Agentschap NL
Ministerie van Volkshuisvesting,
Ruimtelijke Ordening en Milieubeheer

Greenhouse gas emissions from cultivation of maize, rapeseed, sugar beet and wheat for biofuels

NUTS-2 report from the Netherlands

NL Agency
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SUMMARY

The objective of this report is to provide a list of provinces in The Netherlands in which typical greenhouse gas emissions from cultivation of agricultural raw materials can be expected to be lower than or equal to the emissions reported under the heading 'Disaggregated default values for cultivation' in part D of Annex V to the Renewable Energy Directive (Directive 2009/28/EG).
This list was made for four crops which are grown in The Netherlands and which are or might become raw materials for biofuel production: grain maize, winter rape seed, sugar beet and winter wheat. Agricultural data were collected by Wageningen University and Research centre (WUR) and published in a background report. The current report gives a summary of those data. Relative to the agricultural data from which the RED Annex V default values were calculated, yields, diesel use in machinery, N-fertiliser plus manure applications and N_2O emissions in The Netherlands are in general (much) higher.
Based on these agricultural data, greenhouse gas emissions were calculated using a publicly available Excel calculation tool. The results from these calculations were compared with the disaggregated default values for cultivation in part D of Annex V of the Renewable Energy Directive. In the table below, the provinces are listed for which the typical greenhouse gas emissions from cultivation of agricultural raw materials are found to be lower than emissions reported under the heading 'Disaggregated default values for cultivation' in part D of Annex V to the RED.

Table 1 List with provinces and agricultural raw materials for which GHG emissions from cultivation are lower than values in RED Annex V.D. An "X" indicates that the emissions are lower, an empty cell indicates that the emissions are higher

NUTS code	Province	Grain maize	Winter rape seed	Sugar beet	Winter wheat
NL110000	Groningen	X	X	X	
NL120000	Friesland	X	X	X	
NL130000	Drenthe	X	X	X	
NL210000	Overijssel	X	X	X	
NL220000	Gelderland	X	X	X	
NL230000	Flevoland	X	X	X	
NL310000	Utrecht	X	X	X	
NL320000	Noord-Holland	X	X	X	
NL330000	Zuid-Holland	X	X	X	
NL340000	Zeeland	X	X	X	
NL410000	Noord-Brabant	X	X	X	
NL420000	Limburg (NL)	X	X	X	X

For grain maize, winter rape seed and sugar beet the list consists of all provinces. For winter wheat, only the province of Limburg is on the list (the other provinces do not comply).

CONTENTS

1 INTRODUCTION

1.1 Background and objective

Under the Renewable Energy Directive (RED, Directive 2009/28/EG), biofuels must meet sustainability criteria in order to count to obligations or to be eligible for financial support. One of these criteria is a minimum 35% greenhouse gas emission (GHG) saving. In order to comply with this minimum GHG saving, economic operators may use default values that are listed in Annex V of the RED, may use an actual value, or may use a combination of disaggregated default values and actual values.

RED article 19(3) states that default values or disaggregated default values for cultivation may only be used when the raw materials, if cultivated in the European Community, are cultivated in areas included in one of the lists that are provided by Member States. RED article 19(2) gives details of this list:

> *.... Member States shall submit to the Commission a report including a list of those areas on their territory classified as level 2 in the nomenclature of territorial units for statistics (NUTS) or as a more disaggregated NUTS level in accordance with Regulation (EC) No 1059/2003 of the European Parliament and of the Council of 26 May 2003 on the establishment of a common classification of territorial units for statistics (NUTS) where the typical greenhouse gas emissions from cultivation of agricultural raw materials can be expected to be lower than or equal to the emissions reported under the heading 'Disaggregated default values for cultivation' in part D of Annex V to this Directive, accompanied by a description of the method and data used to establish that list. That method shall take into account soil characteristics, climate and expected raw material yields.*

The objective of this report is to provide such a list for The Netherlands.

1.2 Planning and actors involved

In April 2009, the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM) requested SenterNovem to

- write a report on GHG emissions from crops that are, and in the future can be, grown as feedstocks for biofuel production in The Netherlands, and make the list that is mentioned in paragraph 1.1; and
- as input for that report commission a study to collect agricultural data.

In June 2009 SenterNovem (which became NL Agency per 1-1-2010) commissioned a study to WUR (Wageningen University & Research centre). The study was carried out by a research team of LEI-WUR (Agricultural Economics Research Institute) in The Hague and PRI-WUR (Plant Research International) in Wageningen.

In February 2010 a second phase of this study was commissioned. The final WUR report (which will in the remainder of this report be referred to as "background report") was delivered by WUR to NL Agency in June 2010 and is publicly available [1].

The current report was written in June 2010 based on the background report by WUR and using the Excel-based GHG calculation model as developed in the IEE project BioGrace (see www.BioGrace.net). The report was presented to VROM on June 24, 2010.

The WUR study and this report have been commented upon by an advisory board which consisted of the following members:

Ben Hasselo	LTO - Land- en Tuinbouw Organisatie *Dutch Federation of Agriculture and Horticulture*
Klaas Hoekstra	NAV - Nederlandse Akkerbouw Vakbond *Dutch Union for Agriculture*
Frans Tijink / Toon Huijbregts	IRS *Institute of Sugar Beet Research*
Arjan Kuijsterman / Tjitse Bouwkamp	PA - Productschap Akkerbouw *Commodity Board for Agriculture*
Puck Bonnier	Ministerie LNV *Dutch Ministry of Agriculture, Nature and Food Quality*
Sjaak Conijn	WUR - PRI (Plant Research Internationaal) *Wageningen University and Research Centre - Plant Research International*
Marcel van der Voort	WUR - PPO (Praktijkonderzoek Plant & Omgeving) *Wageningen University and Research Centre - Applied Plant Research*

2 CULTIVATION DATA

This chapter gives a summary of the methodology and results of data collection. Details can be found in the background report [1] which also gives the data sources used.

2.1 Introduction

2.1.1 Crops investigated

This crops reported upon in this study are winter rapeseed, winter wheat, sugar beet and grain maize. Out of these four, winter rapeseed is the only crop that is currently grown in the Netherlands for biofuel production (biodiesel and pure plant oil). The other three crops might be grown for biofuel production in the (near) future. It was assumed that for these four crops there is no difference in agricultural data for biofuel purposes as compared to food and feed purposes.

2.1.2 NUTS-2 areas in The Netherlands

The NUTS-2 level was used to collect data and to calculate GHG emissions. In the Netherlands, the areas classified as level 2 in the nomenclature of territorial units for statistics (NUTS) are the same as the 12 Dutch provinces. These are listed below.

NUTS code	Province
NL110000	Groningen
NL120000	Friesland
NL130000	Drenthe
NL210000	Overijssel
NL220000	Gelderland
NL230000	Flevoland
NL310000	Utrecht
NL320000	Noord-Holland
NL330000	Zuid-Holland
NL340000	Zeeland
NL410000	Noord-Brabant
NL420000	Limburg (NL)

2.1.3 Data collection

In a study commissioned by NL Agency, WUR has collected the required agricultural data to perform the GHG calculations. These are data on area, yield, diesel use for agricultural machinery, use of nutrients, pesticides and seeds, and emission of N_2O from the soil. The data were extrapolated to the year 2011, as this is the year when sustainability criteria from the Renewable Energy Directive (RED) will first apply.

2.1.4 Variation in soil, climate and yield

Variation in soil, climate and yield was included as follows:

- Agricultural data were collected for clay soil and other soil types and were then averaged with a weigh proportional to the crop area on clay and the crop area on other soils;
- Variation in climate and yield were included by collecting data for NUTS-2 areas over a series of years. For the more or less stable parameters, data were collected for the period 2005 - 2008 and averaged. For yield, a trend analysis was made using statistical data over the 1994 – 2009, from which the yield in the year 2011 was estimated. Details can be found in the background report [1].

2.2 Methodology of data collection

2.2.1 Diesel use in field operations

Diesel use of machinery involved in crop cultivation and harvest was calculated taking all operations including contract work into account. Calculations are based on the fuel use and the standard process time per operation applied. Details are given in Appendix 2 of the background report [1].

2.2.2 Application of Ca-, K-, N- and P-fertiliser

Phosphate application rates were determined from a trend analysis based on data from MAMBO (2005-2008). The MAMBO model is further explained in [1].The potassium fertilisation rate was calculated based on the removal with the crop harvest (per province, soil type and year). Lime was only supplied on sugar beet, not on the other three crops. Lime supply was based on registered data from the sugar industry.

Two factors complicated the determination of N-fertiliser application in the year 2011:

1. At the end of 2005, the Dutch nutrient management regulation system MINAS was replaced by application norms. These norms are farm-based (and hence not crop-based) meaning that farmers can apply more fertiliser to one crop if they compensate that through lower application of fertiliser to other crops.
2. Due to abundant stockbreeding in The Netherlands, animal manure is readily available and is an attractive (because cheap) alternative for N- and P-fertilisers. Until 2009 application of manure in autumn was quite common, especially on farms with clay soils. An important recent change in Dutch regulations is the ban on manure application in autumn. As a result, it is difficult to estimate for the coming years how farmers will fertilise their crops.

These two complicating factors made it rather difficult to estimate nitrogen applications per crop in 2011 from trend analysis based on available data until 2008. Therefore, an expert meeting was organised to make estimations of nitrogen management in 2011. Details on this expert meeting and its outcomes are given in the background report [1].

2.2.3 Field N_2O emissions

Early in the project contacts were established with JRC [2] to see whether the Stehfest and Bouwman model that JRC is developing, could provide the NUTS-2 level N_2O emissions as input to this study. Our conclusion was that the data from this model were not suitable to be used. Firstly, the model used quite different fertiliser input data as compared to the data described in this report, which would make N_2O field emissions incompatible with the inputs used. Secondly, the model was still under development and N_2O experts questioned some of the draft results. As a result, we decided to use the IPCC 2006 Tier 1 method to calculate N_2O field emissions. Details on the method are given in chapter 2.8 of the background report [1]. For almost all factors needed in the calculation, standard IPCC 2006 factors were used:

Source of N	**Unit**	**Type of emission**		
		Direct	**Indirect after volatilisation**	**Indirect after leaching**
Synthetic N fertilisers	kg N_2O-N per kg N	0.01	0.001	0.00225
Organic N applied as fertiliser		0.01	0.002	0.00225
N in crop residues, left at harvest (above and below ground)		0.01	0	0.00225
N mineralisation from loss of soil organic matter		0.01	0	0.00225
Drainage/management of temperate organic soils	kg N_2O ha^{-1} yr^{-1}	8		

The only deviation of the IPCC standard Tier 1 factors was for the indirect emission after volatilisation (the values 0.001 and 0.002 in the table above), these factors were determined by WUR per crop and per region [1]. These alternative factors were used in the calculation of the N_2O emissions.

2.2.4 Other inputs

Data on other inputs (pesticides and seeds) are given in the background report [1].

2.3 Collected data

Tables 2-1 to 2-4 compare results - averaged over clay and other soils – for the four crops in the year 2011 with the data from the JEC consortium relevant to calculating default GHG emissions from biofuels according to RED methodology. These JEC data are taken from the Excel file that can be downloaded from the JRC website [3]. More detailed data for each of the NUTS-2 areas are given in Annex I. Individual results for clay soils and for other soils are given in the background report [1].

Table 2-1: Parameter values for grain maize. Minimum and maximum of range from 12 NUTS-2 areas, as compared to JEC values

Parameter	Unit	Values reported by WUR [1]		JEC value [3]
		Minimum	Maximum	
Yield	kg / (ha, yr)	11909	12620	3500
Moisture content	%	35	35	15
Diesel use	MJ / (ha, yr)	6153	6344	3600
N-fertiliser	kg N / (ha, yr)	45	54	52
Manure	kg N / (ha, yr)	176	176	0
P_2O_5-fertiliser	kg P_2O_5 / (ha, yr)	74	74	35
K_2O-fertiliser	kg K_2O / (ha, yr)	99	187	26
CaO-fertiliser	kg CaO / (ha, yr)	0	0	0
Pesticides	kg / (ha, yr)	0.7	4.0	2.4
Seeds	kg / (ha, yr)	27	27	-
N_2O field emission	kg N_2O / (ha, yr)	5.8	6.2	0.74

Table 2-2: Parameter values for winter rapeseed. Minimum and maximum of range from 12 NUTS-2 areas, as compared to JEC values

Parameter	Unit	Values reported by WUR [1]		JEC value [3]
		Minimum	Maximum	
Yield	kg / (ha, yr)	3810	4290	3113
Moisture content	%	8	8	10
Diesel use	MJ / (ha, yr)	6247	6495	2963
N-fertiliser	kg N / (ha, yr)	175	175	137
Manure	kg N / (ha, yr)	35	35	0
P_2O_5-fertiliser	kg P_2O_5 / (ha, yr)	25	39	34
K_2O-fertiliser	kg K_2O / (ha, yr)	72	187	50
CaO-fertiliser	kg CaO / (ha, yr)	0	0	0
Pesticides	kg / (ha, yr)	0.5	0.5	1.2
Seeds	kg / (ha, yr)	4.0	4.0	6.0
N_2O field emission	kg N_2O / (ha, yr)	5.6	5.7	3.10

From Tables 2-1 to 2-4 it can be observed that in The Netherlands in 2011, in comparison with JEC numbers, yields, diesel use in machinery, N-fertiliser plus manure applications and N_2O emissions are in general (much) higher. Two general explanations can be given for these observations. Firstly, as both ground and labour are expensive in The Netherlands, farmers strive for maximum yields, which are increasing year by year. Therefore, it is understandable that Dutch yields in 2011 are much higher than yields taken from Europe from an earlier date. Secondly, manure application is a common practice in The Netherlands. As manure is a cheap fertiliser and as only part of the nitrogen in manure is taken up by the plant (the other part is non-efficient - see also chapter 2.5 of the background report [1]), the application in kg nitrogen per hectare per year is high as compared to this application in other countries. As the inactive nitrogen contributes to N_2O emissions, the higher application of nitrogen also results in a higher N_2O field emission.

Table 2-3: Parameter values for sugarbeet. Minimum and maximum of range from 12 NUTS-2 areas, as compared to JEC values

Parameter	Unit	Values reported by WUR [1]		JEC value [3]
		Minimum	Maximum	
Yield	kg / (ha, yr)	81857	99170	68860
Moisture content	%	74	74	75
Diesel use	MJ / (ha, yr)	5674	5760	6331
N-fertiliser	kg N / (ha, yr)	41	118	119
Manure	kg N / (ha, yr)	37	139	0
P_2O_5-fertiliser	kg P_2O_5 / (ha, yr)	41	85	60
K_2O-fertiliser	kg K_2O / (ha, yr)	83	234	135
CaO-fertiliser	kg CaO / (ha, yr)	113	625	400
Pesticides	kg / (ha, yr)	4.3	5.2	1.3
Seeds	kg / (ha, yr)	2.8	2.8	6.0
N_2O field emission	kg N_2O / (ha, yr)	6.0	6.8	3.3

Table 2-4: Parameter values for winter wheat. Minimum and maximum of range from 12 NUTS-2 areas, as compared to JEC values

Parameter	Unit	Values reported by WUR [1]		JEC value [3]
		Minimum	Maximum	
Yield	kg / (ha, yr)	7445	9410	5200
Moisture content	%	13	13	13,5
Diesel use	MJ / (ha, yr)	6362	6611	3716
N-fertiliser	kg N / (ha, yr)	143	185	109
Manure	kg N / (ha, yr)	38	125	0
P_2O_5-fertiliser	kg P_2O_5 / (ha, yr)	22	76	22
K_2O-fertiliser	kg K_2O / (ha, yr)	54	165	16
CaO-fertiliser	kg CaO / (ha, yr)	0	0	0
Pesticides	kg / (ha, yr)	3.6	4.1	2.3
Seeds	kg / (ha, yr)	151	174	120
N_2O field emission	kg N_2O / (ha, yr)	5.2	7.2	1.8

Table 2-5 gives the range of factors (per crop, range over 12 regions) for the indirect emission after volatilisation, as compared to the IPCC 2006 Tier 1 standard factors.

Table 2-5: Emission factors used for indirect emission after volatilisation, as compared to IPCC 2006 Tier 1 standard factors

Source of N	Unit	Grain maize	Winter rapeseed	Sugar beet	Winter wheat	IPCC standard factor
Synthetic N fertilisers	kg N_2O-N	0.00037	0.00037	0.00037	0.00037	0.001
Organic N applied as fertiliser	per kg N	0.00095 – 0.00177	0.00080 – 0.00167	0.00079 – 0.00172	0.00102 – 0.00196	0.002

3 GHG EMISSIONS OF CULTIVATION

3.1 Calculation of GHG emissions

3.1.1 Methodology

The GHG calculations were performed following the methodology of RED Annex V.C.

3.1.2 Calculation model

The calculations were performed with version "1 – Public" of the BioGrace Excel file, which is publicly available at www.BioGrace.net. This calculation strictly follows the calculations made by the JEC consortium as input to the European Commission to set the Annex V default values. The BioGrace calculations are able to reproduce the JEC calculations with a precision better than 0.05 g $CO_{2,eq}$/MJ. Interested readers can reproduce our calculations using this BioGrace Excel file, the two user-defined standard values given in paragraph 3.1.3 and the input values per NUTS-2 area as given in Annex I.

The public version 1 of the BioGrace Excel file contains the biofuel pathways "wheat-to-ethanol", "sugarbeet-to-ethanol" and "rapeseed-to-FAME". The fourth chain of relevance for this report "maize-to-ethanol" is not included in version 1 of the BioGrace Excel file. We have added this pathway to the calculations ourselves. Later this year, this pathway will become public as part of version 2 or version 3 of the BioGrace Excel file.

3.1.3 Standard values and user-defined standard values

In our calculations, we used the standard values (also called conversion factors, or emission factors) that are available as part of the BioGrace Excel file and which are also published separately in the file "BioGrace standard values – Version 1 – Public.xls" on www.BioGrace.net. The most important values are listed in the Table below.

STANDARD VALUES		GHG emission coefficient							
Parameter:	parameter Unit	gCO_2/kg	gCH_4/kg	gN_2O/kg	$gCO_{2,eq}/kg$	gCO_2/MJ	gCH_4/MJ	gN_2O/MJ	$gCO_{2,eq}/MJ$
Global Warming Potential									
CO_2					1				
CH_4					23				
N_2O					296				
Agro inputs									
N-fertiliser		2827,0	8,68	9,6418	5917,2				
P_2O_5-fertiliser		964,9	1,33	0,0515	1013,5				
K_2O-fertiliser		536,3	1,57	0,0123	579,2				
CaO-fertiliser		119,1	0,22	0,0183	130,0				
Pesticides		9886,5	25,53	1,6814	11025,7				
Seeds- rapeseed		412,1	0,91	1,0028	733,7				
Seeds- sugarbeet		2187,7	4,60	4,2120	3557,9				
Seeds- wheat		151,1	0,28	0,4003	277,3				
Fuels- liquids									
Diesel						87,64	-	-	87,64

For two parameters, we used alternative values:

- For manure we used an emission factor of 0 g $CO_{2,eq}$/kg as manure is a processing residue according to the June 2010 EC communication [4]. This does not implicate that the use of manure is free from GHG emissions, see paragraph 3.3.2.
- Also for N-fertiliser an alternative value was used. The standard value in the list on www.BioGrace.net is 5917 g $CO_{2,eq}$/kg, which is a value for N-fertiliser production in Europe based on "old technology" in which significant amounts of N_2O emissions occur during production of nitric acid from oxidation of ammonia. In The Netherlands,

owners of nitric acid production plants have recently installed N_2O reduction catalysts. As a result, production of N-fertiliser in The Netherlands gives rise to GHG emissions which are much lower than the 5917 g $CO_{2,eq}$/kg.
We have not been able to obtain data for more than one fertiliser producer. Producer DSM has delivered us data which have been verified by an independent auditor under the ETS scheme. The emission factor for production of N-fertiliser from DSM is 2237 g $CO_{2,eq}$/kg [5]. We do know, in addition, that producer Yara has also reduced N_2O emissions by adding a catalyst to the nitric acid plant as part of the nitrogen fertiliser production process.
We were not able to get insight in the market share of companies that sell N-fertiliser in The Netherlands as they consider this to be sensitive information. We were also not able to get insight in the differences in emissions amongst the Dutch N-fertiliser production plants in Geleen (DSM), IJmuiden (DSM) and Sluiskil (Yara). Therefore, we have assumed that N-fertiliser that is used in The Netherlands has the same emission factor as the N-fertiliser produced in the DSM plant where we have data from.

3.1.4 Cultivation includes drying

For the calculation for FAME from rapeseed, the drying of rapeseed was included in the cultivation part as was also done by the EC and JEC calculating the RED default values. The drying of the rapeseed has a small contribution (around 0.4 g $CO_{2,eq}$/MJ) to the overall GHG emission of cultivation (27 – 30 g $CO_{2,eq}$/MJ).

3.1.5 Input data used

For the calculations we used the data as reported by WUR [1], with one exception. It was found that our IPCC Tier 1 N_2O emissions could not properly be compared with the Tier 3 N_2O emissions as determined by JRC with the DNDC model as input to calculating the RED Annex V default values. In order to align the comparison of our GHG calculation results with the Annex V default values, we multiplied the N_2O field emissions with a factor of 0.8 before making the GHG calculation (see also discussion in paragraph 3.3.1).

3.2 Results

A typical example of a calculation result is given in the figure on the next page. This figure shows the BioGrace Excel calculation where the calculation is made for FAME from rape seed in the province of Groningen.

Please note that everyone can reproduce these results using the BioGrace Excel file on the website www.BioGrace.net, the two user-defined standard values given in paragraph 3.1.3 and the input values per NUTS-2 area as given in Annex I.

Production of FAME from Rapeseed — Version 1 - Public

Overview Results

All results in $g\ CO_{2,eq}$ / MJ_{FAME}	Non-allocated results	Allocation factor	Allocated results	Total	Default values RED Annex V.D
Cultivation e_{ec}				25,3	29
Cultivation of rapeseed	42,38	58,6%	24,83		28,51
Rapeseed drying	0,72	58,6%	0,42		0,42
Processing e_p				21,6	22
Extraction of oil	6,50	58,6%	3,81		3,82
Refining of vegetable oil	1,06	95,7%	1,01		17,88
Esterification	17,51	95,7%	16,75		
Transport e_{td}				1,4	1
Transport of rapeseed	0,29	58,6%	0,17		0,17
Transport of FAME	0,82	100%	0,82		0,82
Filling station	0,44	100%	0,44		0,44
Land use change e_l	0,0	58,6%	0,0	0,0	0
$e_{sca} + e_{ccr} + e_{ccs}$	0,0	100%	0,0	0,0	0
Totals	69,7			48,2	52

Allocation factors
Extraction of oil
61,3% to Rapeseed oil
38,7% to Rapeseed cake
Esterification
95,7% to FAME
4,3% to Glycerol

Emission reduction
Fossil fuel reference (diesel)
83,8 $g\ CO_{2,eq}/MJ$
GHG emission reduction
42%

Calculations in this Excel sheet......

☑ **strictly follow the methodology as given in Directives 2009/28/EC and 2009/30/EC**

☐ ~~follow JEC calculations by using GWP values 25 for CH4 and 298 for N2O~~

As explained in "About" under "Inconsistent use of GWP's"

Calculation per phase

Cultivation of rapeseed			Quantity of product	Calculated emissions				Info	
Yield			**Yield**	**Emissions per MJ FAME**				**per kg rapeseed**	**per ha, year**
Rapeseed	4.128	kg ha^{-1} $year^{-1}$	100.261 $MJ_{Rapeseed}$ ha^{-1} $year^{-1}$	$g\ CO_2$	$g\ CH_4$	$g\ N_2O$	$g\ CO_{2,eq}$	$g\ CO_{2,eq}$	$kg\ CO_{2,eq}$
Moisture content	8,0%		1,000 MJ / $MJ_{Rapeseed,\ input}$						
By-product Straw	n/a	kg ha^{-1} $year^{-1}$	0,071 $kg_{Rapeseed}/MJ_{FAME}$						
Energy consumption									
Diesel	6.413	MJ ha^{-1} $year^{-1}$		9,69	0,00	0,00	9,69	136,15	562,0
Agro chemicals									
N-fertiliser (DSM)	175,0	kg N ha^{-1} $year^{-1}$		6,75	0,00	0,00	6,75	94,83	391,5
Manure	35,0	kg N ha^{-1} $year^{-2}$		0,00	0,00	0,00	0,00	0,00	0,0
CaO-fertiliser	0,0	kg CaO ha^{-1} $year^{-1}$		0,00	0,00	0,00	0,00	0,00	0,0
K_2O-fertiliser	172,0	kg K_2O ha^{-1} $year^{-1}$		1,59	0,00	0,00	1,71	24,00	99,1
P_2O_5-fertiliser	35,0	kg P_2O_5 ha^{-1} $year^{-1}$		0,58	0,00	0,00	0,61	8,57	35,4
Pesticides	0,5	kg ha^{-1} $year^{-1}$		0,09	0,00	0,00	0,09	1,33	5,5
Seeding material									
Seeds- rapeseed	4,0	kg ha^{-1} $year^{-1}$		0,03	0,00	0,00	0,05	0,71	2,9
Field N_2O emissions	4,60	kg ha^{-1} $year^{-1}$		0,00	0,00	0,08	23,48	329,84	1361,6
			Total	18,73	0,01	0,08	42,38	595,44	2458,0
			Result	$g\ CO_{2,eq}$ / MJ_{FAME}			42,38		

Results of all the calculations are listed in Table 3-1.

Table 3-1 Results of the GHG calculations for the four crops per province (in g $CO_{2,eq}/MJ_{fuel}$)

NUTS code	Province	Grain maize	Winter rape seed	Sugar beet	Winter wheat
NL110000	Groningen	16.2	25.3	8.9	25.2
NL120000	Friesland	15.9	25.0	8.7	24.9
NL130000	Drenthe	16.0	25.6	9.0	24.2
NL210000	Overijssel	16.6	26.1	9.0	24.5
NL220000	Gelderland	16.3	25.5	9.4	25.2
NL230000	Flevoland	16.0	26.7	7.5	23.2
NL310000	Utrecht	16.6	26.3	8.7	24.3
NL320000	Noord-Holland	16.7	26.3	8.3	24.4
NL330000	Zuid-Holland	16.3	24.9	8.4	23.9
NL340000	Zeeland	16.3	24.0	8.4	23.5
NL410000	Noord-Brabant	16.1	24.3	9.0	23.1
NL420000	Limburg (NL)	15.7	24.1	9.3	22.3
	Average	16.2	25.3	8.7	24.1
	RED Annex V.D	**20**	**29**	**12**	**23**
	Unit of data	g $CO_{2,eq}$ / $MJ_{ethanol}$	g $CO_{2,eq}$ / MJ_{FAME}	g $CO_{2,eq}$ / $MJ_{ethanol}$	g $CO_{2,eq}$ / $MJ_{ethanol}$

In Table 3-2 the provinces are listed for which the typical greenhouse gas emissions from cultivation of agricultural raw materials are found to be lower than emissions reported under the heading 'Disaggregated default values for cultivation' in part D of Annex V to the RED.

Table 3-2 List with provinces and agricultural raw materials for which GHG emissions from cultivation are lower than values in RED Annex V.D.
An "**X**" indicates that the emissions are lower, an empty cell indicates that the emissions are higher

NUTS code	Province	Grain maize	Winter rape seed	Sugar beet	Winter wheat
NL110000	Groningen	X	X	X	
NL120000	Friesland	X	X	X	
NL130000	Drenthe	X	X	X	
NL210000	Overijssel	X	X	X	
NL220000	Gelderland	X	X	X	
NL230000	Flevoland	X	X	X	
NL310000	Utrecht	X	X	X	
NL320000	Noord-Holland	X	X	X	
NL330000	Zuid-Holland	X	X	X	
NL340000	Zeeland	X	X	X	
NL410000	Noord-Brabant	X	X	X	
NL420000	Limburg (NL)	X	X	X	X

In conclusion, for grain maize, winter rape seed and sugar beet the list consists of all provinces. For winter wheat, only the province of Limburg is on the list (the other provinces do not comply).

3.3 Discussion

3.3.1 N_2O field emissions

The N_2O field emission is the parameter with the largest contribution to the GHG emissions calculated. It is also a parameter with a very large uncertainty. The IPCC Tier 1 method was used to calculate N_2O field emissions. The JEC consortium, which provided results that led to the RED Annex V default values with which our results are compared, used the DNDC model to calculate N_2O field emissions. Researchers from WUR filled in the relevant parameters (yield, N-fertiliser use) from JEC [3] in the IPCC Tier 1 calculation and found N_2O field emissions that were significantly higher (125 to 165%) than the ones reported by JEC in [3]. As a consequence, we conclude that there is no common basis for comparison as the JEC GHG results and therefore the RED Annex V defaults are based on a different N_2O field emission model than our calculations. We recommend to the European Commission to decide on the use of one common method to determine N_2O field emissions as input to biofuel GHG emission calculations under legislation implementing the RED and FQD. For our GHG calculations, we decided to multiply the N_2O emissions reported by WUR with a factor of 0.8 (1/125%). We did so in order to align our IPCC Tier 1 numbers and the IPCC Tier 3 numbers of JRC (using the DNDC model) and make our results better comparable with the RED Annex V default values. The factor 0.8 used is a conservative one, we could also have used a factor of 0.69 (1/145%; 145% being the average of 125 and 165%).

3.3.2 Manure versus N-fertiliser

At first sight it might seem that using manure instead of N-fertiliser to fertilise crops will result in a lower GHG emission, because manure has an emission factor of 0 g $CO_{2,eq}$/kg. This is however not true. More N-input is needed to fertilise a crop with manure, as compared to using N-fertiliser, because part of the N in manure is not taken up by the plant. Nitrogen from manure leads, just as nitrogen from N-fertiliser does, to N_2O field emissions. Replacement of N-fertiliser with manure leads to higher GHG emissions as the increased N_2O field emissions are more significant than the decrease in GHG emissions from the avoided N-fertiliser and the avoided P-fertiliser. Thus, in conclusion, the GHG emissions from cultivation of the four crops would have been lower if they had been fertilised with N-fertiliser only.

3.3.3 Emission factors for fertilisers

The emission factor for N-fertiliser of 2237 g $CO_{2,eq}$/kg was the most reasonable estimate that we could make. As the GHG emission from N-fertiliser has a significant contribution to the overall GHG emissions from cultivation of the crops, we recommend that:

1. A European study should be performed to determine the average GHG emission for fertiliser production, per fertiliser type and per producer. The auditors which have verified the emissions of these plants under the ETS scheme should be directly or indirectly involved in this study. The study should result in a list with fertiliser types, their producers and their verified GHG emissions per type and producer. As the number of fertiliser types used in Europe is probably very large, it might proof to be necessary to limit the list to the fertilisers most commonly used.
   Alternatively, as the GHG emission of a fertiliser could become a selling argument, an independent organisation might ask fertiliser producers to provide them with the information (including verifier statement) and make the standard values public. Fertiliser organisations might see the benefit having this information published and therefore volunteer to cooperate.
2. This list should be made publicly available, for instance by being included in the JEC work (including WTT Annex I) and/or in the list of standard values from the BioGrace project.

This would allow farmers or farmers' associations to use the alternative standard values provided that they are able to provide evidence which fertiliser (producer, type) they have used. As a result, this would incentivise the use of fertilisers with low GHG emissions.

4 REFERENCES

[1] A.B. Smit, S.R.M. Janssens, J.G. Conijn, J.H. Jager, H. Prins and H.H. Luesink, Dutch energy crops. Parameters to calculate green house gas emissions in 2011. LEI-rapport 2010-050, June 2010.

[2] Adrian Leip, e-mail communication between June 2009 and February 2010.

[3] JRC Excel file with input data relevant to calculating default GHG emissions from biofuels according to RE Directive Methodology. This file can be downloaded from http://re.jrc.ec.europa.eu/biof/xls/Biofuels%20pathways%20RED%20method%2014Nov2008.xls

[4] European Commission, Communication from the Commission on the practical implementation of the EU biofuels and bioliquids sustainability scheme and on counting rules for biofuels, June 2010.

[5] DSM, private communication with Jac Steevens, 2010

Annex I: Collected data per NUTS-2 area

Tables Annex-I- a, b, c and d give the parameter values in 2011 for grain maize, winter rapeseed, sugar beet and winter wheat for all soils (average over clay soils and other soils). In background report [1] also the separate values for clay soils and other soils are given.

Table Annex-I- b: Parameter values for grain maize in 2011 for all soils

		Groningen	**Friesland**	**Drenthe**	**Overijssel**	**Gelderland**	**Flevoland**	**Utrecht**	**Noord-Holland**	**Zuid-Holland**	**Zeeland**	**Noord-Brabant**	**Limburg (NL)**
Parameter	**Unit**	NL110000	NL120000	NL130000	NL210000	NL220000	NL230000	NL310000	NL320000	NL330000	NL340000	NL410000	NL420000
Yield	kg / (ha, yr)	12,620	12,620	12,620	11,909	12,620	12,590	12,405	12,343	12,452	12,475	12,249	12,620
Moisture content	%	35	35	35	35	35	35	35	35	35	35	35	35
Diesel use	MJ / (ha, yr)	6,320	6,304	6,343	6,344	6,277	6,153	6,225	6,202	6,208	6,188	6,323	6,303
N-fertiliser	kg N / (ha, yr)	46	47	45	45	48	54	50	51	51	52	46	47
Manure	kg N / (ha, yr)	176	176	176	176	176	176	176	176	176	176	176	176
P_2O_5-fertiliser	kg P_2O_5 /(ha, yr)	74	74	74	74	74	74	74	74	74	74	74	74
K_2O-fertiliser	kg K_2O / (ha, yr)	171	157	187	148	147	114	145	109	102	99	157	171
CaO-fertiliser	kg CaO / (ha, yr)	0	0	0	0	0	0	0	0	0	0	0	0
Pesticides	kg / (ha, yr)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	0.7	0.7
Seeds	kg / (ha, yr)	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
N_2O field emission	kg N_2O / (ha, yr)												
As determined by WUR [1]		6.0	5.9	5.9	5.8	6.1	6.0	6.1	6.2	6.1	6.1	5.9	5.9
Used in GHG calculations (see 3.3.1)		4.8	4.7	4.7	4.6	4.9	4.8	4.9	5.0	4.9	4.9	4.7	4.7

Table Annex-I- b: Parameter values for winter rapeseed in 2011 for all soils

Parameter	Unit	Groningen NL110000	Friesland NL120000	Drenthe NL130000	Overijssel NL210000	Gelderland NL220000	Flevoland NL230000	Utrecht NL310000	Noord-Holland NL320000	Zuid-Holland NL330000	Zeeland NL340000	Noord-Brabant NL410000	Limburg (NL) NL420000
Yield	kg / (ha, yr)	4,128	4,122	4,003	3,890	3,993	3,810	3,869	3,860	4,060	4,260	4,236	4,290
Moisture content	%	8	8	8	8	8	8	8	8	8	8	8	8
Diesel use	MJ / (ha, yr)	6,413	6,384	6,247	6,261	6,337	6,489	6,306	6,471	6,468	6,495	6,299	6,275
N-fertiliser	kg N / (ha, yr)	175	175	175	175	175	175	175	175	175	175	175	175
Manure	kg N / (ha, yr)	35	35	35	35	35	35	35	35	35	35	35	35
P_2O_5-fertiliser	kg P_2O_5 / (ha, yr)	35	33	25	26	30	39	29	38	38	39	28	27
K_2O-fertiliser	kg K_2O / (ha, yr)	172	135	187	148	147	111	146	97	85	72	150	170
CaO-fertiliser	kg CaO / (ha, yr)	0	0	0	0	0	0	0	0	0	0	0	0
Pesticides	kg / (ha, yr)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Seeds	kg / (ha, yr)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
N_2O field emission	kg N_2O / (ha, yr)												
As determined by WUR [1]		5.7	5.7	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.7	5.7	5.7
Used in GHG calculations (see 3.3.1)		4.6	4.6	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.6	4.6	4.6

Table Annex-I- c: Parameter values for sugar beet in 2011 for all soils

Parameter	Unit	Groningen	Friesland	Drenthe	Overijssel	Gelderland	Flevoland
		NL110000	NL120000	NL130000	NL210000	NL220000	NL230000
Yield	kg / (ha, yr)	85,531	86,014	85,060	85,150	81,857	99,170
Moisture content	%	74	74	74	74	74	74
Diesel use	MJ / (ha, yr)	5,718	5,758	5,674	5,683	5,729	5,760
N-fertiliser	kg N / (ha, yr)	76	107	41	48	85	118
Manure	kg N / (ha, yr)	86	39	139	128	73	37
P_2O_5-fertiliser	kg P_2O_5 / (ha, yr)	62	42	85	80	56	41
K_2O-fertiliser	kg K_2O / (ha, yr)	234	168	202	182	180	119
CaO-fertiliser	kg CaO / (ha, yr)	229	259	196	249	625	0
Pesticides	kg / (ha, yr)	4.7	5.2	4.4	4.4	4.7	4.4
Seeds	kg / (ha, yr)	2.8	2.8	2.8	2.8	2.8	2.8
N_2O field emission	kg N_2O / (ha, yr)						
As determined by WUR [1]		6.4	6.0	6.8	6.7	6.3	6.1
Used in GHG calculations (see 3.3.1)		5.1	4.8	5.4	5.4	5.0	4.9

Parameter	Unit	Utrecht	Noord-Holland	Zuid-Holland	Zeeland	Noord-Brabant	Limburg (NL)
		NL310000	NL320000	NL330000	NL340000	NL410000	NL420000
Yield	kg / (ha, yr)	87,527	89,260	89,260	88,030	86,241	84,110
Moisture content	%	74	74	74	74	74	74
Diesel use	MJ / (ha, yr)	5,735	5,735	5,760	5,759	5,714	5,690
N-fertiliser	kg N / (ha, yr)	89	112	118	108	73	53
Manure	kg N / (ha, yr)	66	45	37	38	91	120
P_2O_5-fertiliser	kg P_2O_5 / (ha, yr)	53	44	41	41	64	76
K_2O-fertiliser	kg K_2O / (ha, yr)	157	107	87	83	147	185
CaO-fertiliser	kg CaO / (ha, yr)	521	119	113	113	610	587
Pesticides	kg / (ha, yr)	4.7	4.4	4.8	4.8	4.8	4.3
Seeds	kg / (ha, yr)	2.8	2.8	2.8	2.8	2.8	2.8
N_2O field emission	kg N_2O / (ha, yr)						
As determined by WUR [1]		6.3	6.1	6.2	6.2	6.5	6.7
Used in GHG calculations (see 3.3.1)		5.0	4.9	5.0	5.0	5.2	5.4

Table Annex-I-d: Parameter values for winter wheat in 2011 for all soils

		Groningen	Friesland	Drenthe	Overijssel	Gelderland	Flevoland	Utrecht	Noord-Holland	Zuid-Holland	Zeeland	Noord-Brabant	Limburg (NL)
Parameter	**Unit**	NL110000	NL120000	NL130000	NL210000	NL220000	NL230000	NL310000	NL320000	NL330000	NL340000	NL410000	NL420000
Yield	kg / (ha, yr)	8,428	8,504	7,445	7,700	8,379	9,410	8,861	8,710	8,970	9,150	9,070	8,610
Moisture content	%	13	13	13	13	13	13	13	13	13	13	13	13
Diesel use	MJ / (ha, yr)	6,585	6,602	6,362	6,428	6,580	6,611	6,589	6,608	6,613	6,609	6,569	6,415
N-fertiliser	kg N / (ha, yr)	170	169	166	166	156	185	156	185	184	154	153	143
Manure	kg N / (ha, yr)	97	102	38	56	114	90	117	89	91	125	116	84
P_2O_5-fertiliser	kg P_2O_5 / (ha, yr)	60	63	22	33	69	56	71	56	57	76	71	49
K_2O-fertiliser	kg K_2O / (ha, yr)	165	99	163	142	139	91	128	76	59	54	98	165
CaO-fertiliser	kg CaO / (ha, yr)	0	0	0	0	0	0	0	0	0	0	0	0
Pesticides	kg / (ha, yr)	3.8	3.6	4.1	3.7	4.1	4.1	4.1	4.1	4.1	4.1	4.0	3.7
Seeds	kg / (ha, yr)	172.2	173.8	151.2	152.9	158.7	159.8	159.0	159.7	159.9	159.8	158.3	152.4
N_2O field emission	kg N_2O / (ha, yr)												
As determined by WUR [1]		6.8	6.9	5.2	5.7	6.9	7.1	7.1	6.9	7.0	7.2	6.9	6.0
Used in GHG calculations (see 3.3.1)		5.4	5.5	4.2	4.6	5.5	5.7	5.7	5.5	5.6	5.8	5.5	4.8