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GENOMICS UNLOCKS WILLOW'S POTENTIAL IN UK BIOMASS SCALE-UP

Accelerating Willow Breeding and Deployment (AWBD) Project

Short rotation coppice (SRC) willow is a desirable perennial biomass feedstock due to its fast-growing nature and multifunctional benefits. And with the development of new and improved varieties, it could help farm businesses diversify income - even in less favourable growing environments.

On a productive site, SRC willow can produce up to 20t/ha of dry wood per year, averaging around 15t/ha per year. However, current varieties are producing closer to 10-12t/ha per year, making ambitious expansion plans challenging for varieties that have been largely bred for favourable sites and conditions.

Another limitation to upscaling is the likelihood that breeders will be left with a limited stock of propagation material for field testing or commercial release.

"It has always been an ambition to fully exploit the power of genomics in the willow breeding programme – we know what it can do." Steve Hanley, head of genomics at Rothamsted Research

Project

Understanding the potential for genomic selection in overcoming these hurdles, Rothamsted Research is utilising the UK Government-funded Biomass Feedstocks Innovation Programme (BFI) as a springboard to develop the tools to accelerate the breeding and deployment of new and improved SRC willow varieties.

Led by agronomist Ian Shield, the project's objectives cover three key areas:

- **Breeding**: Focusing on the use of genomic selection to accelerate environment-tailored breeding, by modelling genotype and phenotype data to improve the selection of complex traits like yield and disease resistance.
- **Multiplication**: Focusing on the testing and optimisation of protocols for micro-propagation, and the accelerated multiplication of genotypes in a genomic selection breeding programme.
- **Deployment**: Focusing on the planting, growing, and monitoring of willow genotypes in five diverse environments.

These areas of focus will generate the data to calculate genomic estimated breeding values (GEBV), which will be applied to the institute's breeding programme. Combined, the objectives will accelerate SRC willow breeding to develop new varieties for multiple markets and lower breeding costs. The project will also generate robust information to guide the deployment of SRC willow in the UK.

Recognising the hurdle that a narrow set of environments creates for future scale-up of biomass production, the project has established trials of genomic selection training populations ...

"We wanted to broaden the environments we grow in – utilising genomic selection will allow us to breed for a wider and more realistic set of UK environments." William Macalpine, breeder at Rothamsted Research

… it has planted cuttings of SRC willow genotypes in five different environments across the UK, each with its own stressor:

1. Somerset Levels: Assessing flood tolerance.
2. Bedfordshire (sandy soils, low rainfall): Assessing drought tolerance.
3. Aberdeen: Assessing impact of longer day lengths and cooler growing seasons.
4. Northern Ireland (NI) (high humidity and disease pressure): Assessing disease tolerance.
5. Northumberland: A control environment, similar to those used in previous trial work.

Each trial, excluding NI, has a training population comprising 560 genotypes - drawn mainly from up to seven SRC willow species, primarily *Salix viminalis* and its hybrids. The project is generating the genome sequence of each.

The trials are replicated across four blocks, each with 70 sub-blocks of nine plots – with one control genotype plot per sub-block. The high density of controls is designed to explore the effects of spatial variation across each site. In NI, 144 genotypes have been planted as a smaller test population where predictions from the other four sites will be applied and evaluated.

The purpose of these trials is to look at the field data and observable traits (phenotypes) of the SRC willows and compare with the genome sequences to identify consistent patterns for predicting biomass traits of interest. These include establishment, yield, disease and pests under the different growing conditions. Crop management and weather data is recorded at all sites.

Taken together this will provide the data that will inform breeding decisions for superior, new varieties, as well as information matching variety to environment.

Latest

Planting >70,000 cuttings in total, the project's training populations were established in May 2023 and coppiced in February 2024 to encourage the plant to produce multiple branches and shoots.

In March 2024 the project is collating the data for the first year of establishment and coppicing. It is assessing rust, yield potential and early vigour - a valuable trait for willow which is very vulnerable in the first year of growth – as well as senescence time.

Keeping the populations as close to a normal three-year harvest cycle as possible, the project will use a non-destructive method of yield estimation in January 2025 - based on stem diameter and stem numbers per plant.

It will also collect data on new shoot emergence, which alongside senescence time, will give duration of the growing season.

Next Steps

By the conclusion of the BFI in March 2025 the project will have produced its first GEBVs, which will then be applied to Rothamsted's SRC willow breeding programme.

Beyond March 2025, Rothamsted intends to continue its genomic selection programme, which will evolve to continually manage and update the training populations. This will produce robust information and improved varieties for industry use to support the upscaling of SRC willow planting.

"Rust resistance is vital in the willow crop. We need to use genomic approaches to breed plants with multi-gene resistance to rust." Jackie Barker, phenotyping manager at Rothamsted Research

To learn more about the AWBD project please contact:
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