Innovations in breeding for import substitution

Research in VICCI is helping to develop varieties of potatoes and beans that will allow Irish producers to replace imported crops with Irish-grown ones.

Despite our capacity for crop production, Ireland still imports significant quantities of crop-based products to fill gaps in supply for various applications. This represents a potential diversification opportunity for Irish producers, who, with the right tools at their disposal, could displace some of these imports with Irish-grown alternatives. For instance, Ireland is a net importer of potatoes and beans. In both cases, imports are driven in part by a lack of varieties suited to both the targeted end use of the crop and our unique agro-climatic conditions.

Opportunities for import substitution

In 2018, CSO figures indicated that 72,000 tonnes of fresh potatoes were imported into Ireland. In addition to this, a further 120,000 tonnes of frozen potato products are imported annually, mainly to serve the frozen chip market. This represents an opportunity for import substitution using indigenously produced potatoes. Current varieties suitable for chip production can be difficult to grow in Ireland due to environmental, soil and management constraints. Thus, robust varieties that are adapted to the Irish agri-environment, suitable for chip production, and which possess good storage characteristics to support year round supply, would help to exploit this opportunity.

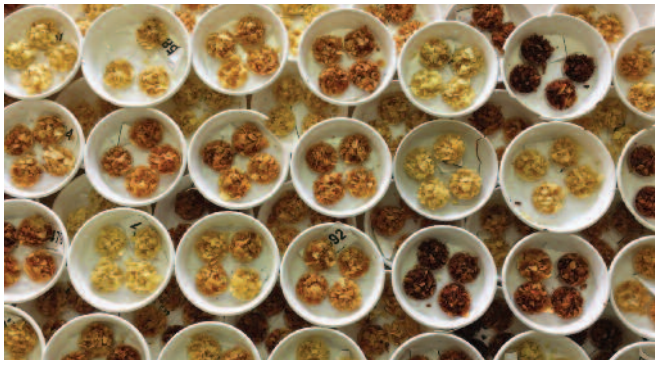
Ireland imports over three million tonnes of protein for animal feed annually, mostly soya, beans and maize. Faba beans constitute a potential home-grown alternative source of protein and are currently used mostly in coarse rations. Legume-friendly greening measures introduced as part of post-2014 Common Agricultural Policy (CAP) reforms, and the surge in feed demand brought about by the expansion of the dairy and beef herds following milk quota abolition, have resulted in an increase in bean acreage in Ireland.

Mild Irish winter agro-climatic conditions permit high yield potential over a wide range of sowing dates in faba bean production, and so-called 'spring' varieties can out-yield 'winter' varieties from autumn sowing when there is low disease pressure, suggesting that UK- and northern Europe-bred varieties are not well targeted to the Irish environment. However, there is currently no dedicated breeding programme focused on developing faba bean varieties adapted for optimal yield in autumn-sown Irish growing conditions, combining performance with improved disease resistance.

Potatoes for chipping

Potatoes for chipping are normally stored at 8°C; below this, reducing sugars accumulate leading to undesirably dark colours on frying. Unfortunately, sprouting occurs above 8°C, necessitating the use of sprout suppressants such as chlorpropham. These are being phased out, and it is therefore necessary to develop potatoes that can be stored below 8°C without accumulating sugars. Fry colour and low temperature sugar accumulation are under polygenic control and therefore challenging to breed for, particularly when they need to be combined with other traits such as yield and disease resistance. This is where new approaches such as genomic selection (GS) can assist traditional breeding. GS is a form of marker-assisted selection that simultaneously estimates genetic marker effects across the entire genome to calculate breeding values. These breeding

Faba bean isolation cage at Oak Park.



Variation in potato chip fry colour.

values can then be used to select individuals for advancement in the breeding cycle without direct phenotyping.

During VICCI, we evaluated fry colour on over 650 candidate varieties from the Teagasc potato breeding programme, after harvest and at various time points during storage at 4.5°C and 8°C (with sprout suppressant). Nearly 10,000 tubers were sliced into crisps, fried, and analysed for fry colour. This "training population" was also DNA-sequenced to identify approximately 50,000 single nucleotide polymorphism (SNP)-based molecular markers. We evaluated various statistical algorithms and determined factors affecting predictive ability of the SNP markers, enabling the identification of subsets of as few as 100 markers that were capable of predicting fry colour and resistance to low temperature sweetening with high accuracy. These are being used to develop a cost-effective genotyping assay to enable GS for these traits in the early stages of the Teagasc potato breeding programme when direct measurement of them is impractical.

Breeding better beans

As part of VICCI, Teagasc has collaborated with the University of Reading to establish a recurrent selection breeding scheme to improve yield and disease resistance for faba beans in Irish growing conditions. A founder population combining yield, quality and disease resistance characteristics, from which better adaptation to late autumn sowing under Irish conditions, along with many more desirable traits, can be selected, was established at Reading by intercrossing diverse faba bean varieties and inbred lines from a number of sources. These included UK elite field bean varieties and broad beans, sources of *Ascochyta* resistance, European lines carrying zero tannin and low-vicine/convicine traits, and Hungarian, Chinese and Egyptian germplasm as sources of diversity. Recurrent rounds of selection for yield are underway at Reading. High-yielding lines from the second round of selection in the UK were established in isolation cages in Oak Park in 2017, to allow crossing and selection under autumn-sown Irish conditions. One cage was maintained under standard commercial faba bean cultivation practice, while fungicide treatments were withheld from the "untreated" cage in order to exercise selection under enhanced disease pressure. Field-based selection for disease resistance will be complemented by screening for resistant progeny of selection in artificial inoculations, with *Ascochyta* and chocolate spot isolates. Survivors of these inoculated screens will be returned to the main recurrent selection population to contribute enhanced levels of disease resistance. Preliminary data from trials show that seed yield per plant is responding to selection, indicating that it should be possible to develop high-performing autumn-sown lines for Ireland. The definitive test of selection response will entail replicated field trials planned for the final year of the project, where yield and disease resistance of the new VICCI selected lines will be compared to the progenitor lines and current recommended varieties.

Conclusion

Real world output in the form of improved Irish-adapted varieties is an important goal for VICCI. These breeding initiatives in potato and beans have the potential to achieve this goal in the near future, supporting diversification and expansion of the Irish tillage sector.

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