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# Using stem segments as propagation material to reduce the establishment costs of *Miscanthus giganteus*

## Key external stakeholders:

- Farmers interested in growing energy crops
- The bioenergy industry and, specifically, biomass supply chain companies
- Policy makers and government departments aiming to replace fossil fuels and reduce greenhouse gas emissions

## Practical implications for stakeholders:

The outcome is……

- *Miscanthus* crops can be established from stem segments at significantly reduced cost compared to current systems

## Main results:

*Miscanthus* crops can be established from stem by harvesting stems in September and sowing them immediately into a field without a need for cold storage

The establishment costs of *miscanthus* can be significantly reduced compared to rhizome propagation through the autumn harvest and direct sowing of stem segments. Greenhouse gas emissions from a stem based establishment system are also significantly lower than conventional rhizome propagation.

## Opportunity / Benefit:

Currently the costs of *miscanthus* establishment are significant (> €2500/ha) but the crop does not yield a return until two-three years after establishment. Such economics have hindered the uptake of *miscanthus* and, consequently, its use as a policy instrument to mitigate the effects of greenhouse gas emissions. This research has shown that *miscanthus* crops can be established for less than half of the cost of the current system by using stem segments as planting material. The use of such a system also has the effect of reducing the greenhouse gas emissions associated with establishment by 75%.

## Collaborating Institutions:

University College Dublin



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**External collaborators:** Prof. Kevin McDonnell

## 1. Project background:

Rising greenhouse gas emissions, limited fossil fuel reserves and price volatility have caused a renewed interest in renewable energy. *Miscanthus x giganteus* is a C4 perennial grass that originated in South East Asia and has been identified as a promising biomass crop due to high annual yields under favourable conditions. Despite some promising characteristics as a biomass crop and initial interest within Ireland which peaked in 2007, the adoption of *miscanthus* as a crop has since stagnated. *Miscanthus* is currently established from rhizomes but establishment costs are high as rhizomes need to be excavated from existing crops. This is a costly and greenhouse gas intensive process which also has the effect of destroying an existing crop. There are various alternatives to the use of rhizomes as propagation material but many alternatives are more expensive than the use of rhizomes. However, *Miscanthus* stems can produce shoots and roots at their nodes under certain conditions suggesting that it might be possible to establish *Miscanthus* crops from stem cuttings. The use of stem segments as propagation material may offer a cheaper alternative to the current rhizome system without destroying the potential of an existing crop.

## 2. Questions addressed by the project:

1) Can *miscanthus* crops be successfully established from stem segments?
2) What is the optimum method for establishing crops from stem segments?
3) Can costs and greenhouse gas emissions be lowered significantly by adopting a stem based system for establishing *miscanthus* crops?

## 3. The experimental studies:

Field trials were established to investigate the optimum harvesting and sowing time for *miscanthus* stem segments. In two planting seasons, stem segments of *miscanthus* were cut in September, October or March and either sown immediately or placed in cold storage. These stem segments were sown horizontally underneath the ground at a depth of 100 mm. Establishment, growth and yield were measured in each treatment. On the basis of these experiments, analyses were conducted in which both the cost and the emission of greenhouse gases from the establishment of *miscanthus* crops by the stem based system were compared to the costs and greenhouse gas emissions from the conventional rhizome system.

Autumn harvests remove more nutrients than spring harvests as nutrients are translocated from stems to the rhizome system during the winter months. Consequently, higher nutrient inputs may be necessary in the growing season after an autumn stem harvest and this may impact on the greenhouse gas balance of the system. Nutrient offtakes were quantified following an autumn harvest and nitrogen trials were conducted in the following growing season to determine nitrogen fertilization requirements.

In a separate set of experiments conducted under control conditions, stem segments from crops planted in



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either 1994 or 2010 were harvested each month from September and either stripped of leaves or left with leaves attached before being planted and placed in a growth cabinet for sixty days. Additionally, glasshouse and field experiments were conducted to compare shoot and root production from the bottom section of the stem compared to the shoot and root production from the middle and upper parts of the stem.

## 4. Main results:

The study demonstrated that *miscanthus* crops can be established successfully from stem segments. Establishment rates and subsequent growth and yield were comparable to rhizome based systems. *Miscanthus* plants established from stem cuttings developed rhizome systems and survived the winter to produce new shoots in the second growing season. Establishment rates, stem height, stem numbers and biomass yield in the field trials was maximized by harvesting stems in September and planting them immediately into soil in both trial years. Treatments in which the stems were stored exhibited reduced or no germination.

**Figure 1:** Sowing miscanthus stem segments (left); shoots and roots growing from the nodes of the sown stem segments (right).

The growth cabinet experiments showed that neither the age of the mother crop or leaf removal had any effect on shoot or root formation but that both root and shoot formation were at a maximum in September and decreased thereafter. Shoot and root production was not increased by the use of lower segments of stems under both control or field conditions and there were no significant differences between the number of shoots and biomass produced by the top half, bottom half, and the whole stem suggesting that further improvements to the efficiency of the system may be obtained by splitting the stem into smaller segments before sowing.

Harvested stems in September removed 150 kg N/ha and 120 kg N/ha was required to maintain yield in the



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subsequent crop.

This study employed economic analyses and life cycle assessment methodology to compare both the cost of the two systems as well as greenhouse gas emissions from both systems. The cost of harvesting and sowing one hectare from stem cuttings was found to be €810/ha, considerably lower than the current costs of rhizome based systems (> €2500/ha). This study also found considerable reductions in greenhouse gas emissions when the stem based system was used, 532 kg $CO_2$/ha compared to 2118 kg $CO_2$/ha for conventional rhizome propagation. Sensitivity analysis was used to investigate the effect of nitrogen rate and three different stem segment sowing densities. Use of the highest sowing rate of 39,999 stems/ha and the application of 150 kg N/ha to the mother crop increased the cost of the system to €982/ha with emissions of 1151 kg $CO_2$/ha. At the lowest sowing rate of 13,333 stems/ha and the application of 0 kg N/ha to the mother crop in the growing season after harvest, the cost of the stem based system fell to €809/ha with emissions of 513 kg $CO_2$/ha. Thus, the study demonstrated that there are significant economic and greenhouse gas advantages of moving from a rhizome based propagation system to a stem based propagation system.

## 5. Opportunity/Benefit:

The costs of *miscanthus* establishment are significant (> €2500/ha) but the crop does not yield a return until two-three years after establishment. Such economics have hindered the uptake of *miscanthus* and, consequently, its use as a policy instrument to mitigate the effects of greenhouse gas emissions. This research has shown that *miscanthus* crops can be established for less than half of the cost of the current system by using stem segments as planting material. The use of such a system also has the effect of reducing the greenhouse gas emissions associated with establishment by 75%.

## 6. Dissemination:

### Main publications:

O'Loughlin, J, McDonnell, K and Finnan, J. (2018). Quantifying the economic and geenhouse gas balance advantages of establishing miscanthus from stem cuttings. Biomass and Bioenergy 109, 147-154

O'Loughlin, J, McDonnell, K and Finnan, J. (2017). Establishing miscanthus giganteus crops in Ireland through nodal propogation by harvesting in autumn and sowing them immediately into a field. Biomass and Bioenergy 107, 345-352

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