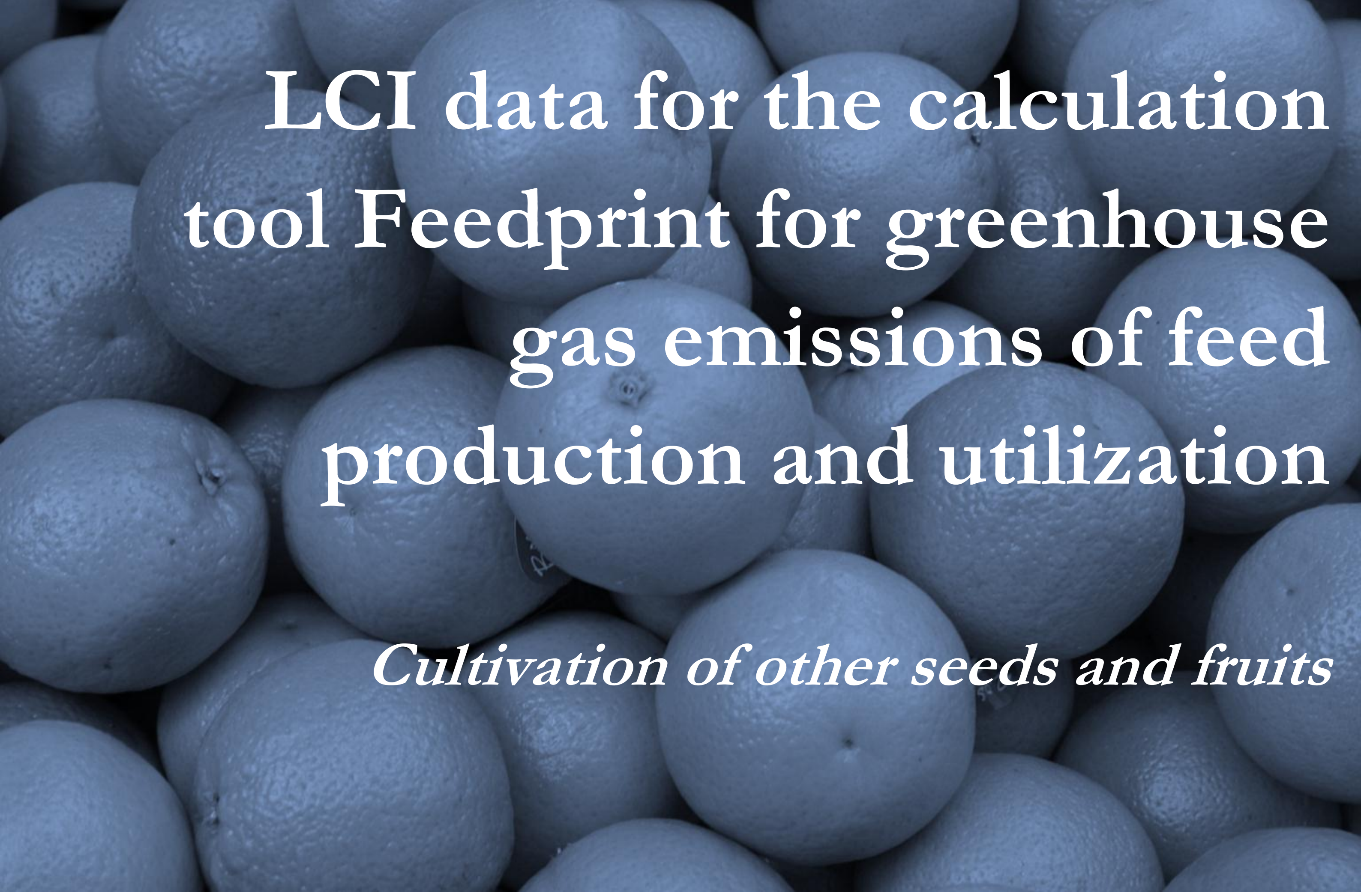

LCI data for the calculation tool Feedprint for greenhouse gas emissions of feed production and utilization

Cultivation of other seeds and fruits

M. Marinussen[1]
H. van Kernebeek[2]
R. Broekema[1]
E. Groen[1]
A. Kool[1]
W.J. van Zeist[1]
M. Dolman[2]
H. Blonk[1]

[1] Blonk Consultants
[2] Wageningen University and Research Centre

November, 2012

blonk›consultants‹

Blonk Consultants
Gravin Beatrixstraat 34
2805 PJ Gouda
the Netherlands
Telephone: 0031 (0)182 579970
Email: info@blonkconsultants.nl
Internet: www.blonkconsultants.nl

Blonk Consultants helps companies, governments and civil society organisations put sustainability into practice. Our team of dedicated consultants works closely with our clients to deliver clear and practical advice based on sound, independent research. To ensure optimal outcomes we take an integrated approach that encompasses the whole production chain.

blonk consultants

LCI data for the calculation tool Feedprint for greenhouse gas emissions of feed production and utilization

Cultivation of other seeds and fruits

M. Marinussen[1]
H. van Kernebeek[2]
R. Broekema[1]
E. Groen[1]
A. Kool[1]
W.J. van Zeist[1]
M. Dolman[2]
H. Blonk[1]

[1] Blonk Consultants
[2] Wageningen University and Research Centre

November, 2012

blonk consultants

Contents

5.1 Introduction

5.1.1 Context of this document & reading guide

This document is part of the background documentation for the FeedPrint program and database and describes the search for life cycle inventory data related to the cultivation of buckwheat, canary seed and citrus.

5.1.2 Products and countries

The EU feed catalogue contains a category called 'other seeds and fruits'. Starting point for the selection of 'other seeds and fruits is the Dutch CVB-table. A crop is selected if the crop product or one or more by-product(s) of industrial processing is listed in the Dutch CVB-table and does not belong to one of the other categories in the EU feed catalogue. Hence buckwheat and canary seed and citrus must be taken into consideration. The search for LCI data related to the cultivation of these crops is reported in separate sections (see also Table 1).

Products and by-products processed by the Dutch animal feed industry are imported from several countries (see also § 3.4 of the methodology report). We searched for cultivation data for countries that were found relevant by the CFPAN cultivation working group, see Table 1.

Table 1: Crops and countries taken into consideration

Crop	Country taken into consideration	Section
Buckwheat	China, Poland, Brazil	3.2
Canary seed	Canada, Thailand, Argentina	3.3
Citrus fruits (Oranges)	Brazil, USA	3.4

5.1.3 Data collection and selection

Data were gathered for inputs and outputs of cultivation. The report concerns input data on annual use of seed or plant material, annual use of N, P and K-fertilizers, lime and pesticides. Data about the application rates of different types of N-fertilizer are scarce. We estimated specification usage breakdown of 8 types of fertilizers (a.o. Ammonium phosphate, CAN, Urea, UAN) for 6 global regions (West-Europe, East Europe, Asia, North-America, South America and Australia). It is assumed that the region specific breakdown holds for every crop in every country in each region. The breakdown is explained in detail in section 8 of the methodology report. This document reports the total unspecified application rates of N-fertilizers.
As explained in § 4.3 of the methodology report, the annual application rate of manure and the annual energy-use for cultivation activities (e.g. soil cultivation, fertilizer application, irrigation, harvesting) are calculated in the FeedPrint model.

Output data that are reported are the annual yields of the crop products. Crop residues are calculated in the FeedPrint model, following IPCC calculation rules as explained in § 4.3 of the methodology report.

Each section of this document starts with an introduction followed by an overview of data that are used in the FeedPrint program. For each country that was found relevant, these data are collated in tables, followed by an explanation about the background of the data. If applicable, general information about the cultivation of the crop is presented followed by a discussion about the LCI data for the cultivation of the crop in each country.

In case more data are available for one parameter, the Pedigree-method as described in § 3.7 of the methodology report was helpful to select the best estimate. In the Pedigree method, each data entry gets a number assigned between 1 and 5 for five indicators (Table 2), according to a prescribed meaning of each value as explained in § 3.7 of the methodology report. As a consequence of relatively high Pedigree numbers, the default data bandwidth (explained in 5.1.4) can be corrected to a larger value.

Table 2: Abbreviations used for Pedigree-indicators

Indicator Pedigree-method	Abbreviation used in this document
Reliability: how is the data measured?	Rel
Completeness: does it describe the whole activity?	Com
Temporal correlation: does the time period correlate?	TRC
Geographic correlation: does the geography correspond?	GSp
(Further) technical correlation: is a similar technology used?	TeC

5.1.4 Uncertainty ranges

For cultivation data uncertainty ranges (and a probability density function) are assigned to:

a. Seed application rates
b. Fertilizer application rates
c. Manure application rates
d. Lime application rates
e. Pesticides application rates
f. Yield
g. Dry matter content (of the crop product)
h. Crop residues

Unless data indicate otherwise, we assumed that the distribution and uncertainty range of these parameters can be described by one of the probability density functions:

1. Normal distribution
2. Uniform distribution

In Table 3 the default probability density functions and bandwidth of the parameters are listed. The choices are underpinned in § 4.9 of the Methodology report

Table 3: Probability density functions (PDF) and bandwidth (BW) for cultivation parameters

Parameter	In EU countries		In USA		In other countries	
	PDF	BW*	PDF	BW*	PDF	BW*
Seed application rates	Normal	±5%*BE	Normal	±5%*BE	Normal	±5%*BE
Fertilizer application rates	Normal	±10%*BE	Uniform	±40% *BE	Uniform	±40% *BE
Manure application rates	Normal	±10%*BE	Uniform	±40% *BE	Uniform	±40% *BE
Lime application rates**	Uniform	0-800 kg/ha	Uniform	0-800 kg/ha	Uniform	0-800 kg/ha
Pesticides application rates	Uniform	±20%*BE	Uniform	±20%*BE	Uniform	±40%*BE
Yield***	Normal	±2*SD	Normal	±2*SD	Normal	±2*SD
Dry matter content (of the crop product)	Normal	±0.05	Normal	±0.05	Normal	±0.05
Crop residues	Normal	See yield	Normal	See yield	Normal	See yield

*BE = Best estimate

** For lime application rates a Uniform distribution between 0 and 800 kg $CaCO_3$/ha will be applied for every crop in every country, unless reliable data suggest something else

*** SD=Standard deviation; the bandwidth is defined to 4 times the SD

5.2 Buckwheat

5.2.1 Introduction

Buckwheat is raised for grain where a short season is available, either because it is used as a second crop in the season, or because the climate is limiting. Buckwheat can be a reliable cover crop in summer to fit a small slot of warm season for establishment. It establishes quickly, which suppresses summer weeds (Wikipedia).
According to FAOstat, the largest part of worldwide buckwheat production is in China and the Russian Federation, whereas in Europe, Poland amounts for the largest part of the production. We focused on the collection of data of cultivation of buckwheat in Poland, because we do not have information about the share of each buckwheat producing country to the export to the Netherlands. Buckwheat is fed to animals without processing. Only drying and storage must be taken into account.

5.2.2 Final input-output data

Explanation footnotes in Table 1

= not relevant
N/A = not available
1) Unless data are available, the standard deviation for each fertilizer application rate is set to 10% in EU countries and 20% in other countries.
2) No data were found on lime application rates. The values are set to the defaults (see methodology report).
3) The default SD for pesticide application rate is set to 10% in EU countries and the US, and to 20% in other countries.

Table 1: Cultivation in Poland

Input	Parameter	Distribution	Best estimate	SD	Min	Max	Unit
Plant material	amount	Normal	37.5		30	45	kg/ha
Fertilizer	P_2O_5	Uniform	20	10			kg/ha[1)]
	K_2O	Uniform	20	10			kg/ha[1)]
	N	Uniform	20	10			kg/ha[1)]
Lime	lime	Uniform	400		0	800	Kg $CaCO_3$/ha[2)]
Pesticides	active ingredients	Uniform	0				kg/ha[3)]
Output							
Buckwheat grains	yield	Normal	1026	202			kg/ha
	dry matter content	Normal	0.85	0.025			kg/kg

5.2.3 Growing buckwheat in Poland

Buckwheat is not produced to a large extent. Data about cultivation therefore are hard to find. Despite its name, buckwheat is not related to wheat, it is not a cereal or a grass. Instead, buckwheat is related to sorrels, knotweeds, and rhubarb (Wikipedia).
Information about seed application rate is obtained from Wikipedia.
Data about fertilizer use in buckwheat are not provided by the FAO nor the IFA. Searching for data on internet, we found an article by Beuerlein and Heinz, working at the OHIO university. They write: "*Many growers do not fertilize buckwheat due to its relatively low value and modest fertility needs. However, for optimum yields, some fertilizer may be needed. Nitrogen fertilizer may improve growth, particularly if available soil N is depleted following wheat. Low rates of N should be used, since more than 50 pounds of nitrogen per acre may lead to lodging. Buckwheat can get by without P and K on soils testing medium to high in these nutrients, but on soils testing low in P or K, application is recommended to achieve optimum yields*". From this article we assumed that application rates of each N, P, K-

fertilizer in buckwheat is moderate, say 20 kg/ha. Although Poland is a EU-country, the distribution function for fertilizer application rates is set to Uniform, with a standard deviation of 10.
Pesticide application is assumed to zero.
Data about yield is obtained from FAOstat and is the average value of the annual yield in the period 2005-2009.

5.2.4 References

FAOstat: Internet: faostat.fao.org
Wikipedia: Internet: nl.wikipedia.org and en.wikipedia.org

Beuerlein, Jim and Dr. Ed Lentz. *Buckwheat production* In: Ohio Agronomy Guide, 14th Edition. Downloaded from internet: ohioline.osu.edu/b472/0011.html (year of publication unknown)

5.3 Canary seed

5.3.1 Introduction

According to FAOstat, the largest part of worldwide canary seed production is in Canada (average annual production in 2005-2009 is 17,500 tons). In Europe, there is a small production in Czech Republic (60 tons), Hungary (912 tons), Spain (6 tons) and Turkey(6 tons). We focused on the LCI data for cultivation of canary seed in Canada, since it is reasonable to assume that this country amounts for the largest part of the export to the Netherlands. Canary seed is fed to animals without processing. Only drying and storage must be taken into account.

5.3.2 Final input-output data

Explanation footnotes in Table 1

= not relevant
N/A = not available
1) Unless data are available, the standard deviation for each fertilizer application rate is set to 10% in EU countries and 20% in other countries.
2) No data were found on lime application rates. The values are set to the defaults (see methodology report).
3) The default SD for pesticide application rate is set to 10% in EU countries and the US, and to 20% in other countries.

Table 1: Cultivation in Canada

Input	Parameter	Distribution	Best estimate	SD	Min	Max	Unit
Plant material	amount	Normal	34	4			kg/ha
Fertilizer	P_2O_5	Uniform	46	9.2			kg/ha 1)
	K_2O	Uniform	7.6	1.5			kg/ha 1)
	N	Uniform	50	10			kg/ha 1)
Lime	lime	Uniform	400		0	800	Kg $CaCO_3$/ha 2)
Pesticides	active ingredients	Uniform	2	0.4			kg/ha 3)
Output							
Canary seed	yield	Normal	1140	161			kg/ha
	dry matter content	Normal	0.87	0.025			kg/kg

5.3.3 Growing canary seed in Canada

The annual production of canary seed is low, data about cultivation are scarce. We searched for information on internet and found an article about canary seed cultivation prepared by DeMilliano at the website of the Government of Alberta (Western Canada). According to DeMilliano information seed application rate varies between 30 and 38 kg/ha and the fertilizer applications are about the same as in the cultivation of wheat.

The FAO does not provide information about fertilizer application in the cultivation of canary seed. Therefore we used their figures of application rates in the cultivation of “other cereals” in Canada. The N, P and K application rates in “other cereals” are 50 kg N/ha, 20 kg P/ha and 6.3 kg K/ha. The latter two values are converted to 46 kg P_2O_5/ha and 7.6 kg K_2O/ha.

Since canary seed does not develop very fast, it is reasonable that herbicides are used to control the weed growth. The crop is also sensitive to diseases and insects, so it is reasonable that also fungicides and insecticides are used. No data about pesticide use could be found, so we assumed it to 2 kg a.i./ha.

Data about yield are obtained from FAOstat and are average figures from the period 2005-2009. The dry matter content (87%) is obtained from DeMilliano (1998).

The canary seeds can be stored without additional drying if harvested at a moisture content of 13%.

5.3.4 References

FAOstat: Internet: faostat.fao.org
DeMilliano, Emil (1998). Internet: www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex120

5.4 Citrus

5.4.1 Introduction

Citrus pulp as a by-product of processing citrus fruits is used in Dutch animal feed in considerable amounts. In both the CVB Table and the EU Feed catalogue, no distinction is made between citrus pulp from the different species of citrus fruits, examples of which are grapefruit, lemons and oranges. Worldwide oranges are cultivated in the largest quantities (Table 1). Therefore, we focus entirely on the cultivation of oranges. Brazil and USA are considered the most important countries for the citrus pulp used in Dutch animal feed, hence we gathered LCI data for the cultivation in these countries. Brazil and USA account for 38% of the annual production of oranges (Table 4) and for 90% of the citrus pulp imported to the Netherlands (PDV, 2007-2008).

Table 1: Worldwide annual production of citrus fruits; figures are average amounts of the years 2005-2009. Data are obtained from FAOstat.

Fruit	amount (tonnes)	percentage
Citrus fruit, nes	9308565	8%
Grapefruit (inc. pomelos)	5645910	5%
Lemons and limes	13255716	11%
Oranges	66531108	57%
Tangerines, mandarins, clementines	22881383	19%
total amount	117622682	100%

5.4.2 Final input-output data

Explanation footnotes in cultivation tables

= not relevant
N/A = not available
1) Unless data are available, the standard deviation for each fertilizer application rate is set to 10% in EU countries and 20% in other countries.
2) No data were found on lime application rates. The values are set to the defaults (see methodology report).
3) The default SD for pesticide application rate is set to 10% in EU countries and the US, and to 20% in other countries.

Table 2: Cultivation of oranges in Brazil

Input	Parameter	Distribution	Mean	SD	Min	Max	Unit
Plant material	amount	Normal	#	#	#	#	kg/ha
Fertilizer	P_2O_5	Uniform	55	11			kg/ha[1)]
	K_2O	Uniform	55	11			kg/ha[1)]
	N	Uniform	55	11			kg/ha[1)]
Lime	lime	Uniform	543	108			Kg $CaCO_3$/ha[2)]
Pesticides	active ingredients	Uniform	3.26	0.64			kg/ha[3)]
Output							
Oranges	yield	Normal	22365	242	#	#	kg/ha
	dry matter content	Uniform	0.13	0.02			kg/kg

Table 3: Cultivation of oranges in USA

Input	Parameter	Distribution	Mean	SD	Min	Max	Unit
Plant material	amount	Normal	#	#	#	#	kg/ha
Fertilizer	P_2O_5	Uniform	70	14			kg/ha[1)]

Input	Parameter	Distribution	Mean	SD	Min	Max	Unit
	K_2O	Uniform	100	20			kg/ha[1)]
	N	Uniform	175	35			kg/ha[1)]
Lime	lime	Triangular	543		141	8688	Kg $CaCO_3$/ha[2)]
Pesticides	active ingredients	Uniform	3.26	0.33			kg/ha[3)]
Output							
Oranges	yield	Normal	30906	4337			kg/ha
	dry matter content	Uniform	0.13	0.02			kg/kg

5.4.3 Growing citrus

As illustrated in Table 4, oranges are by far the largest contributors to the worldwide annual production of citrus fruits. Therefore, we focus entirely on the cultivation of oranges.

Brazil and USA account for almost 40% of the world production of oranges (Table 4). Therefore we focus on the cultivation of oranges in Brazil and the USA.

Table 4: Annual citrus fruit production in the world, in Brazil and in the USA. Figures are average productions in tonnes in the years 2005-2009. Data are obtained from Faostat

Product	World		Brazil		USA	
Citrus fruit, nes	9308565	8%	0	0%	42998,6	0%
Grapefruit (incl. pomelos)	5645910	5%	69782	1%	1220648	22%
Lemons and limes	13255716	11%	1003658	8%	751330	6%
Oranges	66531108	57%	18145460	27%	8179722	12%
Tangerines, mandarins, clementines	22881383	19%	1176484	5%	377934	2%
total amount	117622682	100%	20395384	17%	10572634	9%

Mordini *et al.* (2009) did a literature review for the GHG emissions for orange production. They found GHG emissions for orange production for Brazil, Italy and Spain. Two detailed studies from Spain (Ribal *et al.*, 2009; Sanjuán *et al.*, 2005) report the GHG emissions for different production steps of the agricultural phase of orange production in Spain. Becalli *et al* (2009) calculated the emissions for Italian oranges and orange juices. In four other articles reviewed by Mordine *et al.* the emissions for Brazilian orange juice are quantified, but these papers did not gave specific information about the agriculture phase. Two other articles about GHG emissions related to oranges were found by Mordini *et al*, but also these papers did not gave specific information about the agriculture phase, even the country of origin was not clear. The latter 6 articles are not used for our research.

In this report we will use data from Fertistat and from LCA studies by Beccali *et al.* (2009), Coltro *et al.* (2009), and Ribal *et al.* (2009). Although Beccali *et al.* and Ribal *et al.* did not study the cultivation of oranges in Brazil, their data are printed here, because data of cultivation in Brazil appeared hard to get. Sanjuán *et al.* (2005) did not give clear information about the agricultural inputs and their results are not used in our research.

According to Coltro *et al.* (2009) the N,P,K fertilizers application rate is 11.75 kg N, P, K/1000 kg oranges. Unfortunately they did not specify the application rates for each of the N, P, K fertilizers. They report an average yield of 30,576 kg/ha, which yield corresponds with an N,P,K fertilizer rate per hectare of 360 kg. This conversion may not be correct, as we are not sure how Coltro *et al.* determined the N, P, K application rates. Maybe, they found data of application rates, or they rate based the application rate

upon the annual production of oranges and the annual use of fertilizers. Since it is not clear how they came to the application rates, their data seem not very useful for using in FeedPrint.
Ribal *et al.* (2009) provided a lot of information about fertilizer use. The described 3 scenarios to fertilize the plantation: furrow irrigation, drip irrigation and organic fertilizing. The application rates for furrow irrigation are summarized in Table 5.

Table 5: Fertilizer use (kg/ha) in the cultivation of oranges as derived from Ribal et al. (2009)

Fertilizer	Application	N	P	K	N-rate	P-rate	K-rate
NPK 15-15-15 (March)	600	0.15	0.15	0.15	90	90	90
Sheep manure (March)	3600	0.02**			72	0	0
Ammoniumnitrate (33.5%) (May/June)	300	0.335			100.5	0	0
Ammoniumnitrate (33.5%) (July/August)	300	0.335			100.5	0	0
Ammoniumnitrate (33.5%) (irrigation)	100*	0.335			33.5	0	0
Phosphoric acid (54%)	100*	0	0.54		0	54	0
Potassium sulphate (13-0-46)	100*	0.13		0.46	13	0	46
Yield							
Production	30000						
Total application rates					409.5	144	136

*) The application rates of ammoniumnitrate, phosphoric acid and potassium sulphate are estimates and therefore uncertain.
**) The N-content of sheep manure is estimated at 2% (expert judgement BMA)

The information about fertilizer use is summarized in Table 6. It seems that fertilizer use in European countries is much higher than in Brazil or USA. It is a pity that we could not find detailed information about fertilizer use in Brazil and USA in other sources than Fertistat. Information about cultivation of oranges in the USA, downloaded from internet (http://www.hort.purdue.edu/newcrop/morton/orange.html) says that 0.45 kg N per tree per year should be sufficient to maintain high yields of oranges cultivated in California. The number of trees is 405 per hectare, so the N-application rate is 182.5 kg N/ha. This is more than the application rate according to fertistat.

Table 6: Fertilizer use in cultivation of oranges in Brazil, Italy, Spain and USA

	Coltro[A] (Brazil)	Beccali[B] (Italy)	Ribal[C] (Spain)	FertiStat (Brazil)	Fertistat USA
N, P, K –fertilizers (kg/ha)	360				
N (kg/ha)		240	360-420	55	110
P_2O_5 (kg/ha)		100	100-144	55	70
K_2O (kg/ha)		180	100-136	55	100

(A) amounts are calculated by us, using data from Colto *et al.*(B) calculated by Beccali *et al.* (2009). (C) Calculated by us, using data from Ribal *et al.* (2009)

5.4.3.1 Brazil

Fertiliser use

For the sake of reliability, we will use the values from FertiStat (Table 6), because these values are expressed in amounts per hectare and are specific figures about fertilizer use in Brazil. It must be noted that the application rates according to Fertistat are much lower in comparison with the data from LCA studies (Table 6). Moreover the application rates in Brazil seem much lower than in the USA and European countries (Fertistat).

Energy use

Coltro *et al.* (2009) include in the total energy consumption the energy for transport of the fertilizers and pesticides and the transportation of the oranges from the farm to the processing industries and Beccali *et al.* (2009) provided data on the diesel consumption. As explained in § 4.3 of the methodology report, the energy use of cultivation activities are calculated in FeedPrint. Table 7 and 9 give specific representative values found in literature.

Table 7: Energy consumption for cultivation

	Coltro[A] (Brazil)	Beccali[B] (Italy)
Total energy	1540 MJ/1000 kg oranges	
Off which electric energy	744 MJ/1000 kg oranges	
Diesel	4.19 kg/1000 kg oranges	522.5 MJ/1000 kg

References: (A) Coltro, L. *et al.*, *Assessing the environmental profile of orange production in Brazil,* In J Life Cycle Assess (2009) 14: 656 – 664; (B) Beccali, M. *et al.*, *Resource Consumption and Environmental Impacts of the Agrofood Sector: Life Cycle Assessment of Italian Citrus-Based Products*, Environmental Management (2009) 43: 707 -724.

Plant material

Citrus trees have a life span of 20-25 years (Beccali *et al.* (2009). Since the annual yield of oranges is about 20-40 ton per hectare. None of the articles mention the use of plant material (or seeds), maybe because over the total life cycle of 25 years the contribution will be negligible.

Table 8: input cultivation of citrus fruits in Brazil

product	parameter	Value			Unit	Data analysis					Ref
		Mean	Min	Max		Rel	Com	TRC	GSp	TeC	
Plant material	amount	#	#	#	kg/ha						
Fertilizer	P_2O_5	55			kg/ha	4	2	2	1	2	C
	K_2O	55			kg/ha	4	2	2	1	2	C
	N	55			kg/ha	4	2	2	1	2	C
Lime	lime	543	141	8688	kg $CaCO_3$/ha	5	5	5	5	5	A
Pesticides	active ingredients	3.26			kg/ha	4	1	2	3	2	B
Herbicides	Active ingredients	1.08			kg/ha	4	1	2	3	2	B

References: (A) Coltro, L. *et al.*, *Assessing the environmental profile of orange production in Brazil,* In J Life Cycle Assess (2009) 14: 656 – 664; (B) Beccali, M. *et al.*, *Resource Consumption and Environmental Impacts of the Agrofood Sector: Life Cycle Assessment of Italian Citrus-Based Products*, Environmental Management (2009) 43: 707 -724. (C) FertiStat

Table 9: Energy use cultivation of citrus fruits in Brazil

product	parameter	Value			Unit	Data analysis					Ref
		Mean	Min	Max		Rel	Com	TRC	GSp	TeC	
energy use cultivation	diesel	250			kg/ha	4	1	2	3	2	B

References: (B) Beccali, M. *et al.*, *Resource Consumption and Environmental Impacts of the Agrofood Sector: Life Cycle Assessment of Italian Citrus-Based Products*, Environmental Management (2009) 43: 707 -724.

Yield

In Table 10 the average annual yield per hectare is shown, calculated from FAO data for 2005-2009.

Table 10: Output cultivation of citrus fruits in Brazil

Product name	Parameter			Value		Unit						Ref
		Mean	SD	Min	Max		Rel	Com	TRC	GSp	Tec	
Oranges	yield	22,365	242			kg/ha	1	1	2	1	1	F
	dry matter content	0.13				kg/kg	4	1	5	5	1	D

References: (D) USDA, Nutrient Composition of food, www.nal.usda.gov/fnic/foodcomp, oranges, raw, all varieties, searched on: 9 Nov. 2011. (F) FAOStat, crop yields.

5.4.3.2 USA

Fertilizers

We decided to use the information for cultivation of fruits in general, obtained from Fertistat as no complete information about current fertilizer application rates in oranges was available. The amounts used in European countries may be used as maximum application rates.

Table 11 Fertilizer use in fruits (orchards) in USA. Data obtained from Fertistat

	FertiStat (USA: fruits)[C]	European values (from Ribal *et al.*, see Table 6)
N fertilizer (kg/ha)	110	240
P fertilizer (kg/ha)	70	100
K fertilizer (kg/ha)	100	180

Refernces: (C) FertiStat

Table 12: Input for cultivation of citrus fruits in USA

product	Parameter	Value			Unit	Data analysis					Ref
		Mean	Min	Max		Rel	Com	TRC	GSp	TeC	
Plant material	Amount	#	#	#	kg/ha						
Fertilizer	P_2O_5	30	N/A	N/A	kg/ha	5	5	5	5	5	C
	K_2O	80	N/A	N/A	kg/ha	5	5	5	5	5	C
	N	110	N/A	N/A	kg/ha	5	5	5	5	5	C
Lime	lime	543	N/A	N/A	kg $CaCO_3$/ha	5	5	5	5	5	A
Pesticides	active ingredients	3.26	N/A	N/A	kg/ha	5	5	5	5	5	B
Herbicides	Active ingredients	1.08	N/A	N/A	kg/ha	5	5	5	5	5	B

References: (A) Coltro, L. *et al.*, *Assessing the environmental profile of orange production in Brazil,* In J Life Cycle Assess (2009) 14: 656 – 664; (B) Beccali, M. *et al.*, *Resource Consumption and Environmental Impacts of the Agrofood Sector: Life Cycle Assessment of Italian Citrus-Based Products*, Environmental Management (2009) 43: 707 -724. (C) FertiStat

Yield

In Table 13 the average yield per hectare is shown.

Table 13: Output cultivation of citrus fruits in the USA

Product name	Parameter	Value				Unit						Ref
		Mean	SD	Min	Max		Rel	Com	TRC	GSp	Tec	
Oranges	yield	30,906	4337	N/A	N/A	kg/ha	4	1	5	5	1	F
	dry matter content	0.13	N/A	N/A	N/A	kg/kg	4	1	5	5	1	D

5.4.4 References

(A) Coltro, L. *et al.*, *Assessing the environmental profile of orange production in Brazil,* In J Life Cycle Assess (2009) 14: 656 – 664;

(B) Beccali, M. *et al.*, *Resource Consumption and Environmental Impacts of the Agrofood Sector: Life Cycle Assessment of Italian Citrus-Based Products*, Environmental Management (2009) 43: 707 -724.

(C) FertiStat, Fertilizer Use Statics: http://www.fao.org/ag/agl/fertistat/index_en.htm, viewed on 9 Nov. 2011.

(D) USDA, Nutrient Composition of food, www.nal.usda.gov/fnic/foodcomp, oranges, raw, all variaties, searched on: 9 Nov. 2011.

(E) FAOstat, production 2009, viewed on 7 Nov 2011.

Ribal, Javier, Neus Sanjuán, Gabriela Clemente, M. Loreto Fenollosa (2009) *Medición de la ecoeficiencia en procesos productivos en el sector agrario. Caso de estudio sobre producción de cítricos* Economía Agraria y Recursos Naturales. 9: 1 pp. 125-148

Sanjuán, N., Úbeda, L.,Clemente, G., Mulet, A. and Girona, F. (2005) *LCA of integrated orange production in the Comunidad Valenciana (Spain)*, Int. J. Agricultural Resources, Governance and Ecology, Vol. 4, No. 2, pp.163–177