Mitigation of Greenhouse Gas Emissions by the Energy Grass, *Miscanthus* X *giganteus*

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Introduction As a result of the increasing demand for biomass energy crops to replace the fossil fuels oil , gas and coal there has been a renewed interest in identifying suitable energy crops which are close to carbon neutral . Biomass crops not only have the capacity to reduce fossil fuel consumption , but can aid in greenhouse gas (GHG) mitigation by acting as carbon sinks . Hence the construction of a full GHG budget for these crops is of vital importance . Reliable budgets depend on validation from long term growth trials but because of the relatively recent interest in dedicated energy crops these trials are few in number . Clifton Brown *et al* (2007) have recently reported on 16 years of growth trials with the perennial rhizomatous C_4 grass *Miscanthus* × *giganteus* , Life-cycle assessment has been used to synthesise the net environmental impact of energy crop cultivation compared with conventional agricultural land uses , and energy crop combustion compared with fossil fuels , with particular regard to GHG emissions .

Materials and methods A field trial of *Miscanthus* × *giganteus* has been established near Cashel , Co . Tipperary , Ireland (52° 39′N , 07°50′W) since June 1990 . From 1991 to 2005 , yield was determined in late February or early March (average 9 t dry-matter ha^{-1} a^{-1}) . To determine the amount of carbon sequestered to the soil by 2005 , 15 years after planting , one soil core was taken from each of the eight replicate plots and the *Miscanthus* derived organic carbon present in the soil was detected by measuring the change in the ^{13}C stable isotope signal (average 0 .675 t C ha^{-1} a^{-1}) . For details of this procedure see Clifton Brown et al . (2007) . A life-cycle approach was used to quantify the major GHG emission sources associated with the production of useful heat (kWh_{th}) from *Miscanthus* that is harvested and pelleted before combustion (Styles and Jones , 2007 & 2008)-these calculations were updated with Cashel data .

Results Life-cycle GHG emission reductions (average per hectare) possible where *Miscanthus* displaces conventional fuels for electricity generation and heat production , and dominant agricultural land-uses .

	Fuel displaced	Fuel GHG-intensity	Useful energy	Energy GHG reduction		Land-use displaced	Displaced LU emis.	Soil CO_2 seq.	LU GHG reduction
		kg CO_2 eq. kWh^{-1}	kWh a^{-1}	t CO_2 eq. a^{-1}			t CO_2 eq. a^{-1}		
ENERGY DISPLACEMENT	Peat (elec)[a]	1.15	17,472	**19.33**	LAND-USE DISPLACEMENT	Tillage	3.49	4.25	**4.03**
	Oil (heat)[b]	0.331	40,961	**12.54**		Set-aside	0.00	4.25	**2.32**
	Gas (heat)[b]	0.248	40,961	**9.14**		Extensif	0.00	2.48	**0.54**
	Electric (heat)[b]	0.624	40,961	**24.54**		Sheep	3.75	2.48	**4.29**
						Cattle	5.24	2.48	**5.77**
COMBINED ENERGY AND LAND-USE GHG REDUCTION (t CO_2 eq. a^{-1})			MIN	**9.68**		Dairy	12.07	2.48	**12.60**
			MAX	**37.15**					

Conclusions Fuel chain GHG emissions attributable to *Miscanthus* are between 70% and 88% lower than those for oil , gas and electric heating fuel chains , and 86% lower than for the peat-electricity fuel chain . However , long-term soil C sequestration when *Miscanthus* is grown on either grassland or tillage land exceed cultivation emissions , and , along with possible displacement of marginal agricultural production , could result electricity and heat production better than C-neutral . With life-cycle GHG reductions of between 9 .68 and 37 .15 t CO_2 eq . ha^{-1} a^{-1} , energy crop electricity and heat production represent highly efficient land-use options for GHG mitigation .

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