AHDB

from theory to field

Vegetable GIN solutions

While the problems facing growers may make it tempting to reach for the gin, plant breeders are finding that GINs are actually providing the answers. *CPM* takes the top off VeGIN and gets a taster of what's inside.

By Lucy de la Pasture

Nature never stands still. As well as pathogen evolution, keeping up with changing weather patterns and the pest and disease pressures that result is no easy task for plant breeders, particularly as finding genetic solutions to introgress into conventional breeding programmes isn't a speedy process.

Behind the scenes, academia performs many of the painstaking pre-breeding processes that underpin the commercial traits eventually brought to market by commercial plant breeders, but both need to be aligned for maximum benefit to the industry. Recognising this, Defra supports a major, long-term research platform for the genetic improvement of arable crops and fresh produce.

The 'Genetic Improvement Networks (GINs)' bridge a gap by bringing together industry and academics to drive forward R&D on genetics while also focusing on longer-term issues, such as resource efficiency, sustainability and resilience, which complement and augment commercial breeding programmes, explains AHDB's Dhan Bhandari.

Public good

"The key rationale to Defra funding the GINs is to address issues of public good that are not necessarily captured in commercial breeding programmes but can deliver significant benefits for UK crop production."

AHDB doesn't contribute to funding the networks but has a role as a stakeholder which helps influence the direction of research to meet industry needs, he explains.

"Being involved also helps us to keep our finger on the pre-breeding research pulse — and be at the start of the variety pipeline that ends with the AHDB Recommended Lists."

Since 2003, four GINs — WGIN (wheat), OREGIN (OSR) VeGIN (brassicas, leafy salads, onions and carrots) and PCGIN (Pulses) — have been set up with the overall aim of generating pre-breeding material carrying novel traits so breeding companies could ultimately produce improved varieties.

"At the time of the GINs conception, it was widely felt that there was a disconnect between academia and commercial plant-breeding companies. The idea was to bring them together to improve collaboration and communication between researchers and industry."

The last, but not least, of the GINs to be featured in *CPM* is VeGIN, which follows on from OREGIN and PCGIN (featured in July 2020) and WGIN (July 2017). Part of AHDB's role is to communicate the progress of the networks to the industry, adds Dhan.

The VeGIN team is led by Guy Barker at the University of Warwick. He explains that

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the aim is to build and sustain a stakeholder network for UK vegetable crops.

"This involves maintaining and improving existing experimental populations and diversity sets of carrot, onion, brassica and lettuce. At the Warwick Crop Centre, we have our own gene bank in the form of the Vegetable Genetic Resources Unit (GRU)."

The GRU has a reservoir of diversity — with current and old varieties, landraces and crop wild relatives providing genes a plenty to facilitate research.

Breeding for resistance to insect pests, such as the diamond back moth, is extremely complex.

"Using this resource, we select a reference sample (diversity foundation sets) from the available diversity then fix the diversity in the form of homozygous lines to produce fixed foundation diversity sets. This allows us to capture 95% of the genetic diversity in just a couple of hundred lines," explains Guy.

Where necessary, the VeGIN programme is producing new mapping populations for important commercial traits (i.e. disease resistance, yield, crop establishment and rooting traits).

Using markers

"New technologies are being used to analyse existing germplasm and develop new molecular markers for traits predicted to expand the VeGIN crops' market potential. Genetic markers are used to identify different features in a mapped DNA sequence and can be used to differentiate between individuals in a population — to work out what's different and what's the same in different accessions or wild species — or to classify individuals between different cultivars within a species.

"The different features in the sequence can be used to identify if that particular region was inherited from the female or male parent. By using this information we can build up a more complete picture of the genotype at each marker. This allows us to track the inheritance of different regions of the genome," he explains.

VeGIN is peculiar in that it covers such a large number of species, which can make it hard to address all the concerns of the industry, says Guy Barker.

Guy says that VeGIN has been instrumental in making the resources held in the gene bank at Warwick available on a wider basis for vegetable plant breeding in the UK, where vegetables are an economically important crop sector. ▶

VeGIN offers multiple benefits

Dr Richard Tudor, vegetable breeding manager at Elsoms, believes VeGIN is helping plant breeders to tackle some of the more complex issues facing vegetable growers, some of which wouldn't be cost-effective without the resources it offers.

"Plant breeding is quite a slow process and often academic projects are three-year post-doctorate studies, sometimes five years. So the fact academia has been able to secure funding for a longer period of time through VeGIN enables bigger, more ambitious projects that wouldn't normally be covered by other sources of funding," says Richard.

"Although there are some traits which are interesting and would be nice to look at, at the end of the day plant breeders are a business so have to assess whether the traits and varieties they're looking at are likely to provide a financial benefit. However, that isn't the same thing as solving some of the problems those lines have. That's where VeGIN comes in," he says.

"Certain traits, like disease resistance, are relatively easy for a private company to work on, but there are other traits, such as pest resistance, which require much more investment because of the complexities involved. Fortunately, VeGIN can approach these kinds of problems."

Because VeGIN is government funded, it enables a wider approach to be taken by plant breeders. "It would be better if crops were more nutritious, but a variety that has more vitamin C or beta carotene, for instance, probably isn't worth more to the consumer to justify the investment by commercial plant breeders. But that doesn't mean nutritional traits aren't important. It's another area that VeGIN has advantages for breeders."

One thing that takes a lot of time is phenotyping large populations, adds Richard. "As a breeder, you want to understand a bit about the lines when you have an end goal in mind. VeGIN has the genetic resources and scans the germplasm available, narrowing it down if you're looking for specific traits of interest."

Richard also highlights numerous projects which have resulted as spin-offs from the VeGIN programme. These include BBSRC's Brassica, Rapeseed and Vegetable Optimisation (BRAVO) project; and another important project using genomics to look at biotic and abiotic stress tolerance in mustard rape for economic and environmental sustainability, which also overlaps with OREGIN. Other projects are looking at fusarium in lettuce, cavity spot and virus resistance.

Richard Tudor says VeGIN can approach some of the more complex problems in breeding which wouldn't be economic for a private company to look at.

But the benefits of VeGIN are even wider, he says. Its genetic resources have also been used in spin-out projects investigating seedling establishment, nutrient deficiency, pathogen resistance and postharvest discolouration.

The mesocosm facility at Warwick University enables researchers to carry out inoculated 'field trials' to screen diversity sets for cavity spot resistance.

▸ "The turnover from horticultural crops exceeds that of broadacre crops, even so, vegetable production in the UK continues to decline even though the value of the UK vegetable market is increasing year on year," says Guy.

He sees plant breeding as having a key role in supporting UK vegetable producers grow crops efficiently and productively for maximum economic gain, with minimal environmental impact. So what has VeGIN achieved so far to help facilitate this?

VeGIN differs from all the other GINs in that it has a wider focus because it covers such a crop range which come under the umbrella of brassicas, leafy salads, onions and carrots. "VeGIN is peculiar in that it covers such a large number of species, and this can make it hard to address all the concerns of the industry. It also means it has a wider knowledge and interaction base," says Guy.

The network has already delivered downy mildew resistance resources in brassicas and onions, clubroot resistance in brassicas, found sources of fusarium resistance in lettuce and developed cavity spot resistance resources in carrots, he explains.

But the pre-breeding efforts aren't just confined to diseases, there is plenty of industry need for resistance to pests — such as cabbage stem flea beetle, diamondback moth and aphids — which cost the industry millions in wastage through contamination and lost yield due to the plant viruses they can transmit when feeding.

The VeGIN network has already delivered downy mildew resistance resources in onions and brassicas.

"The importance of viruses was highlighted in work by John Walsh, who found a number of viruses had a significant impact on yield and that genetic resistance does exist. Ultimately it should be possible to produce varieties with broad spectrum resistance which can yield up to 40% more in situations where aphid incidence (and virus) is high. Collaboration with industry is underway and the first release of virus-resistant plant varieties emanating from research at the University of Warwick is anticipated to be released in 2023.

Complex mechanisms

"Breeding for insect resistance is terribly difficult because of the multiple gene interactions involved," adds Guy. "We're also looking at the mechanisms behind resistance breaking down in the field and are trying to figure out how it develops and then how to stop it from happening in the future."

VeGIN is also expanding its work in lettuce. Having found resources for fusarium resistance, work is ongoing to find a more durable resistance in light of a new race of the disease which has overcome plant resistance and has been causing devastation in Europe.

The network isn't limited to pests and diseases. Finding genetic resources to help counter abiotic stresses, such as drought and salinity, is another major strand of work running within VeGIN.

Dawn Teverson is one of AHDB's knowledge exchange managers for field veg and has been on the sharp end of problems encountered in the field.

"Commercially there is only one gene used for club root resistance and it's already breaking down in some situations, so VeGIN is helping to address that problem," she says.

Cavity spot (caused by Phythium violae) is another disease that's all too familiar to Dawn but she believes the development of a new inoculation techniques by John Clarkson at Warwick will prove to be a huge step forward in combatting the disease.

"The industry is looking more and more to resistance as an answer to problems but for disease like cavity spot, testing in the field is tricky. It's notoriously difficult because of cavity spot's sporadic nature."

An additional resource at Warwick Crop Centre is its macrocosm plots (large concrete pipes), which can be inoculated with *P. violae*, enabling field testing to take place.

There are crossovers and transferences between VeGIN and OREGIN, which have brassica crops in common, and solutions being sought across these GINs for cabbage stem flea beetle and club root.

"The inoculation technique enables screening of the diversity set, which means it's possible to test chemistry or bioprotectants in an outdoor situation which doesn't infest grower's fields, as well as screen them for resistance," she explains.

The GINs are set to continue until 2023, adds Dhan. "It's been a successful programme and the four GINs have been encouraged to share ideas and experience across the networks," he says.

The collaboration to date has been particularly useful where there are crossovers and transferabilities between some of GINs — notably VeGIN and OREGIN which have the brassica genus in common, explains Guy.

"VeGIN has the vegetable diploid brassica species — *Brassica rapa* and *Brassica oleracea* — which were the parents of the allopolyploid oilseed rape species (*Brassica napus*). They have common diseases and insect problems so there has been collaboration on these."

It's hoped that any potential continuation of the GINs programme would allow future crop rotation experiments, adds Dhan, which would enable the GINs to work more closely together in a practical way. ■

Research roundup

From Theory to Field is part of AHDB's delivery of knowledge exchange on grower-funded research projects. *CPM* would like to thank AHDB for its support and in providing privileged access to staff and others involved in helping put these articles together.
For further information: *ahdb.org.uk/gins*