# Sustainable Liquid Biofuels from Biomass Biorefining (SUNLIBB)

## **Work Package 8:** Sustainability Assessment

**Task 8.4:** Application to Miscanthus Biorefineries

**Deliverable D8.1:** Supporting Sustainability Criteria: Miscanthus

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# Executive Summary


1. This report investigates relevant environmental sustainability criteria for miscanthus as a biomass feedstock for biofuel production in biorefineries within the context of the “Sustainable Liquid Biofuels from Biomass Refining” (SUNLIBB) Project. The SUNLIBB Project is funded by the European Commission (EC) under the 7th Framework Programme within the Energy Theme: Second Generation Biofuels and involves collaboration with the CeProBio Project in Brazil. The aims of the SUNLIBB Project are outlined and the rôle of Work Package 8 in addressing sustainability assessment is explained.

2. The current European Commission framework of sustainability criteria for biofuels and bioliquids in the European Union is introduced, particularly in terms for the Renewable Energy Directive. It is noted that the quantitative assessment of sustainability criteria is mainly restricted to the evaluation of the total greenhouse gas emissions associated with biofuel and bioliquid production. Currently, it has been proposed that biofuels and bioliquids derived from miscanthus should be given relatively favourable status under classification as non-food cellulosic materials. As such, they are not covered by the proposed addition of greenhouse gas emissions factors based on implied indirect land use change.

3. Other sustainability criteria are identified although these are addressed more broadly in the current regulatory framework for biofuels and bioliquids. They are evaluated in a necessarily qualitative manner using existing research, studies and published literature. These sustainability criteria for miscanthus include land use, carbon sequestration, soil erosion, water use, emissions to water, emissions to air, biodiversity and other impacts such as the potential invasiveness of miscanthus and traffic levels likely to be generated by large-scale, commercial biorefineries.

4. Conclusions are formulated and mitigation measures are described which might ensure or enhance the environmental sustainability of miscanthus as a source of biomass feedstock for biorefineries. In particular, the potential benefits of miscanthus as a means of reducing soil erosion and assisting flood control are noted.

5. To avoid any future concerns over indirect land use change, it may be necessary to consider the use of non-productive land in the European Union for the miscanthus plantations provided these can achieve economically-attractive yields. The production of miscanthus on unused permanent grassland may depend on demonstrating the potential for significant carbon sequestration.

6. Other sustainability aspects of this biomass feedstock crop are largely influenced by site-specific considerations including the location, scale and management of miscanthus plantations. Careful planting designs, management plans and harvesting schedules will be needed to avoid reduced rain run-off to any local surface reservoirs for public water supply, to minimise nitrate leaching from establishment, and to maximise comparative biodiversity.

7. The potential invasiveness of miscanthus can be controlled by suitable biosecurity measures and local concerns over traffic levels around biorefineries can be addressed by careful consideration of timing and routes.

## Contents

## 1. INTRODUCTION

The "Sustainable Liquid Biofuels from Biomass Refining" (SUNLIBB) Project is funded by the European Commission (EC) under the 7th Framework Programme within the Energy Theme: Second Generation Biofuels. Its support came about through the European Union (EU) – Brazil Co-ordinated Call and its activities involve collaboration with the CeProBio Project in Brazil. The aims of the SUNLIBB Project are:

- to use modern crop breeding approaches and cutting edge plant cell wall research to identify genes that will allow modification of cell wall composition so as to reduce costs associated with conversion processes,

- to upgrade residues and by-products, and to produce other value streams from biomass feedstocks so that the total energy output and profitability of second generation biofuels will be increased,

- to improve the process of converting sugars in biomass feedstocks into biofuels,

- to bring together improvements in biomass feedstocks and conversion processes in biorefineries so that the economic and environmental sustainability of second generation biofuels can be enhanced, and

- to review all pertinent guidelines, policies and regulatory frameworks for sustainable biofuels in both the EU and Brazil in order to take into account any influential developments that could affect the future potential for harnessing benefits from this work.

Within the SUNLIBB Project, Work Package (WP) 8 is concerned with "Sustainability Assessment". Task 8.1 involves reviewing the policy and regulatory context at EU and Member State (MS) levels which have been reported in Deliverable D8.1 (Ref. 1). Specific environmental aspects of biorefineries supplied with sugar cane, maize and miscanthus feedstocks are addressed in Tasks 8.2 to 8.5. In particular, primary energy inputs, as indicators of energy resource depletion, and prominent greenhouse gas (GHG) emissions, in the form of carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$), as indicators of global climate change, are quantified by means of MS Excel workbooks for sugar cane biorefineries (Task 8.2), maize biorefineries (Task 8.3) and miscanthus biorefineries (Task 8.4). Sensitivity and comparative analysis are the main activities of Task 8.5. In addition to the quantification of specific environmental concerns, both Tasks 8.3 and 8.4 involve the qualitative assessment of other sustainability criteria for biofuels derived from biorefineries which process maize and miscanthus, respectively. This report covers the qualitative assessment of miscanthus as a biorefinery feedstock.

## 2. SUSTAINABILITY CRITERIA

Sustainability criteria for biofuels and the biomass feedstocks from which they can be derived have evolved over a period of time in the EU. Officially, the initial consideration of sustainability criteria was raised in the EC's Renewable Energy Directive or RED (Ref. 2). Within the RED, the main focus for biofuels is the evaluation of total GHG emissions within the context of target net savings relative to fossil fuel comparators. However, other aspects of environmental sustainability are related to the conversion of land to biomass feedstock cultivation and potential threats of carbon stock destruction (Ref.2; paras. 70 – 73); the protection of ground water and surface water quality (Ref. 2; para. 74); the avoidance of soil erosion (Ref. 2; para. 77); and the promotion of biodiversity (Ref. 2; para. 69). The specific sustainability criteria set out in the RED stated that biofuels should not be derived from land with highly biodiverse value (primary forests and other undisturbed wooded land, protected areas and highly diverse grassland) nor from wetlands and continuously forested areas (Ref. 2; Article 17, paras. 1 -6). Furthermore, a requirement was laid on the EC to report periodically on these aspects and soil, water and air protection associated with the provision of biomass feedstocks for biofuel production, and implementation of the Cartagena Protocol of Biosafety and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Ref. 2; Article 17, para. 7). Additionally, the issue of social sustainability was addressed by emphasising compliance with Conventions of the International Labour Organisation regarding forced or compulsory labour; freedom of association and protection of the right to organise; application of the principles of the right to organise and to bargain collectively; equal remuneration of men and women workers for work of equal value; abolition of forced labour, discrimination with respect of employment and occupation; minimum age of admission to employment; and prohibition and immediate action for the elimination of the worst forms of child labour (Ref. 2; Article 17, para. 7).

The conversion of land for the cultivation of biomass feedstocks for biofuel production is generally covered by the term "direct land use change" (dLUC). This is now accommodated with GHG emissions calculations by the evaluation of carbon stock changes as specified by a standard approach established by the EC (Ref. 3). Broadly speaking, in order to meet required net GHG emissions savings by biofuels, the incorporation of the effects of dLUC into GHG emissions calculations discourages the cultivation of biomass feedstocks on land whose recent conversion has involved the destruction of high carbon stocks, such as forests, peatlands and grasslands. The RED also pointed to concern over the impact of biofuel production on food prices (Ref. 2; Article 17, para. 7). This, in turn, relates to the issue of "indirect land use change" (iLUC) in which the cultivation of biomass feedstocks displaces previous food production that results, eventually, in the destruction of carbon stocks as land is converted elsewhere to arable and livestock farming. This is a very controversial issue since estimation of the actual magnitude of carbon stock changes which can be attributed to the original biomass feedstock cultivation depends on the reliability and accuracy of global land use modelling. However, this has led the EC to propose additional iLUC factors for the cultivation of certain biomass feedstocks as part of amendments to the Fuel Quality Directive (FQD) and the RED (Ref. 4). Currently, these factors cover cereals and other starch-rich crops, sugars and oil crops. As such, this would affect biofuels derived from starch in maize and sugar in sugar cane. Conversely, measures are also proposed to encourage the production of biofuels from specific residues, including bagasse from sugar cane processing, and "non-food cellulosic material", such as that provided by whole maize and miscanthus[1]. The EC has also elaborated the interpretation of sustainability criteria for biofuels (Ref. 5). In addition to adding details to specific calculations of total GHG emissions, this seeks to clarify definitions of land with high carbon stocks and high biodiversity value.

[1] The proposed mechanism for encouraging the use of such biomass feedstocks is to inflate the contribution of biofuels derived from them to the revised targets of the contributions for the proportion of biofuels and bioliquids to transport fuel supply.

## 3. MISCANTHUS SUSTAINABILITY CRITERIA

There is a defined methodology for quantifying total GHG emissions associated with the production of biofuels and bioliquids in the EU in order to meet specified targets for net GHG emissions savings. Such quantification is addressed for biorefineries supplied by miscanthus in a specially-developed MS Excel workbook which forms the other part of this Deliverable, the current version of this being SUNLIBB Miscanthus Biorefinery v02.xlxs (Ref. 6). The current official approach other sustainability criteria is more generalised. However, it is possible to identify broad categories of sustainability criteria that need to be considered for miscanthus. In particular, these include land use; carbon sequestration; soil erosion; water use; emissions to water; emissions to air; biodiversity and other impacts such as invasiveness and traffic issues.

### 3.1 Land Use

Miscanthus is a perennial crop which provides an annual supply of biomass feedstock once it has been established by means of planting rhizomes or sowing seeds. It is an attractive biomass feedstock for both biofuel and bioenergy, in the form of heating, cooling and electricity generation, because it is a relatively low input energy crop with a high yield that can be grown in many EU MSs outside “frost kill” and “drought kill” regions (Ref. 7). Under current proposals, it would be regarded as a non-food cellulosic material which would be encouraged as a source of biofuels. Additionally, it would not be affected by any currently-proposed iLUC “penalty factor” in terms of the evaluation of associated GHG emissions. However, it can still be grown on land which might otherwise have been used for food production and, hence, strictly speaking, could cause iLUC and an overall increase in total GHG emissions. Hence, it is possible that, in the future, the cultivation of miscanthus on land that could be used for food production might be discouraged by regulation in within the EU. Under such circumstances, it may be necessary to grow miscanthus on other types of land, especially if it is intended to produce large quantities of this biomass feedstock.

Along with other perennial energy crops, it has been suggested that miscanthus might be grown on marginal land, degraded land or contaminated land. Leaving aside uncertainties over the precise classification and identification of such land that might not be suitable for food production, the cultivation of miscanthus on these types of land raises a number of important issues. Most significantly, there is the concern that cultivation of miscanthus on land which is in any way less fertile or suitable might reduce its annual yield which is an economically attractive attribute of this particular biomass feedstock. For examples, studies in Portugal and the United Kingdom (UK), reported in Ireland (Ref. 8) indicate that miscanthus yields are lower on land contaminated with heavy metals. If miscanthus cultivation were to be forced onto less productive land, it may be tempting to counteract any underlying decline in yields by applying significant amount of nitrogen (N) fertiliser. Whilst field trials in the UK have indicated miscanthus yield does not respond to N fertiliser application rates (Ref. 9), any increases in such application would undermine the potential benefits of this biomass feedstock in terms of relatively low GHG emissions associated with its provision. This concern would have to be addressed by conducting field trials of yield response to N fertiliser application for miscanthus gown on less productive land.

With regard to the possible cultivation of miscanthus on contaminated land, there may be no immediate concerns over likely take up of pollutants such as heavy metals and organic chemicals based on field trials conducted in the UK (Ref. 10). However, it would be necessary to establish that such contaminants do not interfere with the pre-treatment and/or subsequent processing of this biomass feedstock in proposed biorefineries. This would have to be investigated by testing of miscanthus samples with different types and amounts of possible contaminants. Additionally, there might be concerns that such contaminants could ultimately appear in the waste products from these biorefineries. The ways in which such contamination might have to be addressed would depend on the subsequent treatment of these waste products. For example, if used in anaerobic digestion to generate biogas, the resulting digestate may become contaminated which could pose problems for its subsequent use as an organic fertiliser. Alternatively, if dried and burnt for energy recovery, flue gas controls may have to be imposed and ash disposal restricted. Clearly, careful evaluation of potential impact pathways would have to be considered although the possibility of using contaminated land in such a productive manner could be extremely attractive in the future.

### 3.2 Carbon Sequestration

Another particularly attractive feature of energy crops such as miscanthus and short rotation coppice (SRC) is that they may offer the potential for carbon sequestration in the soils in which they are grown over duration of their cultivation and harvesting. Indeed, there is evidence that miscanthus increases soil organic carbon (SOC) from research undertaken in the United States of America (USA) into derivation of a relationship for carbon sequestration (Ref. 11). In addition to possible general environmental benefits, this has significant implications for the evaluation of total GHG emissions associated with biofuel production from miscanthus. This is because the GHG emissions calculation methodology within the RED provides for effective "credits" from carbon sequestration due to increased SOC (Refs. 2 and 5). In particular, widespread demonstration of substantial carbon sequestration by miscanthus could justify conversion of grassland, especially if it is currently unused, to this biomass feedstock cultivation in terms of required targets for net GHG emissions savings. However, it would be necessary to obtain robust evidence that significant increases in SOC could be achieved and maintained over a reasonable period of time for miscanthus grown on different types of land involving conversion from different previous uses.

### 3.3 Soil Erosion

Water- and wind-induced erosion of cultivated land is a major impact in a number of regions of the world. These impacts, which are likely to increase with global climate change, may begin to occur more frequently in a wider number of areas within the EU. Research has been conducted on relative water-induced soil erosion rates when annual arable cropland and grassland has been converted to miscanthus production (Refs. 12 to 15). In general, it has been concluded that miscanthus would decrease soil erosion compare with conventional annual crops but increase soil erosion relative to grassland (Ref. 16). This indicates again that the choice of land for miscanthus cultivation and its former use are important considerations for the environmental sustainability of this biomass feedstock.

## 3.4 Water Use

The relatively high water requirements of $C_4$ plants, such as miscanthus, due to their leave surface evaporation rates, are well-known. For this reason, miscanthus cultivation is most suitable for regions for the EU with rainfall higher than 600 mm/a based on guidelines published in the UK for SRC which is considered to have similar requirements to $C_4$ plants (Ref. 17). However, further considerations influence the planting and cultivation within any given area with respect to water use. Given the water demands of miscanthus, run-off from planted areas can be significantly reduced. This implies that the planting of substantial areas of similar miscanthus cultivars should be avoided in catchment areas which contain surface reservoirs for public water supply. This is because such miscanthus plantations could reduce run-off to these reservoirs during summer months when the demand for public water supply is high (Ref. 16). Conversely, reduction in run-off is a beneficial attribute in autumn and winter months when miscanthus plantations could prevent flooding, especially during periods of sustained, heavy rainfall. From this, it is apparent that careful planning of miscanthus planting, in terms of location, scale and choice of cultivar, is required in certain water catchment areas. Additionally, the timing of miscanthus harvesting may also be an important consideration. This is because harvesting typically occurs during autumn and winter months and the sudden removal of the substantial ground cover provided by miscanthus could lead to subsequently sudden increases in run-off. Hence, selective harvesting of different areas of this crop may be required to avoid localised flooding events.

## 3.5 Emissions to Water

The main emissions to water from miscanthus cultivation appear to be related to nitrate leaching during its establishment phase (Ref. 18). This might be expected since N fertiliser is sometimes applied during the establishment of miscanthus. However, relatively high nitrate levels in water have been observed even when no N fertiliser has been applied. This has been attributed to high nitrogen mineralisation rates and relatively low growth rates in the first year of cultivation (Ref. 19). However, this appears to be a short-lived effect and subsequent nitrate levels in water have been measured at similar or lower levels to those associated with other crops.

## 3.6 Emissions to Air

The main emissions to air associated with miscanthus relate to diesel combustion during establishment, cultivation, harvesting and transportation. Apart from prominent GHG emissions, diesel combustion is chiefly responsible for the release of oxides of nitrogen (NOx), particulates, sulphur dioxide, carbon dioxide and non-methane volatile compounds. Many of these emissions are related to air quality problems although these are usually an issue in urban areas where diesel combustion is concentrated principally due to high levels of traffic. These emissions to air are of less concern because most if not all operations related to miscanthus production take place in rural settings where activities are dispersed over comparatively large areas.

### 3.7 Biodiversity

The relative biodiversity of miscanthus plantations would appear to depend on the phase of cultivation under consideration and the comparative land use chosen. In general, younger stands of miscanthus would seem to have no detrimental impacts on mammal and bird populations although lower numbers have been observed as stands grow and mature (Ref. 19). This is mainly due to the open nature of plantations at an early stage of growth which disappears with age as the ground cover increases, the canopy closes and foliage becomes denser. However, it has been reported by numerous studies that biodiversity in miscanthus plantations is higher than that observed with conventional annual crops (Ref. 16). This appears to be due mainly to the fact that there is less frequent disturbance and lower or no agrichemical use with miscanthus. Additionally, depending on the schedule for harvesting, miscanthus can provide protection for fauna in some winter months. The planning of miscanthus plantations clearly influences their relative biodiversity and it has been concluded that the size of fields, their proximity to other types of vegetation and the timing of harvesting are all important considerations (Ref. 16). The relative reduction in disturbance associated with miscanthus is also regarded as a positive feature for biodiversity as disruption of predator-prey relationships, especially those involving insects, is minimised (Ref. 19). This has crop benefits in reducing damage by pests and diseases.

### 3.8 Other Impacts

Concerns have been expressed about the potential for miscanthus to become an invasive weed due to its growth characteristics which include quick establishment, highly efficient nutrient and water utilisation, and transfer of nutrients to rhizomes (Ref. 20). However, this is not considered to be a major threat because miscanthus produces sterile seed so that propagation cannot occur by this particular mechanism (Refs. 21 and 22). The other mechanism for propagation is via the spread of miscanthus rhizomes. However, these do not migrate naturally at a rapid rate as evidence indicates that, over a period of more than 20 years, miscanthus rhizomes have not moved more than 1 metre from their original planning positions (Ref. 23). There is the possibility of accidental propagation by human intervention, such as the spreading of rhizomes from agricultural machinery and vehicles. This may require adequate biosecurity measures and the eradication of rogue miscanthus plants as part of an appropriate management plan. This would include transporting rhizomes and cut stems for planting in containers, field margins to ensure containment and set back or buffer zone for separation from potential means of dispersal, such as water courses (Ref. 20).

Another issue which affects most biomass feedstocks is the generation of traffic levels, especially during the harvesting period, around the biorefinery. As a biomass feedstock, miscanthus is a relatively low bulk density material. Normally, it is supplied initial as chopped or baled miscanthus with bulk densities of 70 $kg/m^3$ and 240 $kg/m^3$, respectively (Ref. 24). Some increase in bulk density can be achieved by pelletising. However, pelletising is unlikely in terms of supplying a biorefinery which might be expected to be located near the sources of miscanthus supply. However, transportation from farms to a biorefinery by bulk road freight lorries would be favoured from an economic perspective, thereby reducing vehicle movement relative to the use of tractors and trailers. Transportation is likely to be spread out over a period of time if storage at the biorefinery is limited. Additionally, transportation would coincide with the harvest during the autumn and winter months when other agricultural traffic would be low. Hence, traffic levels should not create major problems if access routes and schedules are carefully organised to minimise nuisance for local inhabitants.

## 4. CONCLUSIONS

A number of sustainability criteria have been established for biofuels and bioliquids within the EU under the RED from the EC. In particular, quantitative regulations exist for the production of biofuels from miscanthus in terms of associated total GHG emissions and net GHG emissions savings relative to conventional diesel and petrol used as transport fuels. However, other sustainability criteria are broader and can only be addressed in a qualitative manner. In general, these sustainability criteria depend on site-specific considerations including the location, scale and management of miscanthus plantations. In particular, the establishment, cultivation, harvesting and transportation of miscanthus appear to present no impacts on emissions to air greater than other existing agricultural activities. Other environmental aspects raise opportunities to apply particular approaches for ensuring or enhancing the sustainability of miscanthus as a biomass feedstock for supplying biorefineries:

- to avoid possible future conflicts related to iLUC whilst establishing large-scale commercial production within the EU, it may be necessary to consider the use of non-productive land, in the form of marginal land, degraded land, contaminated land, and, perhaps, unused permanent grasslands, for the miscanthus plantations provided it can be demonstrated that economically-attractive yields can be achieved and maintained,

- to achieve minimum net GHG emissions savings associated with biofuels derived from miscanthus grown on unused permanent grassland, it may be necessary to demonstrate the potential for significant carbon sequestration by this energy crop,

- to benefit from the ability of miscanthus to reduce comparative soil erosion and heavy rain run-off, planting and management plans should be integrated into local and regional soil conservation and flood prevention measures,

- to avoid problems with reduced rain run-off and initial nitrate emissions to water, it will be necessary to devise careful planting designs, management plans and harvesting schedules for individual or groups of miscanthus plantations which avoid conflict with the requirements of local surface water reservoirs and minimise nitrate leaching during establishment,

- to maximise comparative biodiversity, it will also be necessary to devise careful planting designs, management plans and harvesting schedules for individual or groups of miscanthus plantations which results in a sequence of establishment and harvesting that provides different levels of ground cover across a given area,

- to prevent any threat of miscanthus as a possibly invasive weed, management plans with reasonable biosecurity measures may be necessary to ensure the containment of rhizomes and stem cuttings during transportation and to provide separation zones that prevent accidental propagation during cultivation, and

- to address any potential concerns over traffic levels, especially in the vicinity of biorefineries, harvesting and transportation plans for miscanthus should be devised to prevent congestion and minimise vehicle movements through careful consideration of timing and routes.

## REFERENCES


1. "Sustainability Policy and Regulatory Review Report" by L. C. Stringer and S. Afionis, SUNLIBB Deliverable D8.1, University of Leeds, Leeds, United Kingdom, March 2012.

2. "Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the Promotion of the Use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC" European Commission, Brussels, Belgium, 5 June 2009, http://ec.europa.eu/energy.

3. "Commission Decision on the Guidelines for the Calculation of Land Carbon Stocks for the Purposes of Annex V of Directive 2009/28/EC" Official Journal of the European Union, L151, p. 19 - 41, European Commission, Brussels, Belgium, 17 June 2010, http://ec.europa.eu/energy.

4. "A Proposal for a Directive of the European Parliament and of the Council Amending Directive 98/70/EC Relating to the Quality of Petrol and Diesel Fuels and Amending Directive 2009/28/EC the Promotion of the Use of Energy from Renewable Sources" COM(2012) 595 Final, European Commission, Brussels, Belgium, 17 October 2012, http://ec.europa.eu/energy.

5. "Communication from the Commission on the Practical Implementation of the EU Biofuels and Bioliquids Sustainability Scheme and on Counting Rules for Biofuels" 2010/C 160/02, European Commission, Brussels, Belgium, 19 June 2010, http://ec.europa.eu/energy.

6. "Miscanthus Supply Chain Workbook" by C. Hatto, O. Mwabonje and N. D. Mortimer, SUNLIBB Miscanthus Biorefinery v02.xlxs, Deliverable D8.4, North Energy Associates Ltd., Sheffield, United Kingdom, March 2013.

7. "The European Potential to Produce Bioenergy: Miscanthus Potential for Current and Future Climates" by A. Hastings, Institute of Biological and Environmental Sciences, University of Aberdeen, Aberdeen, United Kingdom, www.euagri.org, accessed 31 March 2013.

8. "Report from the Republic of Ireland: Update Report" by A. Donnelly, B. Rice and M. Jones, Interactive European Network for Industrial Crops and their Applications (IENICA) Project, Centre for the Environment, Trinity College Dublin, Dublin, Ireland, December 2003.

9. "Growth, Yield and Mineral Content of *Miscanthus X Giganteus* Grown as a Biofuel for 14 Successive Harvests!" by D. G. Christian, A.B. Riche and N. E. Yates, Industrial Crops and Products, Volume 28, Issue 3, pp. 320 – 327, November 2008.

10. "Biomass, Remediation, Re-gasification (BioReGen Life Project): re-using brownfield sites for renewable energy crops" by R. Lord, J. Atkinson, A. Lane, J. Scurlock and G.Street, GeoCongress08, ASCE Geotechnical Special Publication 177, pp. 527 – 534, New Orleans, United States of America, 9 – 12 March 2008.

11. “Soil Carbon Changes under Miscanthus Driven by $C_4$ Accumulation and $C_3$ Decomposition – towards a default sequestration function” by C.Poeplau and A. Don, Global Change Biology Bioenergy, 29 January 2013, DOI: 10.1111/gcbb.12043.

12. “Sustainability of Energy Crops in Europe” by E. E. Biewinga and G. van der Bijl, Centre for Agriculture and the Environment, Utrecht, the Netherlands, 1996.

13. “Erosion-preventive Crop Rotations for Landscape Ecological Stability of Upland Regions of Lithuania” by B. Jankauskas and G. Jankauskiene, Agriculture, Ecosystems and Environment, Volume 95, pp. 129 – 142, 2003.

14. “Miscanthus Environmental Profile” Bical Industrial Crops Ltd., United Kingdom, 2005.

15. “Evaluating Environmental Consequences of Producing Herbaceous Crops for Bioenergy” by S. B. McLaughlin and M. E. Walsh, Biomass and Bioenergy, Volume 14, pp. 317 – 324, 1998.

16. “The Economical and Environmental Performance of Miscanthus and Switchgrass Production and Supply Chains in a European Setting” by E. M. W. Smeets, I. M. Lewandowski and A. P. C. Faaij, Renewable and Sustainable Energy Reviews, Volume 13, pp. 1230 – 1245, 2009.

17. “Short Rotation Coppice for Energy Production: Hydrological Guidelines” by R. L. Hall, Centre for Ecology and Hydrology for the Department of Trade and Industry, London, United Kingdom, 2003.

18. “Nitrate Leaching Losses Under Miscanthus Grass Planted on a Silty Clay Loam Soil” by D. G. Christian and A. B. Riche, Soil Use Management, Volume 4, pp. 131 – 135, 1998.

19. “Planting and Managing Giant Miscanthus as a Biomass Energy Crop” by M. J. Williams and J. Douglas, Technical Note No. 4, United States Department of Agriculture, Gainesville, Florida, United States of America, July 2011.

20. “Adding Biofuels to the Invasive Species Fire?” by S. Raghu, R. C. Anderson, C. C. Daehler, A. S. Davis, R. N. Wiedenmann, D. Simberloff and R. N. Mack, Science, Volume 131, p. 1742, DOI:10.1126/science.1129313, 2006.

21. “Miscanthus: European Experience with an Novel Energy Crop” by I. Lewandowski, J. Clifton-Brown, J. M. O Scurlock and W. Huisman, Biomass and Bioenergy, Volume 19, pp. 209 – 227, 2000.

22. “Miscanthus (*Miscanthus X Giganteus*) for Biofuel Production” www.extension.org, 15 June 2012.

23. “Benefits Versus Risks of Growing Biofuel Crops: the case of miscanthus” by U. Jørgensen, Current Option on Environmental Sustainability, Volume 3, pp. 24 – 30, 2011.

24. “NF0403 – Miscanthus Agronomy (for fuel and industrial uses)” by M. Bullard, Final Project Report for Ministry of Agriculture, Fisheries and Food, London, 1998.