



# Development of seed-based *Miscanthus* hybrids will accelerate uptake by farmers

To meet climate targets the UK will need to rely on a variety of energy sources, including energy produced from burning biomass crops. Researchers at the Institute of Biological, Environmental & Rural Sciences (IBERS) Aberystwyth University, with funding from BBSRC, have developed new hybrids of the biomass crop *Miscanthus* that will enable growers to scale-up production to meet the UK's future biomass energy production needs. Such biomass can also be used as a feedstock to replace chemicals and materials currently derived from fossil fuels or energy demanding processes, and therefore further helps to decarbonise the economy<sup>1</sup>.

The new hybrids are adapted to UK conditions and to growing on areas of lower-quality land that are less suitable for food production. They are produced from seeds instead of rhizomes, which allow for more rapid scale-up of the commercial planted area, at a lower cost and with less environmental impact.

Industry partner Terravesta, which holds licences for the most promising new hybrids, is aiming for commercial roll-out of the crop in 2020. The new hybrids are also undergoing commercial trials in six European countries.

## An ideal energy crop

The UK is committed to a target of net zero greenhouse gas emissions by 2050, as recommended by the Committee on Climate Change<sup>2,3</sup>. Achieving this target will require drastic decreases in energy use, a diverse mix of renewable energy sources, and negative emission technologies. Sustainably produced biomass, either waste from forest management or from purpose-grown energy crops, is a low carbon energy source that will be required to supply 5-10% of the UK's energy demand<sup>2</sup>. If combined with carbon capture and storage technologies, it will become a negative emission technology.

Alongside fast-growing tree species such as poplar and willow, the perennial grass *Miscanthus*, which originated in South East Asia, is an ideal energy crop for the UK<sup>4</sup>. It grows quickly and, with relatively low nutrient inputs, it can be grown on low-grade land. It is estimated that there are around 1.4 million hectares of low grade land in the UK which is less suitable for growing food crops<sup>5</sup>. *Miscanthus* is adapted to a wide range of

environmental conditions and exhibits cold tolerance, high water use efficiency and efficient carbon fixation. With UKRI funding including a BBSRC Core Strategic Programme in Resilient Crops<sup>6</sup> and Supergen Bioenergy<sup>7</sup>, IBERS researchers are developing the tools, including genomic prediction models, to increase and sustain *Miscanthus* yield<sup>8,9</sup>. They are also seeking to understand the environmental impacts of planting these crops including the effects on soil carbon and hydrolog<sup>10,11</sup>.

The current commercial variety *Miscanthus x giganteus* (Mxg), grows three to four metres high each year. *Miscanthus* biomass is left to stand over the winter and is then harvested by cutting down to just above ground level in the spring, before new shoots emerge. Typically, growers can harvest between eight and fourteen tonnes per hectare in the UK with minimal inputs. The biomass can then be burned in straw-fired power stations to produce electricity or processed into a variety of bio-based construction materials or chemicals.

Until recently, the rate at which we could potentially expand the commercial production of *Miscanthus* was relatively slow. Conventional *Miscanthus* crops are replicated via cloned rhizome material, where a portion of the root called the rhizome is taken and cut into small pieces. These will then develop into new *Miscanthus* plants. A key objective for the Aberystwyth team is to produce seed-based hybrids that can be multiplied quickly to cover large areas of land and this has been the subject of public-private investments including from UKRI-BBSRC and Innovate UK.

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Number of novel hybrids for which licences have been signed, currently in commercial trials in six European countries

£1.3M

Value of BBSRC/InnovateUK funding for the research (MUST)

2006

The year that Defra/BBSRC-supported germplasm collection began in SE Asia



Seeded *Miscanthus* hybrid plug plants soon after planting. Photo credit: Terravesta Ltd.



Harvesting *Miscanthus* in the spring.  
Photo credit: Terravesta Ltd.

## Access and benefit sharing

In 2006, researchers from Aberystwyth University began a series of expeditions across Asia to collect germplasm that would form parent plants from which new varieties could be bred. Species from the *Miscanthus* genus were collected from sites across South East Asia and site-specific environmental factors were recorded as well as key plant characteristics (e.g. stem density, stem to leaf ratio, plant height to canopy)<sup>12</sup>.

Under the UN Convention on Biological Diversity each country is sovereign over its own genetic resources. The researchers therefore put in place access and benefit sharing agreements with each country from which they collected plant material, so that whenever a new variety of *Miscanthus* is developed in the future, the country of origin of the parent plant derives benefit<sup>12</sup>.

## Domestication and breeding

Once the material was back in the UK, Aberystwyth began a domestication and breeding programme to provide a range of hybrids to reduce reliance on the dominant commercial variety, *Mxg*.

“After import into the UK, new accessions were quarantined for a year until an all clear was given by FERA plant health inspectors. Diverse *Miscanthus* accessions were characterised in the field and then selected for exploratory crossing to identify parental combinations producing promising hybrids,” says Professor John Clifton-Brown of Aberystwyth University.

Key features the researchers were looking for included: the ability to produce large quantities of biomass annually; an ability to grow on relatively poor-quality land; and the capacity to withstand UK climatic extremes<sup>4</sup>. The best progeny from the nursery-based breeding programme were then planted in trial plots across the UK and Europe to determine their suitability for a range of conditions.

## Seed-based hybrids as a climate change solution

While *Mxg* produces a large amount of biomass, its sterility makes it difficult to increase the amount of land planted with the crop. Using rhizome propagation, one hectare of existing *Miscanthus* can provide sufficient material for planting 20 hectares of new crop. In contrast, seeded *Miscanthus* hybrids can enable growers to produce enough material from one hectare to plant 2000 hectares of new crop, thereby allowing planting rates of thousands of hectares per year.

In order to maximise the growing season and reduce the risk of the *Miscanthus* plants spreading beyond the farms, Aberystwyth have been developing *Miscanthus* hybrids which will not flower under the environmental conditions in the areas in which they will be grown. Instead, the researchers first produced seed from promising parents in climate-controlled glass houses in the UK. Then, support from UKRI- BBSRC and InnovateUK allowed Terravesta and Aberystwyth University to grow parent plants in Southern Europe as part of the MUST (*Miscanthus* Upscaling Technology) project.

The parent plants are carefully managed to ensure synchronous flowering and to maximise pollination and seed production. Seeds are then collected, cleaned, brought to the UK and sown in a commercial nursery to produce machine-plantable plug plants.

“These seeded hybrids are vital to our future business model and the rapid deployment of *Miscanthus* as part of the climate change solution,” explains William Cracroft-Eley, Chairman at Terravesta. “We hold licences for some of the most promising seed-based hybrids developed in Aberystwyth, with the first commercial roll out starting in 2020”.

The team has also been developing the agronomy required for seed-based hybrids, including the use of mulch films to accelerate establishment. According to the NFU’s Chief Advisor on Renewable Energy and Climate Change, Jonathan Scurlock “More rapid

establishment of the *Miscanthus* crop results in it reaching maximum yields a year earlier, and this combined with guaranteed prices paid to the farmer within a long term contract makes the crop very attractive”.

Through collaborative projects, a number of these hybrids are also being trialled in other locations across Europe and beyond. In the EU funded GRACE project, for example, Terravesta and Aberystwyth University are part of a 21-partner consortium in which hybrids are grown on marginal and degraded land in six countries across the EU. Biomass arising from these trials will then be converted into a range of products such as platform chemicals for bioplastic production, building insulation and fibre-reinforced composites, thus ensuring that research and innovations developed in the UK provide benefit across Europe.

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