CULTIVATION & VALORISATION OF BIOMASS ON BORD NA MÓNA CUTAWAY PEATLANDS 2016

Prepared by: Mr. Eamonn Lee
Biomass Project Manager

For the Attention of: Ms. Joanne Sheahan
Programme Executive
Sustainable Energy Authority Ireland,
Wilton Park House,
Wilton Place,
Dublin 2.

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1.0 NON TECHNICAL SUMMARY

2015

Bord na Mona were awarded SEAI funding to carry out trials on Bord na Mona cutaway peatland during 2015. This trial focused on the growing of biomass crops while simultaneously measuring Greenhouse Gas Emissions, harvesting of wetland biomass and evaluating the potential of the harvested material for various end-uses, including; composting, anaerobic digestion and calorific value. The results of the 2015 trials demonstrated the following key deliverables;

1. Reed Canary Grass, Rush and Italian Rye Grass can be successfully established on peatland.
2. Harvesting trials showed high yields (>10dt/ha) for Rush & Reed.
3. Analysis of end uses showed that rush would be a suitable feedstock for combustion.

2016

The results of the 2015 provided the platform for the 2016 trial. Thus the objectives of the 2016 trial were to;

1. Establish Reed Canary Grass/Rush on a larger scale based on success at Boora (2015)
2. Create a robust environmental monitoring programme to determine the impact of fertilisation and cultivation on; groundwater, surface-water and greenhouse gas emissions.
3. Determine the annual yield of Reed Canary Grass by harvesting the Boora (2015) trial plots.
4. Determine the suitability of Reed Canary Grass/Rush for steam explosion.

Growing Trials

A 70 acre site at Cul na Mona was selected for growing Rush (35 acres) & Reed Canary Grass (35 acres). Experimentation was done with 2 different fertilisation rates to determine the impact to seedling establishment success. It was found that 100kg 10:10:20 is required for optimum establishment of both crops.

Dr. David Wilson was employed to conduct an extensive 3 year study on the effect of crop establishment / water table / fertilisation on greenhouse gas emissions from the cutaway. His initial positive findings show that the high water table at this site are causing a net Carbon sink (Ssee Appendix 2). The overall conclusions of GHG emissions will be delivered in yr2 (2017) when the net crop yield (tonnes) is offset against the GHG emissions.

Harvesting Trials

Existing crops of Rush and Reed Canary Grass were harvested at Boora, Co. Offaly. The material was harvested using standard agricultural machinery (tractor, mower, hay-bob, baler). No issues were encountered as Boora is a dry site and weather conditions were unseasonably favourable. For most BNM sites the pioneer equipment employed during 2015 would be preferable. It was found that Rush yielded >10dt/ha while the Reed Canary Grass yielded (>13 dt/ha).

End Uses

Harvested Reed Canary Grass was analysed for composting and thermal combustion value. It was found that it has significant value as compost material. It is however unknown as yet if plant seed will be sterilised during the composting process. This will not be known until late December 2016. It was found that Reed Canary Grass is a good combustion material but are not suitable for co-firing the Edenderry Power station due to high Chlorine content. It is however be suitable for the domestic market through biomass briquetting or through a pelletizing process. Both these avenue are currently being explored to determine their true economic potential.

Future Roadmap

It is now known that Rush & Reed Canary Grass yield exceptionally well. Based on the yields achieved and costs incurred it was found that these crops are potentially viable for biomass briquetting, palletising. Crops established during this trial (2016) will be harvested in September 2017. The outcome of yields obtained, coupled with results of GHG monitoring and financial input will determine the potential for crop establishment on a much larger scale.

2.0 INTRODUCTION

Bord na Móna's peat resource and associated land bank were acquired in the national economic interest. It was originally envisaged as Bord na Móna began to drain and develop the bogs, that in time and as peat layers were removed, the cutaway bogs that remained would present wide ranging opportunities in terms of creating improved land from bogland which was viewed at the time as wasteland and marginal. It was hoped that these cutaway bogs would serve as vast new lands capable of development for commercial after-uses such as cultivation of trees, vegetables and tillage crops, and places to fatten cattle on good agricultural grasslands. This led to the establishment of a number of commercial and agricultural crop trials between the 1970s and 1980s. While there was some limited success in terms of the output and viability of these after-use options, the cutaway bogs did not fulfil those commercial expectations due to poor yielding crops and the infestation of rushes.

2.1 - Objectives

Bord na Mona have over 80,000ha of peatland, of which 30,000ha are cutaway peatland. In addition BNM have given a commitment to cease energy peat harvesting by 2030. With this commitment in mind there will be vast quantities of cutaway peatland coming on-stream in the coming years with no assigned after-ruse.

The purpose of this project is to determine the optimum crop establishment, cultivation, and harvesting methods for growing biomass on cutaway peatland. In addition to growing biomass it is also a requirement of this project to assess its suitability for a range of end uses such as renewable fuel briquettes, direct combustion in power stations and composting for growing media.

- To determine an environmentally sustainable after use for the cutaway peat-land. This will involve the re-establishment of green cover crops on the cutaway in-line with Bord na Mona's commitment to prevent carbon release to the atmosphere.
- To determine the feasibility of harvesting crops of soft rush & Reed Canary Grass for different end-uses. End uses will include; fuel characterisation (BNM Fuels business) and composting (BNM Horticulture business).
- To develop an end to end process to convert wetland biomass into a final revenue stream, resulting in the creation of rural jobs for the local economy.

2.2 – Additional Benefits

- Improved reserve management, both in quality and size of area managed, resulting from mechanisation and utilisation of harvested biomass.
- Improved areas for biodiversity.
- Additional revenue for delivery of conservation.
- Ability to manage larger areas in the future.
- Reduction in CO2 (from more sustainable material disposal) and through the creation of bioenergy products.
- Encouraging the formation of new habitat areas with the potential to generate revenue streams.
- To create new wetland areas to perform roles in flood alleviation and flood storage, with the potential to generate a revenue.
- The opportunity to form new partnerships and meet new people to communicate about the wider importance of nature conservation areas and their potential to contribute to a richer rural economy.

3.0 CROP CULTIVATION

3.1 Site Selection

The Bord na Mona land bank exhibits variable character in terms of peat type, depth, pH, nutrient level and drainage. Therefore selecting a site which is typically representative of cutaway peatland is a difficult challenge. After much deliberation a representative 70 acre site was chosen at Cul na Mona, County Laois.

The site location can be viewed in map below.

Figure 1 – Site location for growing trials

The selected site is relatively free draining and has an underlying silty blue/limestone subsoil. There is approx. 3-4 feet of peat which is typical of cutaway peatland.

3.2 Crop Establishment/Methodology

Fertilisation (RGG/Rush)

One objective of the growing trails is to demonstrate crops establishment using two different fertilisation rates, i.e.; 50kg vs 100kg 10:10:20 (N:P:K) per acre.

Plate 1 – Pre-planting fertilisation at Cul na Mona (26/7/16)

Crop Establishment

Rush seeds last up to 60 years lying dormant. For this reason fertilisation alone is sufficient to cause establishment (based on results of 2015 trial). Reed Canary Grass was established using a standard one pass system. A one pass system is a combination of an air-seeding drill mounted on a power harrow. This unit tilled the soil and placed that artificial fertiliser and seed into the ground. See below picture.

Plate 2 – Sowing RCG at Cul na Mona (27/7/16)

Rolling

After fertilisation and sowing, crops were rolled using an 18ft Cambridge ring roller. The purpose of this is to produce a firm flat seedbed for optimum growing conditions.

Plate 3 – Rolling seedbed at Cul na Mona (29/7/16)

3.3 Results & Observations

Grass Growing Trials

Yield

The below table shows the effect of fertilisation on each of the trial plots;

TABLE 1 – Fertilisation 10:10:20 (N:P:K)		
Crop	Fertilization Rate kg/ac	Observation
Reed Canary	50	Poor establishment, foliage stress – pale yellow – thin leaf
Reed Canary	100	Good establishment, no foliage stress evident – wide green leaf
Rush	50	Slight greening – will take until early spring to see full evidence
Rush	100	Appears significantly more green – too early to determine

4.0 GREENHOUSE GAS EMISSIONS

It is not known if cultivating crops on cutaway peatland causes excess release of CO2, N2O of CH4 to the atmosphere. For this reason Dr. David Wilson was employed to conduct an extensive 3 year study on the effect of crop establishment / water table & fertilisation on greenhouse gas emissions from the cutaway peatland. His initial positive findings show that the high water table at this site are causing a

net Carbon sink (Ssee Appendix 2). The overall conclusions of GHG emissions will be delivered in yr2 (2017) when the net crop yield (tonnes) is offset against the GHG emissions.

5.0 CROP HARVESTING TRIALS (RCG/RUSH).

5.1 Site/Crop Selection

The sites for this were chosen as part of the 2015 trial. These sites were revisited as to harvest the crops to determine the yield.

Plate 4 – 5ft Tall RCG at Boora (sown 2015)

5.2 Method

RCG & Rush trial plots were mown down using a 10ft conditioner mower on the 10th September. After mowing material was left to settle and wilt (dry out) for 3 days. It was then spread out using a haybob, before being rowed up again with a haybob for baling on the 9-10h October.

Plate 5 – RCG Rowed up with haybob for balling at Boora (9/10/16)

Plate 6 – RCG Bales at Boora (10/10/16)

5.3 Results & Observations

The material was harvested using standard agricultural machinery (tractor, mower, hay-bob, baler). No issues were encountered as Boora is a dry site and weather conditions were unseasonably favourable. For most BNM sites the pioneer equipment employed during 2015 would be preferable.

Yields

The harvested materials were baled and transported to Kilberry composting plant and Littleton Briquette factory on the 11th October 2016. Rush and Reed were weighed in separately upon entering the facilities and moisture readings taken.

Table 5.3 – RESULTS OF HARVESTING TRIALS

Crop	Moisture %	Yield (tonne)	Area (acres)	Yield Green tonne/ac	Yield Dry tonne/acre	Yield Dry tonne/hectare
Rush	28.3	7.2	1.19	6.05	4.338	10.719
RCG	18.4	6.78	1.36	4.99	5.53	13.67

Pricing

Costs were determined based on yield and moisture content. This information is confidential to Bord na Mona and are also outside remit of this report but are available upon request. However it should that be noted that this is valuable information for decision makers with relation to financial viability of various end uses.

6.0 END USES

Harvested Rush material was analysed for composting/thermal combustion and biogas yield as part of the 2015 trial and was therefore not re-evaluated. Harvested rush material was instead delivered to Littleton to form a biomass briquette (separately funded project). Harvested Reed Canary Grass was analysed to determine its potential as a compost diluent and as biomass fuel for thermal combustion. The full reports for each end use are available upon request. A summary of the main findings for each potential end use are discussed below.

6.1 Composting

The Reed Canary Grass was delivered to the BNM composting facility in Kilberry. All material was weighed in prior to being unloaded in the composting yard. The bale netting was removed and the material was stockpiled into windrows for composting. As part of the composting process, additives were included such as brewers grain (to speed up fermentation) and timber sticks (to improve aeration). The stockpiles were then turned at regular intervals using the windrow machine.

Plate 7 – Windrow turning at Kilberry

Composting temperatures of greater than 55^{o}C are required to ensure pathogen kills as well as denaturation of most common weed seeds, both traits (weed and pathogen free) are essential plant growing media. These temperatures were met and indeed exceeded within 1-2 weeks of forming the composting windrows. However, the persistence of RCG seeds remain a concern. Proceeding with RCG as a composting feedstock for growing media would not be possible should these seeds remain viable after composting.

6.2 Biomass Fuel

It was discovered that there slightly elevated levels of chlorine in the RCG material (0.11% to 0.16%). This eliminates the possibility of using this crops as co-firing materials in the Bord Na Mona power stations without some sort of pre-treatment process to remove salts. The limit for the power stations is 0.1% as anything above 0.1% causes corrosion of the boilers within the power stations.

Despite the high chlorine content it was found to be a valuable biomass fuel due to its calorific value (18-19Mj) and so has potential to be used as a fuel in other biomass briquetting and pelletizing. See Fuel Characterisation (Appendix 1) for full detail of the parameter analysis. Bales RGC was delivered to Littleton to for biomass briquettes (separately funded project).

6.3 Biogas Yield (Anaerobic Digestion)

The funding application included capex to conduct biogas analysis on the Reed Canary Grass (€14,000). However this was not completed as there is enough data readily available on this subject. Therefore it was felt and agreed by the BNM working group that this would not be money well spent. The submitted grant claim workbook does not include this costing and therefore comes in under budget.

7.0 FUTURE ROADMAP

It is now known that Rush & Reed Canary Grass yield exceptionally well. Based on the yields achieved and costs incurred it was found that these crops are potentially viable for biomass briquetting, palletising. Crops established during this trial (2016) will be harvested in September 2017. The outcome of yields obtained, coupled with results of GHG monitoring and financial input will determine the potential for crop establishment on a much larger scale.

Appendix 1

Fuel Charachterisation (Lab Report)

CERTIFICATE OF ANALYSIS

Alfred H Knight

EAMON LEE
BORD NA MONA ENERGY LTD
MAIN STREET
NEWBRIDGE
CO. KILDARE
IRELAND

Date of Report: 10-Oct-2016

Sampling Date: 06-Sep-2016 to 29-Sep-2016

AHK Ref: B/341804/DD28152
Client Ref: WILLOW, EUCALYPTUS & REED CANARY GRASS

Material Described As: WILLOW, EUCALYPTUS & REED CANARY

Client Ref.	Test	Unit	As Received	Dry Basis	Dry Ash-Free
Reed Canary Grass 29/9/16					
	Total Moisture	%	32.8		
	Ash Content	%	0.7	1.1	
	Volatile Matter	%	54.9	81.7	82.6
	Fixed Carbon	%	11.6	17.2	17.4
	Total Sulphur	%	0.03	0.04	0.04
	Chlorine	%	0.11	0.16	0.16
	Carbon	%	31.6	47.0	47.5
	Hydrogen	%	4.19	6.24	6.31
	Nitrogen	%	0.42	0.62	0.63
	Oxygen By Difference	%	30.1	44.8	45.3
	Gross Calorific Value	MJ/Kg	12.635	18.802	19.011
	Net Calorific Value	MJ/Kg	10.920		
	Bulk Density	T/m3	0.050		

KNIGHT ENERGY SERVICES LTD

Ken Hepburn
Biomass Manager
For and on behalf of KNIGHT ENERGY SERVICES LIMITED

KNIGHT ENERGY SERVICES LIMITED
Unit 1, Palmermount Industrial Estate, Duncanald, Ayrshire KA2 9BL, Scotland
Tel: (01563) 850375 Fax: (01563) 850830 Email: ahk.scotland@ahkgroup.com

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Client Ref: WILLOW, EUCALYPTUS & REED CANARY GRASS

Client Ref.	Test	Unit	Result
Reed Canary Grass 29/9/16			
	ASH FUSION TEMPERATURES OXIDISING		
	Initial Deformation Oxidising	°C	1205
	Softening Temperature Oxidising	°C	1300
	Hemispherical Temperature Oxidising	°C	1400
	Flow Temperature Oxidising	°C	> 1500

Ken Hepburn
Biomass Manager
For and on behalf of KNIGHT ENERGY SERVICES LIMITED

KNIGHT ENERGY SERVICES LIMITED
Unit 1, Palmermount Industrial Estate, Dundonald, Ayrshire KA2 9BL, Scotland
Tel: (01563) 850375 Fax: (01563) 850830 Email: ahk.scotland@ahkgroup.com

Appendix 2

GHG Emission Report

Earthy Matters Environmental Consultants

The greenhouse gas monitoring site was established on August 12th 2016. This entailed the installation of stainless steel collars (60 x 60cm) in the peat (see photo below). Two collars were placed in an area of bare peat to act as controls (i.e. no disturbance). Four collars were placed close by and were sown with Reed canary grass (*Phalaris arundinacea*) and fertilised with 10.10.20 NPK. A weather station (WatchDog Model 2400; Spectrum Technologies Inc., Aurora, IL, USA)) was also established at the site and was programmed to record photosynthetic photon flux density (PPFD: µmol m^{-2} sec^{-1}) and soil temperatures (°C) at 10 minute intervals. Two perforated pipes were placed close to the collars to permit the manual measurement of water levels. Wooden boardwalks were also established near the collars.

Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) fluxes were measured before and after the RCG was sown. CO_2 is measured in situ (over a 1-3 minute period) with a transparent chamber and infrared gas analyser (IRGA) and the results from Day 1 and subsequent measurement days are shown in Figures 1 and 2. In contrast, CH_4 and N_2O are monitored with an opaque chamber and air samples are collected over a 40 min period, placed in air tight vials and sent to a laboratory in Germany for analysis. Results are not available at the time of preparing this report.


Sowing of RCG at the GHG monitoring site.


CO_2 chamber and IRGA

Chambers for CH_4/N_2O sampling

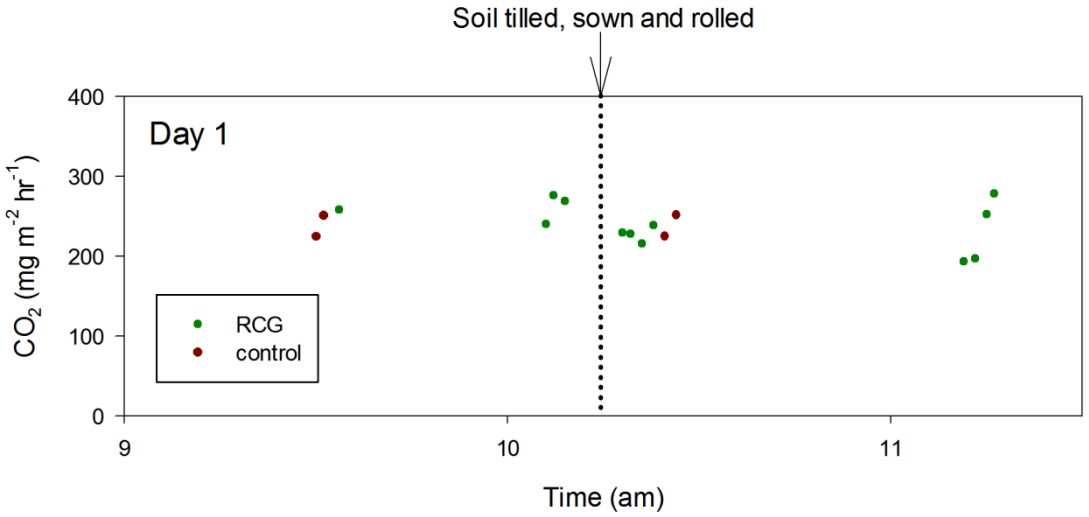

Figure 1 Carbon dioxide (CO_2) fluxes (mg m^{-2} hr^{-1}) from the control and Reed Canary Grass (RCG) plots on day 1. Positive CO_2 values indicate emissions from the soil to the atmosphere. Dotted vertical line indicates when the soil surface was tilled, fertiliser and RCG seeds sown and the soil compacted by rolling.

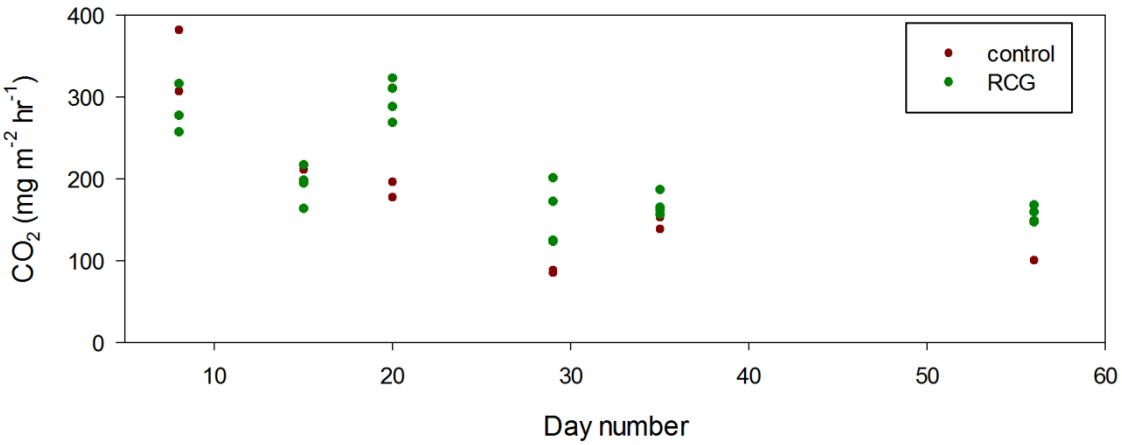

Figure 2 Carbon dioxide (CO_2) fluxes (mg m^{-2} hr^{-1}) from the control and Reed Canary Grass (RCG) plots on days subsequent to sowing (i.e. day 1). Positive CO_2 values indicate emissions from the soil to the atmosphere.

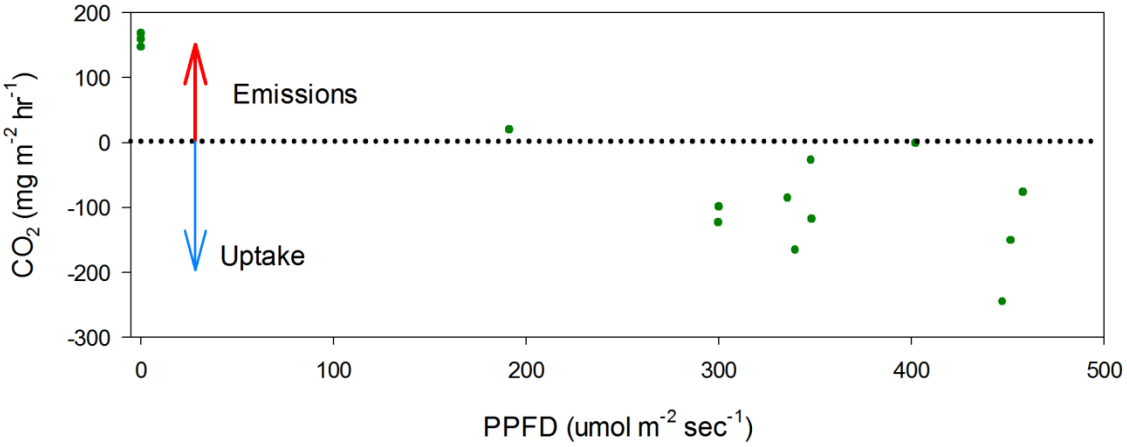

Figure 3 Net ecosystem exchange (NEE; mg m-2 hr-1) versus PPFD at the RCG plots in October 2016. Positive CO_2 values indicate emissions from the soil to the atmosphere an negative values indicate uptake by the RCG plants.

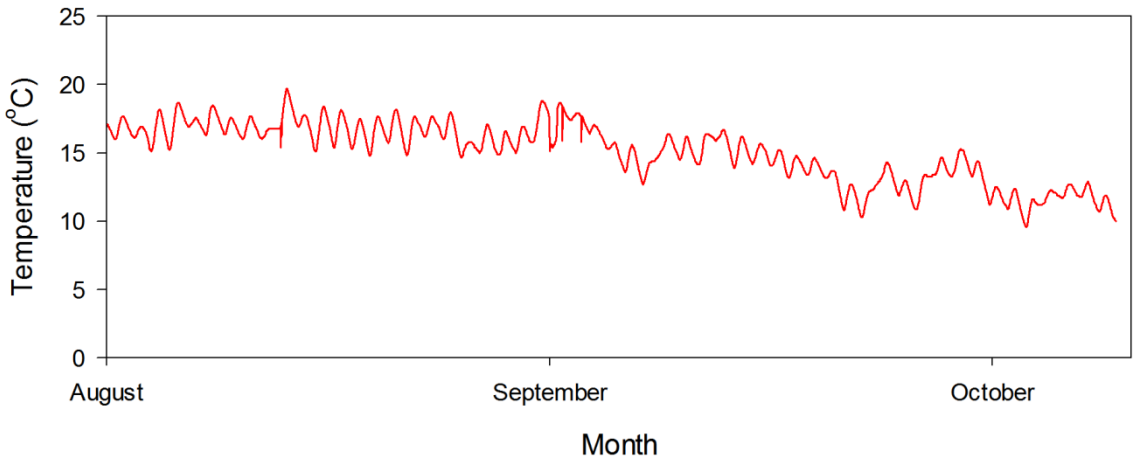

Figure 4 Soil temperature (°C) at a depth of 10cm from August 13th to October 7th 2016.