points of research over the past 50 years and looked at the challenges ahead, *CPM* leapt at the opportunity.

What we've done is to look at three key areas of AHDB activity — improving business opportunities, preparing the industry and informing on-farm decisions. So on the grain markets, for example, what prompted the rise and fall of barley, and where are things going with oilseed rape (page 3)?

What lay behind the big breeding advances of the past, and are we on the cusp of a new Green Revolution (p4)? And how has the industry dealt with the growing problem of resistance, and what challenges lie ahead (p6)?

Today, the farming industry presents a very different landscape to the one growers faced 50 years ago — markets were protected and UK-focused, semi-dwarf varieties hadn't been introduced and pesticides were barely used, let alone overused. But I'd argue the growers who made the most of the opportunities then have the same qualities as the progressive growers of today — a pragmatic approach to trying something new, the yearning to understand more about their resources, and the care and attention to monitor progress.

And they know where to go for information they trust. So if that describes you, we reckon there'll be a fair bit within these eight pages that'll pique your interest.

Tom Allen-Stevens has a 170ha arable farm in Oxon, which in 1965 was a mainly dairy farm, moving out of Shorthorns – actually, quite a change.
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Seeing through the swings

> *"It's not just about reporting on the market, but supplying growers the information they need to interpret what they're seeing."*

Behind the rise and fall of the grain market lies long-term cropping trends. *CPM* looks back over 50 years of market movements to assess where it may be going.

By Tom Allen-Stevens

November 1965 — as Rhodesia moved towards independence, oil markets became jittery, strong world demand for wheat triggered a price recovery and a thick blanket of snow fell across the UK, heralding an unusually sharp pre-Christmas cold snap.

Meanwhile, UK agriculture was enjoying the fruits of significant post-war public investment to increase productivity. Direct price support was scaling back, but deficiency payments and market management protected growers from the harshness of the world grain markets in the pre-CAP era.

"In the post-war agricultural landscape, yields grew as a result of big advances in crop protection," notes Helen Plant from AHDB Market Intelligence. "Cropping changes were more economical and demand-led, spurred on by government policy to become more self-sufficient."

Perhaps the most notable sign in cereal usage of increasing on-farm technology was a sharp decline in oats. "This was due to the drop in the horse population as tractors replaced them for field work. It's interesting that oats are now enjoying a revival — demand has picked up in the past couple of years as consumers have become more aware of the health benefits of porridge."

As oats declined, the barley area almost doubled. "This was almost certainly down to better varieties and agronomy. In the 1980s, wheat yields started to stretch above other crops as new varieties were introduced (see Germplasm Journey on p4) and this growth continued right until the 2000s," notes Helen Plant.

The introduction of good quality wheats meant millers could reduce their reliance on Canadian imports. "The UK shifted from being a net importer of wheat to a net exporter, and that in turn shifted the type of quality wheats that were grown — soft wheats suitable for export, became a farm favourite."

In more recent years, the most dramatic development has been the influence of oilseed rape. "The crop became more widely grown in the early 1980s, again as a result of variety developments. But it was the policy shift of the early 1990s that saw the area take off — the new Arable Area Payments Scheme favoured oilseeds," she points out.

The market for the crop has been something of a chicken-and-egg situation, notes AHDB policy and research manager Harley Stoddart. "OSR came in as a break crop and then a market developed around it."

But it fits well with current consumer tastes. "Rapeseed oil ticks all the right boxes — it cooks at a higher temperature than olive oil, is low in saturated fat and there's no bitter after taste. HOLL oil is even better and opens up further market opportunities. And let's not forget 70% of European rapeseed goes for biofuel."

This market's under threat, however. Currently, fuel derived from crops must have 35% lower total greenhouse gas emissions than fossil fuel to qualify as biofuel under the Renewable Energy Directive.

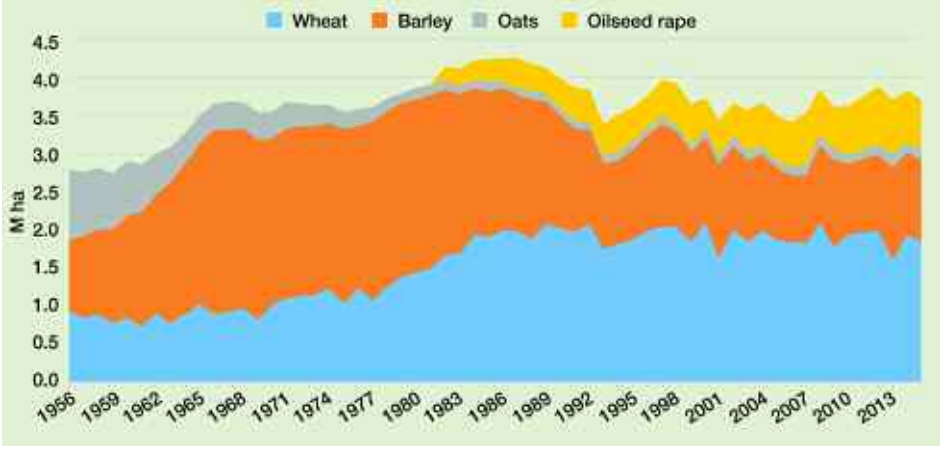
"UK rapeseed just scraped through when the use of regional reporting was introduced in 2013. But the target rises to 50% on 1 Jan 2017. That may adversely affect the crop that's already in the ground at that point," says Harley Stoddart.

So the future for OSR will depend on a grower's ability to grow it well, he predicts. "Pest and disease pressure is such that ironically the crop that came in as a break now needs its own break. The global market for rapeseed will always be there — it will consume as much as growers produce — but at what cost, and at what cost can it be grown?"

For Helen Plant, future cropping changes will be focused on what happens across the whole rotation, rather than individual crops. "One notable aspect of the global market is that we're increasingly seeing feed grains covered off by maize. The food grain market is starting to split away from feed and move independently. It puts an interesting light on UK wheat with the recent move into varieties with quality potential."

That said, the grain market is notoriously difficult to predict and increasingly volatile, she notes, and that's altered the role of the AHDB MI team. "It's not just about reporting on the market, but supplying growers the information they need to interpret what they're seeing. You'll always need a grain merchant to sell your grain, but we're here as a sounding board and impartial reference point." ■

UK arable area



Source: Defra

Germplasm journey

While the Recommended Lists represent the most significant part of AHDB Cereals and Oilseeds activity on varieties, the lifeblood of new lines lies in breeding and pre-breeding research. *CPM* tracks its history and prospects.

By Tom Allen-Stevens

It must have been an odd sight when Dr Francis Lupton arrived for work each morning at the Plant Breeding Institute (PBI) at Trumpington, Cambs: despite standing well over six feet tall, he insisted on driving a Mini.

But it was his work with John Bingham in reducing the height of UK wheat that may have been one of the biggest breeding breakthroughs in its history. "The semi-dwarf varieties were a real quantum step in terms of plant breeding," notes Dr Penny Maplestone of the British Society of Plant Breeders (BSPB).

"By changing the distribution of plant material from the straw and leaf to the grain, they brought about a 20% yield increase for growers, so the work really established the PBI as a centre of excellence for UK breeding. The great attribute the institute had was that it spanned the wheat research spectrum from fundamental science through to finished varieties."

Independent wheat breeding consultant Bill Angus worked in John Bingham's team at PBI. "John Bingham led the market-driven wheat-breeding programme while Francis Lupton worked more in the background developing the material. Together they changed the model of wheat-breeding and brought about a new era of 10t/ha yields," he says.

> *"The main goal isn't to gain intellectual property but to address the science towards pre-competitive industry challenges."*

Semi-dwarfs were far from new, however. The material originated in Japan, was brought over to America in the 1950s and was developed at the International Maize and Wheat Improvement Center (CIMMYT) by Norman Borlaug in Mexico — the start of the 'Green Revolution'. "The PBI didn't get its hands on semi-dwarfs until the early 1960s, but they had to be adapted to the UK climate," explains Bill Angus.

"Some breeders said it was a waste of time, but Francis Lupton soldiered on and developed the genetics, and eventually Hobbit, the first true semi-dwarf, arrived on the scene in 1973."

John Bingham's skill was in spotting the opportunity and he developed the trait into a series of varieties that enjoyed remarkable commercial success. Virtue, Longbow, Galahad and Norman, for example, which appeared in 1981, were the first semi-dwarf varieties to be widely grown across the UK.

Capable talent

Public funds supported the PBI and it grew in size and prominence, spear-heading both pre-breeding research and commercial development of lines across a range of crops. By the mid-1980s there were over 200 staff and it drew in the most capable UK breeding and scientific talent as well as visiting research students. Of 14 wheat varieties on the 1989 Recommended List, 11 were bred by the PBI.

But it was privatised in 1987 and its influence declined. "It had effectively been a government monopoly," notes Bill Angus. "The work on semi-dwarfs and milling wheats was brilliant as was the supporting departmental work on crop physiology and pathology. But there was fairly modest innovation in terms of introgressing new traits — too much of the research was on supporting the breeding rather than taking it a step further."

For Penny Maplestone, however, a chasm then opened up in breeding research. "After the demise of the PBI there was a rather dark period. Varieties progressed in commercial lines and fundamental research continued, but something had to be done to link the two."

The commercial return for breeders was secured when the Plant Royalty Bureau, the pre-cursor to BSPB, was set up in 1966 to gather royalties from the industry. It was further strengthened when royalties on farm-saved seed were introduced in 1996 and today these provide £10M of the £35M total royalties collected by BSPB for breeders.

"It's a level of funding that secures the development of new varieties and ensures the AHDB Cereals and Oilseeds Recommended List average wheat yield progresses at a rate of around 0.5% per year, for example. But it's not enough to fund more strategic research, and breeders must work in partnership with academics through private/public partnership to achieve this."

The LINK programme of agricultural research started in the mid 1990s and as its name suggests, restored this. Commercial interests, including breeders and AHDB, would contribute towards large, government-funded projects and help steer their direction. The development of orange wheat-blossom midge (OWBM) resistance, through a project that ended in 2001, was a particular milestone, recalls Penny Maplestone.

"It meant an insecticide spray could be replaced by good plant genetics, and this benefitted the industry as a whole, rather than one particular breeder. The resistance gene was identified through the collaboration and the commercial partners in the project introduced it to the market through their varieties, making it available to all breeders.

"It was a club arrangement that worked well, securing a commercial outlet for worthy public-funded research but with breeders working together for relatively little cost in a pre-competitive research arena."

The model has continued through various iterations, and today a key pre-breeding research programme is the BBSRC Crop Improvement Research Club (CIRC)."

"It's a relatively small investment for us of just £10,000/year," notes Dr Ellie Marshall of AHDB — one of the club members. "But it gives us access to a programme with total funding of over £7M across 15 projects.

"It also gives CIRC members the opportunity to influence the selection and progress of those projects to ensure some really useful outcomes for growers and processors."

BBSRC is the primary source of funding, with £500,000 provided by The Scottish Government and industry contributing a further £560,000 to the club. End

Work carried out at PBI changed the model of wheat-breeding, says Bill Angus.

users are represented by the likes of the Scotch Whisky Research Institute and nabim, who sit alongside the main UK breeders and AHDB. They steer the projects conducted across 13 research institutions.

"The projects will always have an emphasis on delivering yield, but there are issues of quality, pest and disease resistance, and agronomy they also address. So there's a balance of trying to overcome environmental challenges as well as maintaining crop performance," she continues.

Work developing resistance to turnip yellows virus (TuYV) is a prime example. "The loss of neonicotinoids has brought TuYV forward as a key priority in oilseed rape. The project is now close to delivering a genetic toolkit all breeders will be able to use so the industry no longer has to rely on crop protection products," she points out.

Co-ordinating the projects is Dr Simon Bright. "They're now at an exciting point," he enthuses. "The main goal isn't to gain intellectual property but to address the science towards pre-competitive industry challenges."

The model for all the projects is that they must be high quality inventive science, pointed at a specific problem, he explains. "I have to admit that some of the projects we're supporting I thought at first were a long shot, but they're delivering results."

One example is a project between Essex University and Rothamsted Research, led by Prof Martin Parry, manipulating the photosynthetic carbon metabolism in wheat. "The perception has been that yield is sink-limited, so a whole generation of crop science has largely ignored photosynthesis. This project has looked again at the biochemistry turning carbon dioxide into yield," explains Simon Bright.

What the research team did was to use GM techniques to increase a key enzyme in wheat to get a step-up in photosynthetic ability. "The first plants in the greenhouse look bigger and work harder to produce yield," he continues.

"It's a GM technique, so can't be used in the field at the moment, but it looks like we're fishing in the right pool to increase biomass, whereas before this was just academic speculation. The project finishes in early 2016, but has attracted fresh international funding so it will continue.

"There's also a whole suite of projects around roots which may have a big impact on varieties — this science is really pushing the boundaries."

Work at the University of Nottingham, led by Dr Martin Broadley, for example, has developed rapid root-phenotyping screens for arable crops. "Just as breeders look for traits in the plant above ground, this screening methodology identifies what's going on beneath the soil surface," says Simon Bright.

After the demise of PBI, there was a perception the link between breeding and pre-breeding research had been cut.

The research team used GM techniques to increase a key enzyme in wheat to get a step-up in photosynthetic ability.

"Lab results have now been confirmed in the field, so it's opened a whole new area of breeding for root architecture."

Ten of the projects have associated PhD studentships, he points out. "The great thing about the club is the close involvement with industry — these students get to know people in leading commercial companies, which builds lasting relationships. For BBSRC it's getting cutting-edge science out into the field."

Breeders agree it's a formula that's working. "Breeding research is in a much better place now," comments Bill Angus. "There's a very positive relationship between the private and public sectors, so there's every reason to be upbeat about the varieties we'll see appearing in UK fields in years to come." ■

Web window

www.plantbreedingmatters.com – more on how plant breeding has shaped cropping, food and the environment.
www.bbsrc.ac.uk/circ – full details of CIRC and its projects.

Iconic wheats – milestone varieties of the past 50 years

- **1973** – **Maris Huntsman** – changed the model of higher-yielding wheats, and finally replaced Cappelle Desprez that had been on the RL since 1953.
- **1977** – **Hobbit** – the first true semi-dwarf which heralded the start of a new era of high yielding varieties from PBI.
- **1980** – **Avalon** – the first of the semi-dwarf good bread-makers, allowing less reliance on Canadian imported wheat.
- **1983** – **Galahad** – one of the first modern biscuit wheats and, with Norman and Longbow, opened up the soft milling and valuable export markets.
- **1986** – **Slejpner** – set new standards in high-yielding, short-strawed hard feed wheat, with a good specific weight, and also a private-sector challenge to PBI's market dominance.
- **1988** – **Mercia** – took over from Avalon and at one time had 26% of the UK wheat-growing area.
- **1989** – **Riband** – forged a new strategy for high input, high output wheats – with a stiffness score of 9, it responded well to high N and fungicide inputs.
- **1991** – **Hereward** – quickly became a miller's favourite and stayed on the RL until 2011.
- **1993** – **Brigadier** – eclipsed Riband and took 25% of the wheat area, with an initially robust disease profile, before changes in yellow rust populations.
- **1999** – **Claire** – became a firm favourite with farmers, along with Consort. Good for biscuits and sowing early, it extended the drilling window as farms got bigger. Still on the RL, no other UK wheat variety has earned more in royalties.
- **2003** – **Robigus** – the first popular variety with OWBM resistance, combined with a good agronomic package and high yield potential.
- **2011** – **KWS Santiago** – set new standards for yield potential of a high input, high output feed wheat.

KWS Santiago set new standards for yield potential of a high input, high output feed wheat.

- **2014** – **Skyfall** – a milling wheat with feed wheat yield potential, it captured growers' interest with its good agronomy, as well as OWBM and eyespot resistance.

Note: views on varieties expressed by Bill Angus

Don't lose your RAG

Arguably the unsung heroes in the fight against resistance, the industry-wide action groups bring together experts to agree how best to keep current crop protection measures effective. *CPM* reports.

By Tom Allen-Stevens

When Dr Stephen Moss arrived at a field in Lincs to sample some blackgrass in 1990, the comments made by an industry representative he met there rang in his ears and have done ever since. "It's a waste of time spending taxpayers' money on research into resistance because it's such a minor problem," the man said.

The first case of resistant blackgrass was confirmed in 1982 and the number of farms affected rose throughout the 1980s as scientific understanding of the nature and scale of the problem developed. But the biggest barrier to addressing it at the time was perception, recalls Stephen Moss.

"Resistance was a bit of a taboo subject. There was a view that herbicide resistance was the least likely cause of herbicide failure in the field. That may have been true, but it made it difficult to ensure growers were aware of the issue, let alone agree sound practical advice on how to deal with it."

So moves were made towards forming an independent group. "There was already the Herbicide Resistance Advisory Committee (HRAC), but this was an industry group. We wanted a forum where independent researchers could debate issues and agree common goals with industry representatives."

Practical understanding

In 1989, the Weed Resistance Action Group (WRAG) was set up with Stephen Moss as its first secretary and Long Ashton Research Station colleague Dr George Cussans as chairman. "WRAG was George's idea and he was a very effective chairman — he had the breadth of knowledge and practical understanding of the issues, but also understood the industry point of view," notes Stephen Moss.

Just how much of an impact weed resistance would have on UK farming was the subject of much debate at the first meeting, he recalls. "I would have been crucified if I'd suggested then that 20,000 farms would one day be affected."

But crucially there was some common ground, and enough consensus within the group to issue guidelines on how to manage resistant populations. The first of these was published in 1991, and have been updated six times since, most recently in 2014. They form a notable, key achievement of WRAG.

Another important step was to establish resistance ratings for blackgrass. A resistance test methodology was developed and WRAG agreed how results would be presented — in four categories from S (susceptible) through to RRR (highly resistant).

Stephen Moss recalls that resistance was a bit of a taboo subject.

> *"There's no other forum that comes up with a pragmatic solution and sensible middle ground."*

"The UK is the only country in the world to have industry-wide agreement on how to rate weed resistance," notes Stephen Moss.

But getting consensus and wording agreed by all the diverse members on the group was just one of the arduous challenges it faced. WRAG has no funding nor independent means of income, points out current chairman James Clarke.

"Organisations such as AHDB have contributed funding for publications. Industry-wide support has been fundamental to the success of WRAG, where possible in partnership with government and industry. It's also funded research and knowledge exchange activities."

The communication of agreed strategies to avoid resistance and manage resistant populations remains a core objective of the group. WRAG's scope covers other grassweeds, such as wild oats and ryegrass, as well as broadleaf weeds, especially poppies, chickweed and mayweed. The guidance must respond to changing populations and evolve as farms get bigger and cropping changes, explains James Clarke. It must also respond to regulatory developments.

"WRAG's also there to pro-actively highlight emerging threats. Perhaps the most significant potential problem the industry faces today is glyphosate resistance. It's not yet been identified in any UK field, but historically, growers haven't taken action on weed resistance until they've found a problem on their farm — in this case, that'll be too late."

With weeds there's a key imperative that incentivises growers to take action — resistance is usually a consequence of your own management and results in a problem in your field. That's not necessarily the case with fungicides, however, notes Dr Fiona Burnett who chairs the Fungicide Resistance Action Group (FRAG).

"Diseases blow in the wind, so people struggle to see resistance as their problem. That means the industry must address it in a different way."

Resistance to fungicides was first identified in the mid 1980s. Systemic fungicides had been introduced in the previous decade, and as their use became widespread, growers and agronomists started to notice problems. "Mildew was one of the first diseases to flip," she recalls.

"In the UK, researchers have always had quite a close bond with industry contacts when it comes to disease control. What we needed was a forum to debate the issues where views differ, such as the use of mixtures and frequency and rates of individual actives."

So FRAG was set up in 1995, along the same lines as WRAG. "Our main goal has been to establish consistent messages — it's hard enough to get growers to engage on the issue of fungicide resistance, but a lost cause if the industry gives out mixed messages. So FRAG puts forward a rational view, based on evidence — there's no other forum that comes up with a pragmatic solution and sensible middle ground."

The introduction of strobilurin fungicides, and the resistance in mildew and septoria that subsequently developed, proved a key early lesson. "I'd like to think the industry has moved a large step forward in its approach with SDHIs — they were introduced in mixtures and with label restrictions on the number of applications. Now they're available as straights, so exposed to the same thorny issues."

Good science

The guidelines for SDHIs were not reached lightly, she stresses, and were based on good science. In France, growers are restricted to just one application per crop, for example, but the group felt there wasn't enough evidence to show this would have a significant advantage. But if SDHI seed treatments with foliar activity were launched, these would be considered to count as one application.

"It does mean we rely on good science, and since this is an area where commercial companies have a vested interest, public money is best for research into resistance. AHDB involvement has been valuable, although there's a limit to how far levy funds will stretch. It has proven effective at getting consistent messages out to growers and agronomists, however," notes Fiona Burnett.

But a key achievement for FRAG has been the involvement of CRD, she believes. "They've been very open to the arguments presented, and this shows in the moderate approach they take towards regulation. It's down to the balance of industry and independent representation they're exposed to, and I don't think they'd get that balance if it wasn't for the RAGs."

Sometimes changes in regulation and the nature of a crop threat conspire to alter the resistance landscape to a considerable degree in a short space of time. A good example is the recent withdrawal of neonicotinoids as seed treatments on oilseed rape and the discovery of cabbage stem flea beetle (CSFB) resistant to pyrethroids.

Diseases blow in the wind, points out Fiona Burnett, so people struggle to see resistance as their problem.

"Many samples we tested this year were resistant, although they were often sent in as a result of situations where resistance was suspected," reports Dr Steve Foster of Rothamsted Research, who chairs the Insect Resistance Action Group (IRAG), set up in 1997.

"The interesting aspect is that DNA testing revealed some beetles weren't showing kdr (knock-down resistance) to pyrethroids, and yet they survived treatment. So we think there's another mechanism involved, such as enhanced metabolism resistance (EMR)."

When there's a rapidly evolving picture on resistance, it's crucial that consistent messages on how CSFB is controlled are relayed to growers, he says. "That's where IRAG comes in. The agreed course of action for growers is to apply pyrethroids only where there is evidence of high pest pressure at emergence or if thresholds are exceeded post emergence. Use full recommended field rates and if control is poor, don't make repeat applications," he advises.

AHDB has played a vital role in gathering sound data and relaying this information, he adds. "The initial work on investigating pyrethroid resistance in CSFB populations and developing a PCR-based assay for detecting turnip yellows virus in aphids was funded by AHDB and they've continued to collect data of populations throughout the seasons — IRAG relies on this to make sound judgement calls. AHDB also plays a crucial role in relaying the information to growers and agronomists." ■

Some CSFB weren't showing kdr to pyrethroids, and yet they survived treatment.

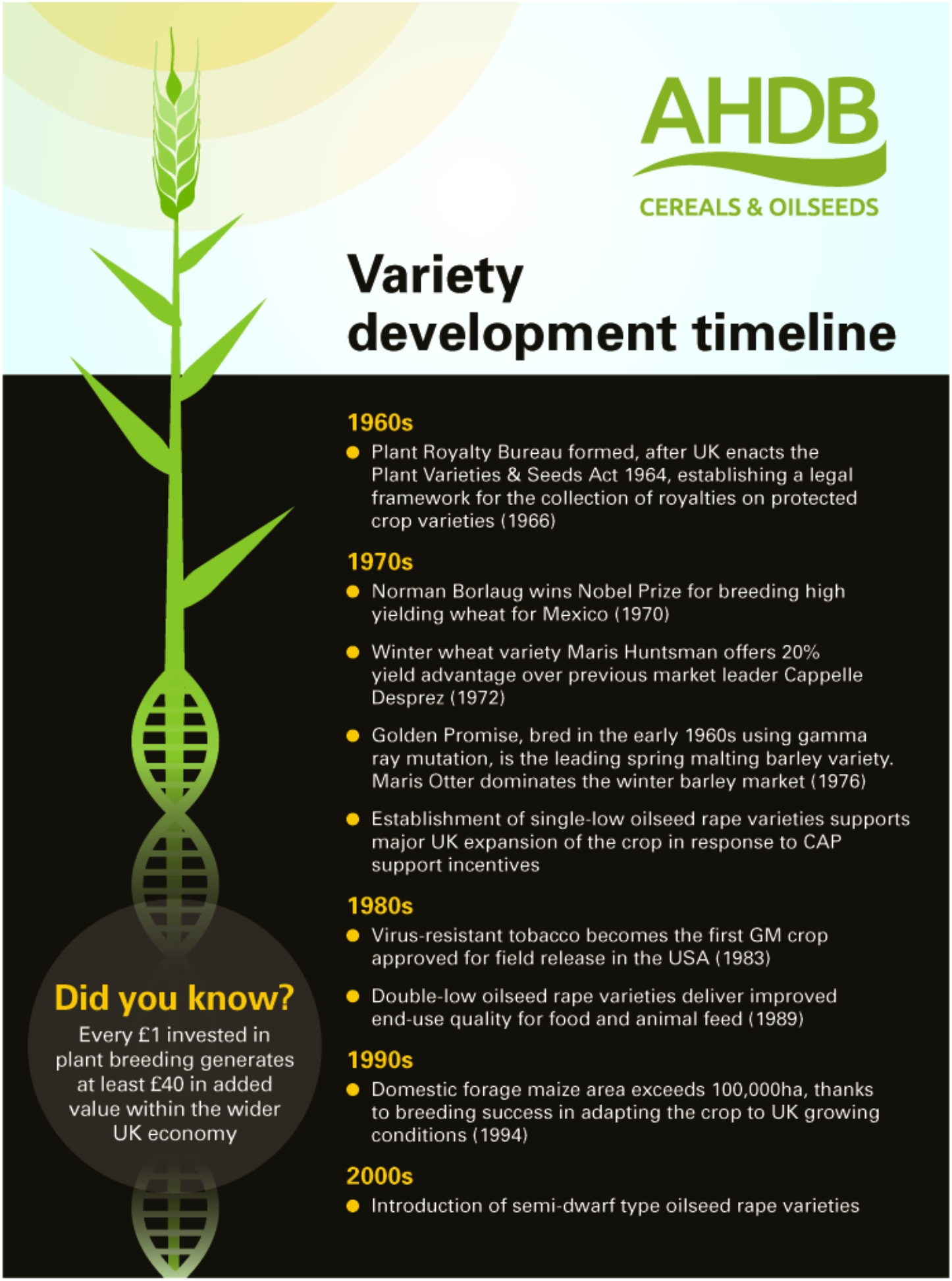
Using a RAG to polish pesticide performance

Notable achievements

- Getting industry-wide consensus and publishing guidelines based on a robust evidence base
- Agreeing and communicating consistent messages
- Rapid identification of emerging problems
- Agreement on test methodologies and interpretation.

Future challenges

- Encouraging growers and agronomists to pro-actively engage in resistance management before problems occur
- Getting consideration and adoption of alternative approaches that reduce the pressure on pesticides
- Securing independent or joint funding to make fully evidenced and long-term decisions on optimum strategies
- Retaining sufficient diversity of modes of action to enable effective resistance management and provide cost-effective crop protection.



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Variety development timeline

1960s

- Plant Royalty Bureau formed, after UK enacts the Plant Varieties & Seeds Act 1964, establishing a legal framework for the collection of royalties on protected crop varieties (1966)

1970s

- Norman Borlaug wins Nobel Prize for breeding high yielding wheat for Mexico (1970)
- Winter wheat variety Maris Huntsman offers 20% yield advantage over previous market leader Cappelle Desprez (1972)
- Golden Promise, bred in the early 1960s using gamma ray mutation, is the leading spring malting barley variety. Maris Otter dominates the winter barley market (1976)
- Establishment of single-low oilseed rape varieties supports major UK expansion of the crop in response to CAP support incentives

1980s

- Virus-resistant tobacco becomes the first GM crop approved for field release in the USA (1983)
- Double-low oilseed rape varieties deliver improved end-use quality for food and animal feed (1989)

1990s

- Domestic forage maize area exceeds 100,000ha, thanks to breeding success in adapting the crop to UK growing conditions (1994)

2000s

- Introduction of semi-dwarf type oilseed rape varieties

Did you know?

Every £1 invested in plant breeding generates at least £40 in added value within the wider UK economy

Selected developments shown. For the full animated timeline, visit cereals.ahdb.org.uk/genetics

BSPB
promoting innovation

Celebrating 50 years