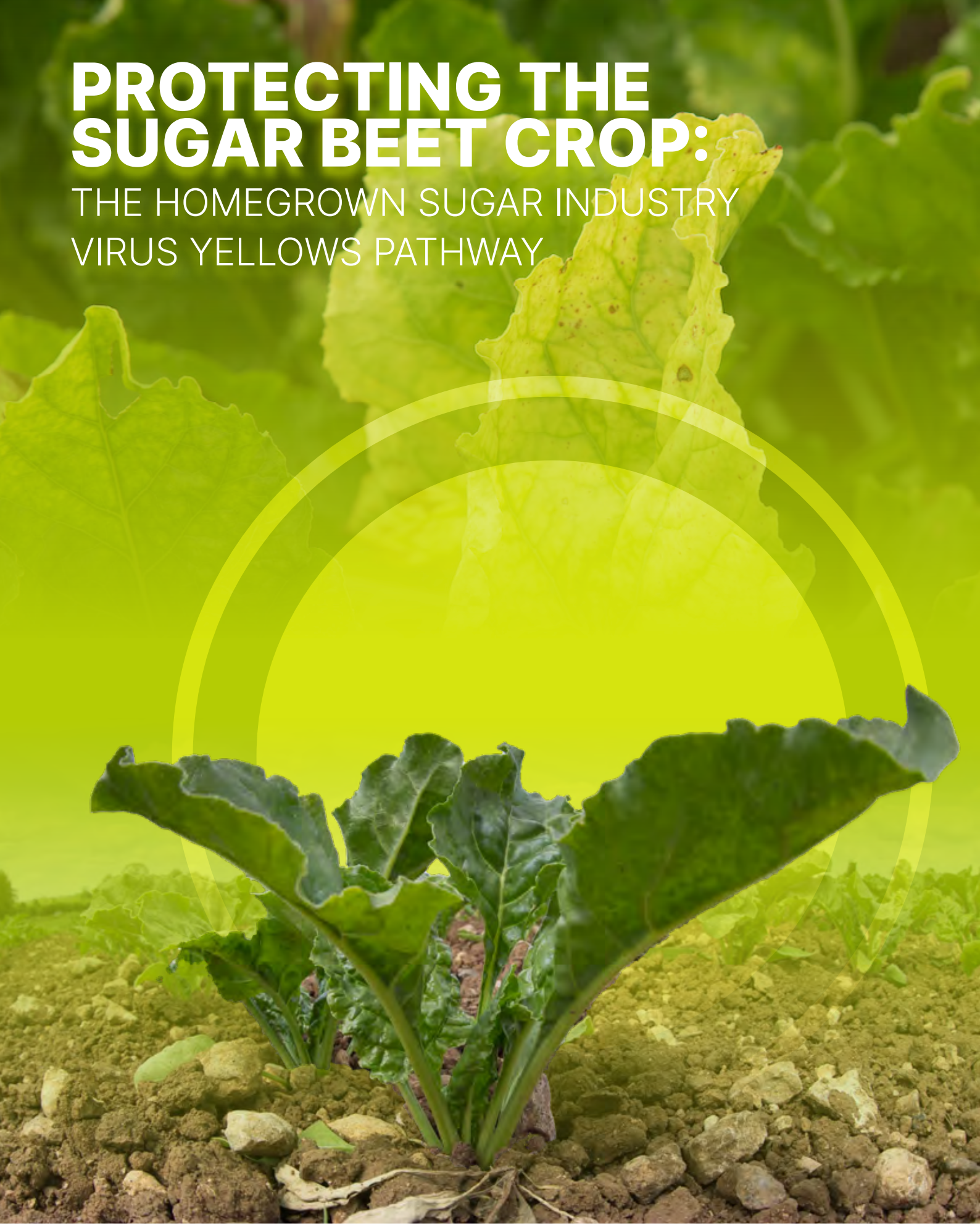
PROTECTING THE SUGAR BEET CROP:

THE HOMEGROWN SUGAR INDUSTRY VIRUS YELLOWS PATHWAY



BritishSugar | NFU SUGAR | British Beet BBRO Research Organisation

2300
GROWERS

SUPPORTING
7000
UK JOBS

SUPPLIES
OVER 50%
SUGAR DEMAND

INVESTS
£2M
A YEAR ON
SUGAR
BEET
RESEARCH

SUGAR BEET
TRAVELS

ON AVERAGE
FROM FIELD
TO FACTORY

SCAN

TO SEE THE FULL
VIRUS YELLOWS
PATHWAY TIMELINE

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THE VIRUS YELLOWS CHALLENGE

In 2020, the British beet sugar industry was hit by the extreme and unprecedented impact of Virus Yellows disease.

38% of the crop was affected nationally, with overall yields down 25% on the five-year average. Some sugar beet growers suffered reductions in yield of up to 80% as a result of the disease. The cost of Virus Yellows to growers in the 2020 season was approximately £43 million, with a subsequent impact to the processor, British Sugar, of a further £24 million.

Historically, farmers were able to routinely use neonicotinoid seed treatments to protect their sugar beet crop from Virus Yellows, however after these were banned by an EU ruling in 2018, the industry has needed to find new solutions to safeguard the crop from disease. Our Virus Yellows Taskforce is a cross industry group dedicated to finding these solutions.

ALISON LAWSON

NORFOLK SUGAR BEET GROWER & NFU SUGAR BOARD MEMBER

"Virus Yellows continues to constitute one of the biggest risks to my sugar beet growing business.

The perfect storm of 2020 was devastating - we suffered yield losses of 30% across our planted area as well as drastic reductions in associated sugar content. We continue to battle against infection and crop losses, but with Virus Yellows representing a complex of three distinct viruses, this fight remains extremely challenging."

'Myzus persicae'

WHAT IS VIRUS YELLOWS?

Virus Yellows is a complex of 3 viruses: Beet Mild Yellowing Virus (BMYV) and Beet Chlorosis Virus (BChV), which are closely related, and Beet Yellows Virus (BYV).

These viruses are transmitted when an infected aphid feeds on the sugar beet crop, with the peach potato aphid (*Myzus persicae*) being the main concern.

When the disease is present in the crop, circular yellow patches appear, usually between June and August. The leaves of infected plants are yellow between the veins, thickened and brittle. Infection reduces the photosynthetic area of leaves, reducing yield and sugar content.

BYV is the most damaging of the viruses, causing yield losses of up to 50% when it infects the crop in early June.

BMYV has been the most common yellows virus in recent years. It causes yield losses of around 28% when it appears in early June. BMYV generally causes leaves to turn an orange-yellow colour, which develops from the tip of the leaves.

BChV produces very similar symptoms to BMYV. Early season infections cause slightly less damage than BMYV but yield losses remain significant, 22% or more.

TYPES OF VIRUS YELLOWS

BMYV

BChV

BYV

FINDING SOLUTIONS

GROWER PRACTICES

The British Beet Research Organisation (BBRO) is jointly funded by UK sugar beet growers and British Sugar to provide sustainable solutions to the challenges faced by sugar beet production. Controlling Virus Yellows is currently the highest priority area of research.

At the core of the industry's approach to finding a sustainable solution is the principle of Integrated Pest Management (IPM). This approach involves combining a range of practices and techniques on farm to control the virus, rather than relying on one single approach or solution.

In IPM systems, providing an economically viable solution with minimal risk to the environment is the priority, with the use of a pesticide always the last option. The industry is looking into innovative grower practices in its work to control Virus Yellows:

PREDICTING & MONITORING APHIDS

An innovative virus predictive model, combined with established aphid trapping techniques, provides growers with real-time data on aphid activity so they know when to take action to protect their sugar beet crop.

Improved diagnostic approaches and the use of Artificial Intelligence are providing increasingly novel solutions.

DISRUPTING HOST CROP LOCATION

Understanding how aphids locate and recognise crops provides opportunities to camouflage sugar beet using inter-row cover crops or explore how natural soil colourings can confuse their detection systems, making it harder for them to find the beet crop.

ATTRACTANTS & DETERRENTS

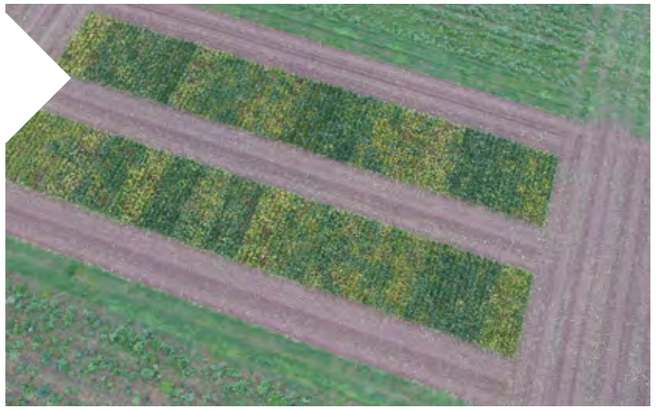
Aphids also detect a host crop by smell (olfactory stimuli). A range of volatile compounds (pheromones) are emitted by both plants and aphids themselves, creating a complex mix of chemical signals in the air. Sensors on the head of aphids can detect these, allowing them to decide whether the plant is attractive as a host or to keep away. A range of natural substances, such as onion, peppermint and garlic, are being explored for their potential role in affecting aphid behaviour to keep them off the crop.

IMPROVING NATURAL PLANT RESISTANCE

As plants age, they become more resistant to virus. This is termed 'mature plant resistance'. Improving soil health for more uniform plant populations and using approaches such as precision fertiliser application are key priorities. World-leading research is beginning to understand the process of mature plant resistance, and how it can be advanced, as is the potential for applying novel products to improve resistance.

PRECISION SELECTION FOR GENETIC PLANT RESISTANCE

A unique approach to testing new varieties for susceptibility to virus has been pioneered in the UK. This involves culturing millions of aphids infected with the three different viruses, and using them to artificially inoculate new plant varieties. This provides a very rigorous test for any new plant variety. Novel detection approaches such as aerial imagery are being used to assess the levels of virus symptoms in crop fields. This can improve the efficiency of screening programmes significantly.



THINKING OUTSIDE THE BOX

New approaches to controlling viruses are constantly being reviewed and explored, learning from best practice around the world. Our industry is trialling the use of endophyte grasses, which contain natural aphid toxins, following promising research in New Zealand. The grass is grown prior to planting sugar beet, which transfers some of the natural resistance to the beet. Early work has been shown to reduce virus symptoms.

LETTING NATURE HELP

Natural predators such as lacewing larvae and ladybirds can be very effective in controlling aphid population. Work is ongoing to understand how we can encourage and support these natural predator populations and how to synchronise their voracious feeding behaviour for optimum impact in reducing aphids.

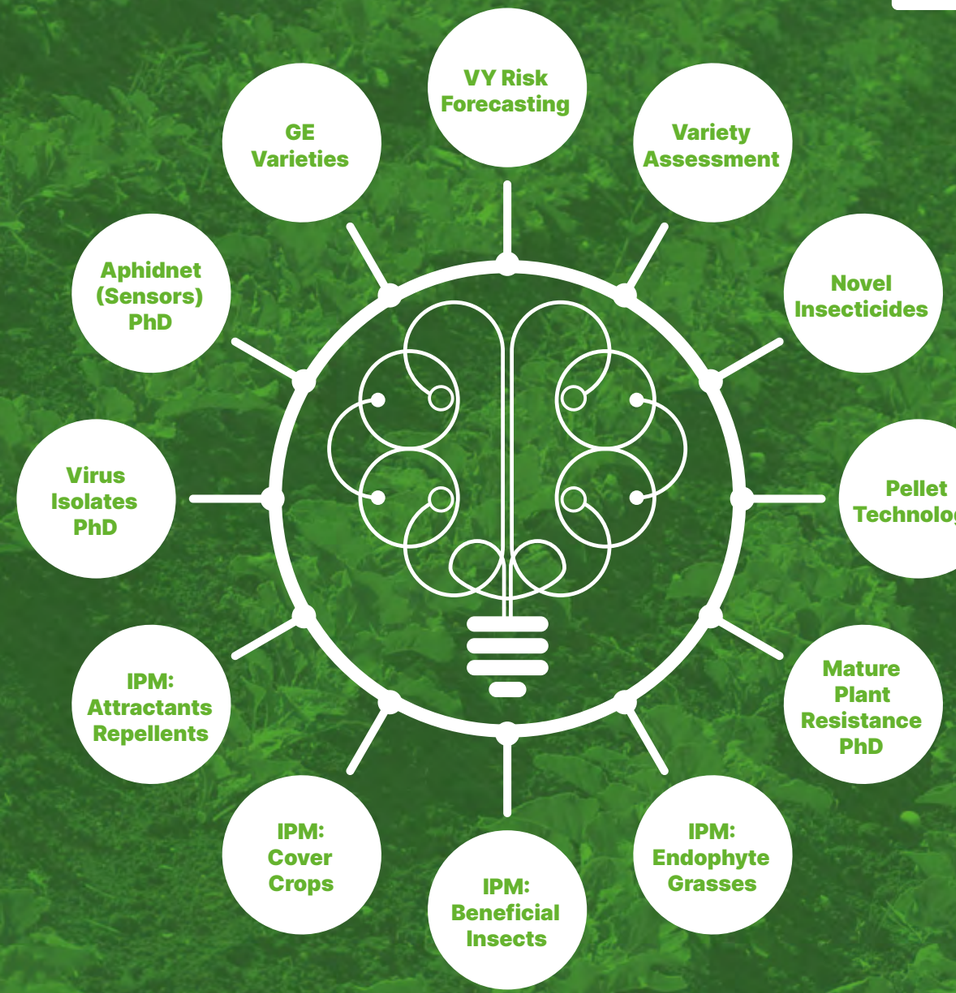
BEST PRACTICE (‘BRILLIANT BASICS’)

Removing sources of aphids and virus on farm through good crop hygiene is a key IPM component and campaigns are run to remind growers about the need for careful management of soil and spoil heaps after harvesting to ensure there is no ‘green bridge’ for aphid and virus on which to survive. Monitoring is ongoing to understand which other commercial and over-winter cover crops are hosts too.

BBRO KNOWLEDGE HUB

The BBRO runs an online Knowledge Hub to keep sugar beet growers abreast of the latest Virus Yellows research and advise on best-practice solutions to implement on-farm.

FIND OUT MORE HERE



GREEN BRIDGE

WHAT IS IT?

The term ‘green bridge’ is used to describe any green plant material which survives over-winter and acts as a host for pests and diseases.

Effectively these plants ‘bridge the gap’ between cropping seasons for pests and diseases, enabling early spread and infection of subsequent crops.

INNOVATIVE SOLUTIONS IN PRACTICE:

SUZANNAH HARDER

As well as work in the field, the IPM approach also involves collaborating with world-leading university partners and supporting novel research through the BBRO PhD programmes.

Suzannah Harder is one of the BBRO's PhD students. Her PhD in association with the University of East Anglia targets an understanding of how different strains of the three yellowing viruses may affect sugar beet. One example of her research is testing whether some strains of the viruses are more aggressive than others, so that targeted solutions can be developed.

As Suzannah reminds us, "Since the COVID-19 pandemic, we all know the potential significance of different strains of virus and this is relevant to sugar beet viruses too. By collecting, isolating, and identifying virus isolates (strains) from across the UK, I have already been able to demonstrate differences in virulence. This knowledge is essential to developing robust variety resistance strategies to protect the sugar beet crop for the future."

THE RESEARCH/ APPLICATION GAP:

TOM CLARKE

Farming in Ely in the heart of the Fens, grower Tom Clarke has implemented a full suite of innovative growing practices in his drive to find long-term sustainable solutions to Virus Yellows within his sugar beet rotation. Whilst some of the interventions trialled were effective in reducing the virus burden, others did not deliver a corresponding reduction in virus infection levels.

Where efficacy was high, the benefit to the crop was ultimately limited by a reduction in yield. The use of "camouflage" crops, for example, was effective in repelling aphid populations within young beet but left both plants competing for the same nutrients - hindering crop development. Similarly, a reduced herbicide programme encouraged a greater diversity of more desirable plant hosts for both aphids and natural predators but limited the soil nutrient availability for the sugar beet crop itself.

Tom's experience highlights the need for continued collaboration, spearheaded by the BBRO, to develop and fine tune grower interventions which are effective without causing an associated drop in yield.

BREEDING FOR VIRUS TOLERANCE

TRADITIONAL CROP BREEDING

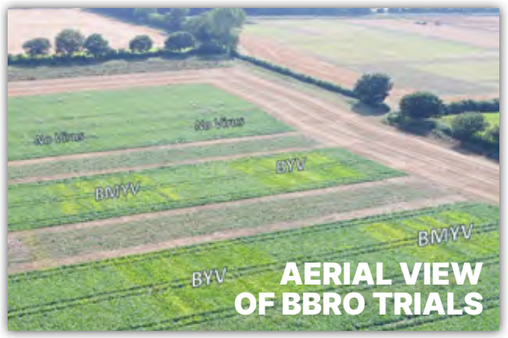
In the long term, variety resistance will be a key component of the IPM approach. The BBRO has developed and deployed a unique approach to testing and screening crop varieties bred using traditional breeding techniques.

This involves raising aphids infected with one of the three yellowing viruses in controlled environments and then inoculating individual sugar beet plants by hand in field plots of different crop varieties. The approach has involved raising millions of aphids every year, and inoculating over 100,000 plants by hand.

All commercial seed breeding houses have invested significantly in finding a solution to the Virus Yellows challenge.

The BBRO screen both existing and future crop varieties for susceptibility to Virus Yellows. These tests are carried out in large complex field trials, as it is important to test varieties in a natural field environment to include the interactions that occur at a farm level, and to ensure new seed varieties can produce an economic yield for growers.

To date, existing varieties have been shown to have little tolerance to any of the three viruses, but newer varieties have shown partial tolerance to one of the viruses. One such variety is already available to growers, and more are in the pipeline, but traditional seed breeding methods can take 10 to 12 years to produce market-ready varieties.



AERIAL VIEW OF BBRO TRIALS

GENE EDITING

Following the Genetic Technology (Precision Breeding) Act passing into law, the industry is investigating the use of gene editing as a way to help protect the sugar beet crop from Virus Yellows disease.

Tropic

British Sugar has invested in a multi-million-pound collaboration with Norwich-based agricultural biotechnology company Tropic, to explore how gene editing can be used in sugar beet to target Virus Yellows, thus protecting yields sustainably and reducing the need for pesticide use on the crop.

The project is using Tropic's ground-breaking GEiGS® (Gene Editing induced Gene Silencing) technology platform to make minimal and precise gene edits to redirect sugar beet's own natural defence mechanisms towards the viral pathogen, thereby enabling natural and durable genetic resistance to Virus Yellows.

Once we have generated these edited designs, they can be passed to commercial seed breeders to integrate Virus Yellows resistance traits into commercial sugar beet varieties.

OFIR MEIR

CHIEF TECHNOLOGY OFFICER AT TROPIC

"Our technology, which combines elements of precision gene editing and a naturally occurring immunity mechanism known as gene silencing, is a game changing platform allowing us to develop crops that are better able to withstand disease pressures to enable much more sustainable cropping practices."

READ MORE ABOUT THIS PROJECT HERE

WHAT IS GENE EDITING?

Gene editing sees precision plant breeding techniques used to change a selected, very specific sequence within the genome of a crop.

It is different from genetic modification because no new genes from other species are incorporated into the plant; instead, changes are made to the plant's own DNA. This process can and does happen in nature, but gene editing speeds up the process to deliver results faster.

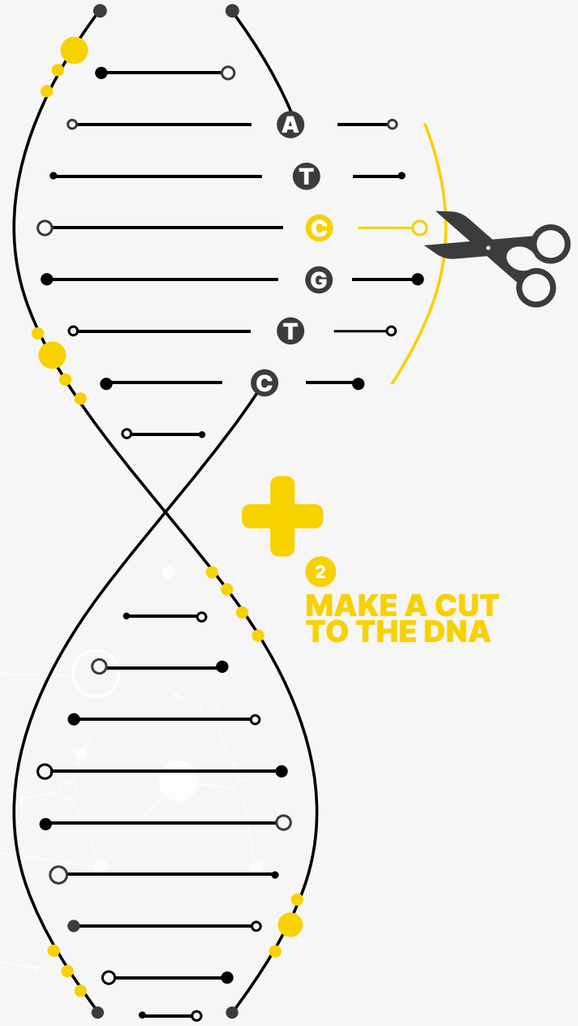
DAN GREEN

BRITISH SUGAR AGRICULTURE DIRECTOR

"We have a need to develop more sustainable solutions when it comes to tackling Virus Yellows.

In securing long-term sugar beet yields through disease-resistant seed, our work with Tropic will play a crucial role in reducing our reliance on pesticides, while safeguarding domestic sugar beet farming and the livelihoods of growers and communities across the UK."

1 FIND A SPECIFIC SEQUENCE IN THE EXISTING DNA



2 MAKE A CUT TO THE DNA

3 A TARGETED REPAIR RESULTS IN EDITED DNA

4 THE CROP HAS INBUILT RESISTANCE TO DISEASE

MONITORING & MANAGING APHIDS:

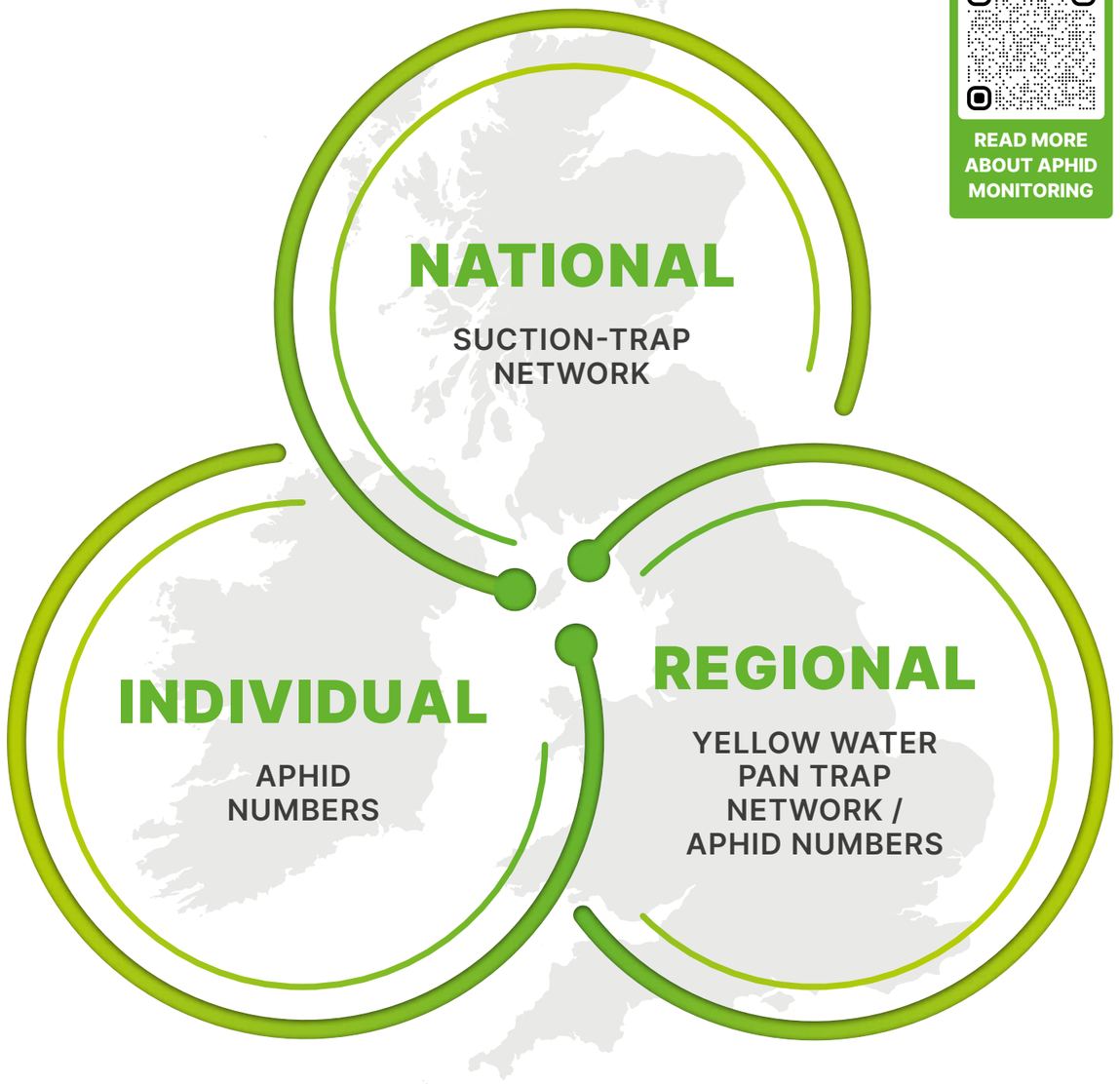
SUSTAINABLE SPRAY PROGRAMME

Our industry is working hard to discover and test new and novel foliar insecticides. Understanding aphid biology, especially how they feed, is paramount to being able to identify how to target aphids (and not the wider range of insects that are also found in sugar beet crops).

Newer products are more targeted and effective. Novel foliar products are also being tested and developed that may not control aphids but make sugar beet crops more resistant to the aphids transmitting the virus when feeding on the crop. Ensuring products are safe for the wider environment is key.

Whatever foliar spray is applied to the crop, the decision on whether or not to use an insecticide is based on comprehensive information on where and how many aphids are present in crops. This is collected by the industry through various methods on a national, regional and individual field level, and collated to provide the bigger picture.

READ MORE ABOUT APHID MONITORING



NATIONAL

The national suction-trap network currently comprises 16 traps (12 in England, 4 in Scotland), each 12.2 metres tall that continuously measure the aerial density of flying aphids.

They provide daily records during the main aphid flying season (April–November) and weekly records at other times. Just over 400 of the 600 aphid species on the British aphid list have been recorded to date. The network provides farmers with information on the expected timing and size of aphid migrations.

REGIONAL

The BBRO network of yellow water pan traps is used to monitor aphids at a more regional level across the sugar beet growing area, from Yorkshire to Essex.

They are yellow as aphids are attracted to this colour and filled with water to collect any aphids that land in them.The traps are emptied twice a week and the numbers are added to a map that growers and agronomists can access on the BBRO website to see the latest aphid counts. The aphids collected are also tested using the latest diagnostics techniques to see if they are carrying one or more of the yellows viruses.

INDIVIDUAL

The national and regional aphid networks are early warning systems providing growers and agronomists with essential information on when aphids can be expected, so they can take decisions on when to act to protect their sugar beet crop.

However, it is vital to check for aphids at an individual field level, as factors such as a surrounding crop, field topography, and how sheltered or exposed a field is can influence aphid numbers. Plants are checked for winged and wingless aphids individually. There is a threshold number that is used to trigger the need for any spray treatment.

INTERIM SUPPORT FOR SUGAR BEET GROWERS:

SEED TREATMENTS

Seed treatments will always offer the most targeted and effective control of virus yellows disease up until the point of mature plant resistance. The BBRO continues to lead the assessment of alternative innovative seed treatments capable of providing effective virus protection during the early stages of plant growth.

Significantly, targeted preventative chemical and biological seed treatment solutions can work in tandem with innovative grower practices and IPM methods to deter pests whilst encouraging beneficial insects.

Given the scale of the threat posed to the homegrown sugar beet industry by Virus Yellows, Defra has previously granted Emergency Authorisations for the limited and controlled application of Cruiser SB seed treatment to sugar beet seed. Authorisation has remained contingent upon an independent forecast of aphid pressure, ensuring that use is only permitted in instances where the burden of Virus Yellows would otherwise result in catastrophic economic harm to the industry. In instances where Cruiser SB has been used, stringent in-year and following crop restrictions have applied. These have been managed by a comprehensive Stewardship programme, delivered and administered by a cross industry taskforce in line with Defra and Health and Safety Executive guidance to protect pollinators and other beneficials.

The UK's sugar beet industry will continue to apply leading innovations in the seed treatment space, for example beneficial fungi and bacteria, plant derived compounds and extracts, and microbial biostimulants that support both virus resistance and more rapid development to plant maturity.

The independent Rothamsted Virus Yellows forecast has been in operation for the UK sugar beet crop since 1965 and is one of the longest running predictive models available anywhere in the world. As well as accurately forecasting Virus Yellows disease pressure it is also capable of projecting the first flight of its vector, the peach potato aphid. In 2022 its projection of the first flight was within 24 hours of when the actual first flight occurred!

As a result of the Virus Yellows outbreak in 2020, a three-year, £12 million Virus Yellows assurance fund was launched at the industry's own expense to compensate growers for a proportion of yield losses suffered where Virus Yellows was present in their crop.

Did you know, sugar beet is a non-flowering crop and therefore not attractive to bees. However, the industry recognises the importance of pollinators to the food chain and supporting bee populations is very important to us.

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