



Driving innovation in plant breeding

TEAGASC is part of the Virtual Irish Centre for Crop Improvement, which aims to develop specifically adapted crop varieties for the Irish sector.

The Virtual Irish Centre for Crop Improvement (VICCI) is a consortium of 15 principal investigators from Teagasc, University College Dublin, NUI Galway, Maynooth University and Trinity College Dublin (TCD). This consortium, established in 2014 through funding from the Department of Agriculture, Food and the Marine (DAFM), seeks to exploit advances in plant breeding-related sciences to enable the development of crop varieties specifically adapted to the future needs of the Irish agri-food sector.

A key driver

Plant breeding can be a key driver of profitability in agriculture. For instance, a report commissioned by the British Society of Plant Breeders outlines the fact that of the 2.1 tonnes per hectare yield increase (from 6.2 to 8.3 tonnes per hectare) experienced in UK wheat crops between 1982 and 2008, 1.9 tonnes per hectare (90%) was directly attributable to the release of new, higher-performing varieties in that period. Based on the 2008 UK harvest area of 2.1 million hectares, this resulted in an additional production of 3.9 million tonnes per annum when compared to 1982, with an associated gross value increase of between £373 million and £445 million per annum based on either feed or bread-making prices for grain.

This direct benefit was accompanied by downstream impacts: the development of UK-adapted wheat varieties with better milling characteristics over this period enabled a 57% increase (1.7 million tonnes) in UK-grown wheat used for milling, while imports of milling wheat fell by 20%. This amply demonstrates the potential of plant breeding to benefit both primary and downstream profitability in the agri-food sector.

An unusual slowdown

Despite the historical efficacy of plant breeding, the 21st century has seen a dramatic slowdown in the rate of genetic gain in major crops (e.g., maize, rice and wheat), which averaged at between 2% and 3% yield gain per annum between 1960 and 1990, but is projected to drop to half, or even less than a quarter of these levels between now and 2050. However, against the backdrop of this drop-off, huge strides have been made in biotechnology-based sciences with the potential to address the problem. Advances in areas such as genomics, transcriptomics, metabolomics, and high-throughput phenotyping not only allow the elucidation of the control of many key characteristics that are required for successful varieties, but offer routes to fast-track their development. Large-scale commercial breeders now routinely use approaches such as marker-assisted selection (MAS) and genomic selection (GS) to cut variety development time and incorporate difficult to breed for characteristics into varieties.

VICCI is using the above approaches to underpin the development of varieties that address four key challenges in Irish tillage and forage agriculture: fertiliser use; crop protection; abiotic stresses; and, the potential to replace imported crop products with Irish-grown alternatives. It would be impossible to address all of these topics for all of the crops and scenarios important to Irish agriculture, so VICCI research has focused on addressing specific challenges in six species:

- nitrogen use efficiency (NUE) in wheat, barley and ryegrass;
- disease resistance in wheat, oats, barley, potatoes and beans;
- cold tolerance in ryegrass;
- waterlogging stress in barley and ryegrass; and,
- frying quality in potatoes.

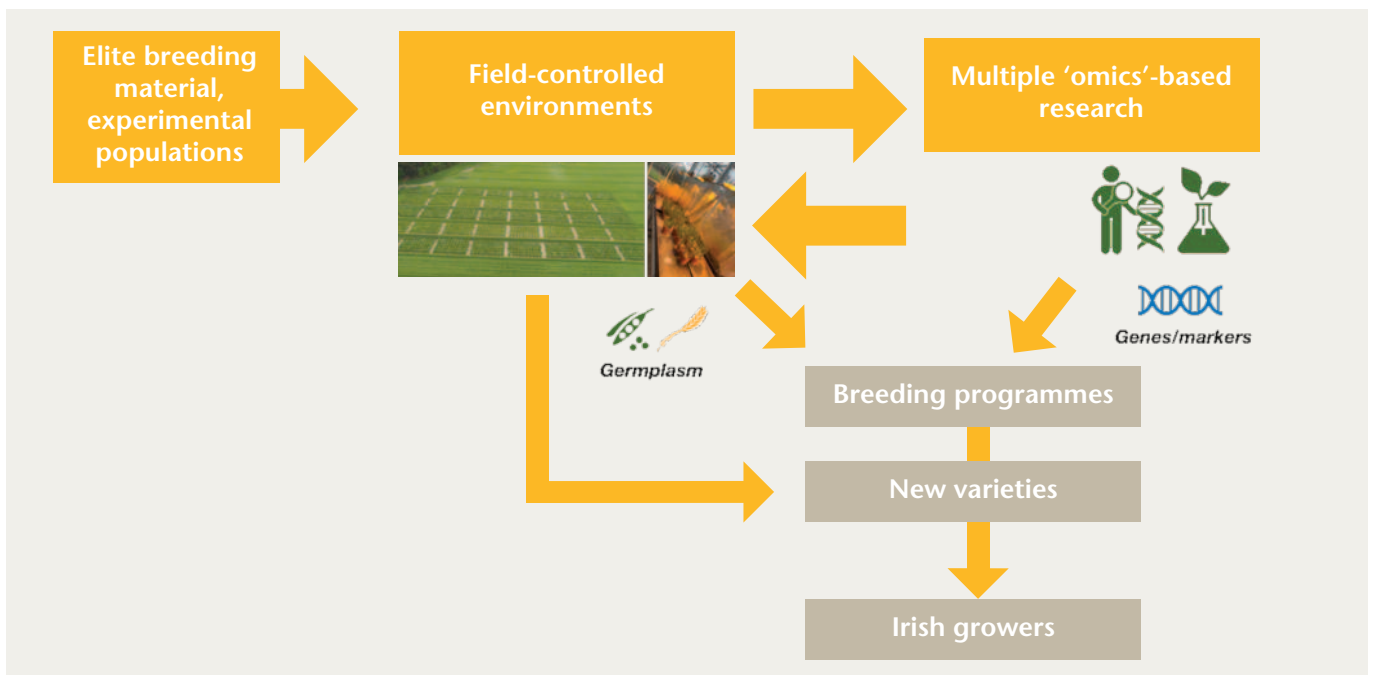


FIGURE 1: Model applied by VICCI to address challenges in Irish tillage and forage agriculture.

In order to address the challenges, VICCI broadly operates using the model outlined in **Figure 1**. Identifying relevant germplasm that can be used as parental material in breeding programmes is a key first step in the project, but rather than undertaking the expensive and lengthy process of developing collections of breeding germplasm, VICCI is collaborating with domestic and international partners who have already developed and characterised such populations.

The benefits of collaboration

VICCI partners are combining field, glasshouse and controlled environment trials to identify plants exhibiting desirable characteristics relevant to Ireland, with a multi-layered 'omics'-based approach to identify the genes and pathways in these plants that are controlling the characteristics. Subsequently, we develop and validate tools such as genetic markers that will provide cost-effective selection for these characteristics in breeding programmes. Making these tools available to breeding programmes that target the Irish market means that improved varieties will become available to growers. As it enters its fifth year, VICCI has had many tangible successes. In this special focus issue of *TResearch*, three sets of authors from VICCI give a series of snapshots of how VICCI research is advancing plant breeding innovation in the areas of disease resistance, abiotic stress tolerance, and developing crop varieties that are simultaneously adapted to Irish growing conditions and market expansion opportunities. Another notable success in VICCI has been the bringing together of Ireland's plant science and applied crop science communities. For example, this special issue of *TResearch* highlights a collaboration between scientists at Teagasc, Maynooth University and UCD that combines expertise in highly controlled field experiments, cutting-edge X-ray computer tomography (CT) imaging, and gene discovery and genetic marker development, to develop approaches to breed waterlogging-resistant winter barley varieties. VICCI activities have also developed new capacities and skillsets that are essential to allow the research community to

effectively impact varietal development for Irish agriculture. Perhaps one of the biggest indirect benefits of VICCI has been the leveraging power that the consortium has given its participants. Since the project began, VICCI partners have successfully exploited both VICCI research, and the demonstrable existence of a co-ordinated crop improvement community, to participate in bidding for EU Horizon 2020 projects worth in excess of €10 million, further extending the potential of the VICCI community to impact variety development for Irish agriculture.

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