Evaluation POTATO PRODUCTION CHINA

Frank de Ruijter, Corné Kempenaar, Anton Haverkort, 11 January 2013

Data collection

Data were collected by email, after sending a questionnaire (Appendix 1). Below the regions and persons that were contacted.

Table 1. Regions and contact persons – data delivered

Region	County or city	Contact person	Other persons
Ningxia	Xiji county	Cui Shuli (cuishuli@yahoo.com)	Mr. Zhu
Ningxia	Yanchi county	Cui Shuli (cuishuli@yahoo.com)	Mr. Zhu
Inner Mongolia	Dalate	Chen Lan (lan.chen@syngenta.com)	David Liu (david.liu@syngenta.com)
Heilongjiang	Keshan	Chen Lan (lan.chen@syngenta.com)	David Liu (david.liu@syngenta.com)
Hebei	Chabei, Zhangjiakou city	Chen Lan (lan.chen@syngenta.com)	David Liu (david.liu@syngenta.com)
Fujian	Yutian	Zhaonian Yuan (yzn05@sina.com)	

Table 2. Other regions and contact persons – no data delivered

Region	Contact person	Comments
Yunnan	Liping He (lipinghe03@yahoo.com; lipinghe01@tom.com)	Contact of Romke, recommended Dr Prof Guo Huachun
Yunnan	Dr Prof Guo Huachun (ynghc@126.com)	No response
Sichuan	Xie Jiang (xiejiang2010@gmail.com)	Positive first response, but no data delivered
Sichuan	Yunliang Peng (pengyunliang@yahoo.com.cn)	Positive first response, but no data delivered
Sichuan	He Wei (hewei2008@yahoo.com.cn)	Positive first response, but no data delivered
China	Gregory Scott (CIP)	Mails were undeliverable, no response on question through CIP website

Together with the questionnaire, a form was sent for monthly weather data. The contact persons only could deliver temperature (minimum and maximum) and precipitation and had no information on daily radiation and open pan evaporation. Therefore, for model calculations data were derived from the PRI-database containing weather data of the Climatic Research Unit (CRU) (Jones and Harris, 2008):

- Tmax, monthly average of daily maximum temperature (°C), averaged over 2000-2009 (from CRU TS 3.10)
- Tmin, monthly average of daily minimum temperature (°C), averaged over 2000-2009 (from CRU TS 3.10)
- Precipitation, monthly sum (mm), averaged over 2000-2009 (from CRU TS 3.10.01)
- Potential evapotranspiration, monthly sum (mm), averaged over 2000-2009 (from CRU TS 3.10)
- Radiation, monthly sum (W/m2), averaged over 1961-1990 (from CRU CL 1.0)

Results

Collected data

An overview of all answers in the questionnaires is given in Appendix 2. These data are also given in the file "Questionnaire responses - 20121130.xlsx" where additional information as described the questionnaire is given in comments in individual cells.

A summary table of soil type and growing period is given in Table 3. A fixed harvest date was chosen to be used in calculations with the crop growth model. Harvest dates have been asked in a separate email (responses below Table 3). Data on crop yield and irrigation are presented together with the results of calculations with the crop growth model.

Table 3. Soil type and growing period

	Soil texture	Clay and silt (%)	Rooting depth (cm)	Planting date	Harvest date	#days growth
Ningxia - Xiji	medium	10	50	May 12	Sept 1	112
Ningxia - Yanchi	medium	36	50	April 25	Oct 1	159
Inner Mongolia - Dalate	course	1[a]	40	April 28	Oct 1	156
Heilongjiang - Keshan	medium	15[b]	40	April 28	Sept 23	148
Hebei - Chabei	medium	20	40	May 1	Sept 20	142
Fujian - Yutian	course	15	50	Nov 15	Mar 15	121

[a] value of 0 reported; [b] no data returned

Harvest dates as given by contact persons:

- Ningxia: The harvesting date very much depends on the variety. In Xiji, the early-matured potato is harvested in July and late-matured potato is harvested in October, while in Yanchi, early-matured is harvested around 15 September, and late-matured is harvested around 15 October.
- Inner Mongolia: harvest date from Sep 18 to Oct 15 for 500 ha.
- Heilongjiang: harvest date from Sep 1 to Oct 15, for 670 ha.
- Hebei: harvest date from Sep 1 to Oct 10, for 550 ha.
- Fujian: planting is from October 28 to December 28, mostly from November 15 to December 15. Length growing period is usually about 100-120 days. Typical planting-harvest dates: November 25 - March 15.

Crop growth model – yield and water use

A simple crop growth model was used to calculate potential yield and water requirements (See the file "Model China – FdR 20121206.xlsx" for the crop growth model with input data and results). Input data for the different locations are given in Table 4. Figure 1 shows monthly values for temperature (minimum and maximum) and precipitation. The green bars indicate the potato growing season.

Table 6: input data for crop growth model

	General input	Ningxia - Xiji	Ningxia - Yanchi	Inner Mongolia	Heilongjiang	Hebei - Chabei	Fujian - Yutian
Month of planting (1-12)		5	4	4	4	5	11
Day of month of planting (1-31)		12	25	28	28	1	15
Planting depth (mm)		200	150	150	150	90	200
Month of harvest		9	10	10	9	9	3
Day of harvest		1	1	1	23	20	15
Sprout growth rate (mm/degree day)	0.7						
Degree days emergence-100% crop cover	650						
LUE (all radiation) (g/MJ light intercepted)	1.25						
Harvest index (%)	75						
DM concentration tubers (%)	21						
Rooting depth (m)		0.2	1.5	0.4	0.4	0.4	0.5
Texture (%clay and silt)		10	36	1	15	20	15
Soil texture		medium	medium	course	medium	medium	course
Min temp photosynthesis (Tmax)	8						
Min temp optimal photosynthesis (Tmax)	20						
Max temp optimal photosynthesis (Tmax)	25						
Max temp photosynthesis (Tmax)	33						

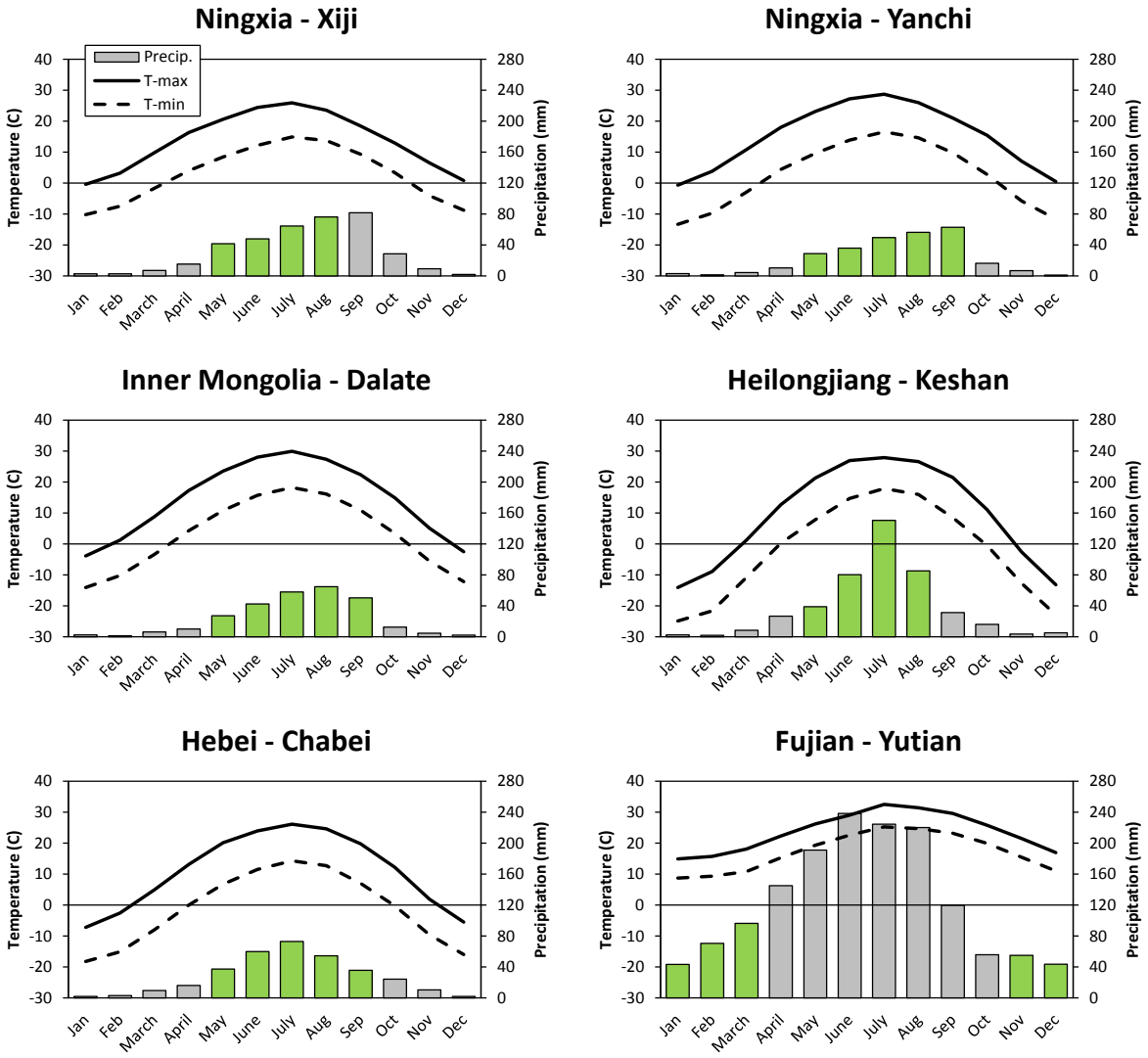

Figure 1. Monthly average minimum and maximum temperatures (°C) and total precipitation per month (mm) for six locations in China. Green bars indicate the potato growing season.

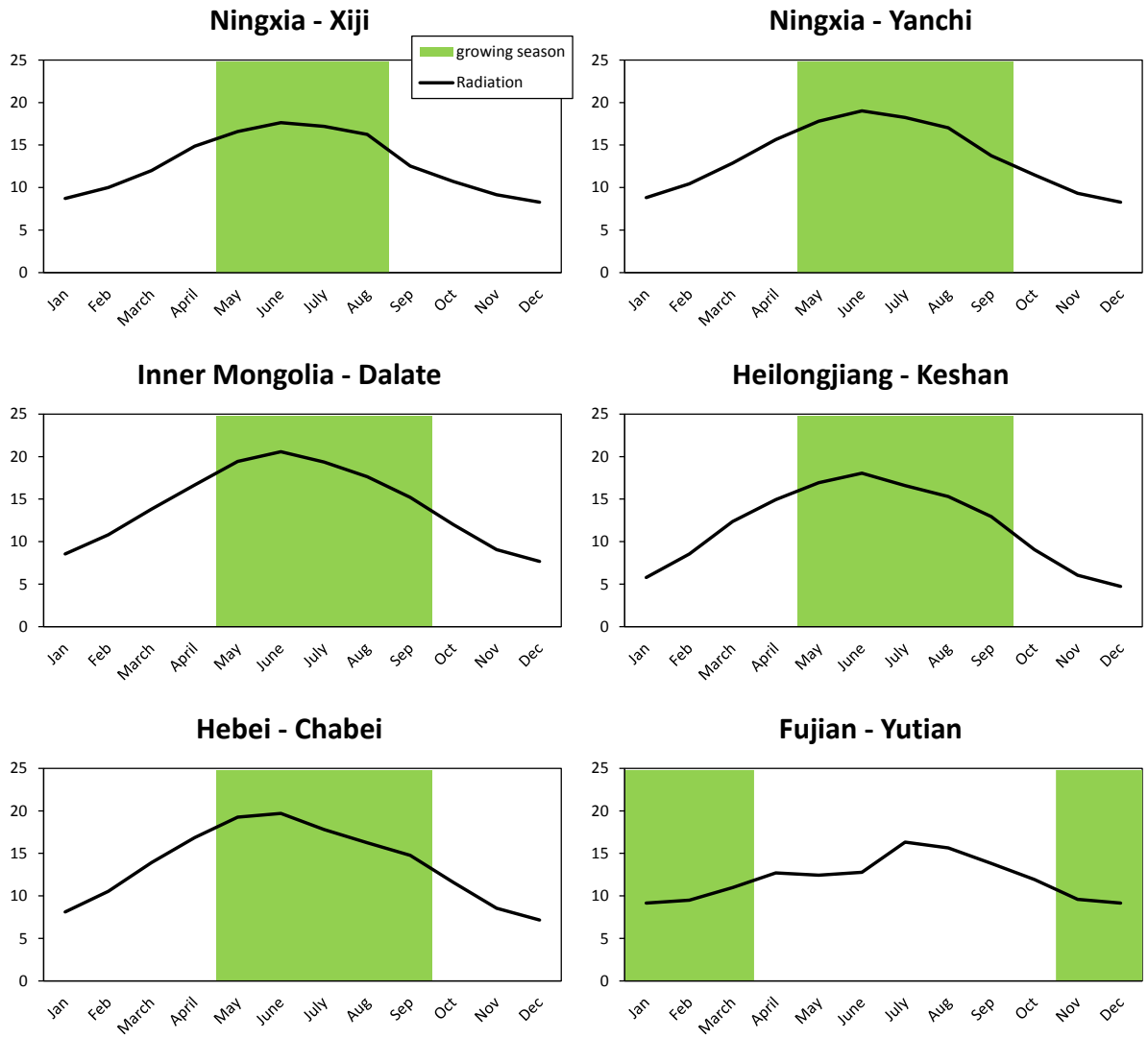

Figure 2. Average daily radiation per month (MJ/m^2) for six locations in China. The green area indicates the potato growing season.

Table 7. Planting depth and soil texture.

	Planting depth (mm)	Soil texture	Clay and silt (%)	Soil field capacity (mm water/m soil)	Irrigation point (mm water/m soil)
Ningxia – Xiji	200	medium	10	160	50
Ningxia - Yanchi	150	medium	36	240	130
Inner Mongolia - Dalate	150	course	1[a]	70	40
Heilongjiang - Keshan	150	medium	15[b]	180	60
Hebei - Chabei	90	medium	20	200	80
Fujian - Yutian	200	course	15	180	60

Table 8. Water balance and irrigation requirements (mm).

	Precipitation between planting and harvest	ETP between planting and harvest	Accumulated precipitation deficit	Soil water reserve	Irrigation need	Irrigation need per ton fresh potato
Ningxia - Xiji	218	279	97	22	75	1.36
Ningxia - Yanchi	230	501	285	165	120	1.58
Inner Mongolia - Dalate	238	564	338	12	326	4.59
Heilongjiang - Keshan	379	432	92	48	44	0.68
Hebei - Chabei	245	455	229	48	181	2.20
Fujian - Yutian	231	160	5	60	0	0

Table 9. Modelled crop growth and yield.

	Growing period (days)	Days between planting and emergence	Days between emergence and 100% ground cover	Days between 100% ground cover and harvest	DM tuber yield (ton DM/ha)	Fresh tuber yield (ton/ha)
Ningxia - Xiji	112	18	35	59	11.6	55
Ningxia – Yanchi	159	15	36	108	15.9	76
Inner Mongolia - Dalate	156	14	33	109	14.9	71
Heilongjiang - Keshan	148	17	36	95	13.5	64
Hebei - Chabei	142	11	41	90	17.3	82
Fujian - Yutian	120	16	48	56	4.9	24

Table 10. Comparison of model results and average data from practice for irrigation and yield.

	Irrigation need (model)	Irrigated (practice)	Yield (model) (ton/ha)	Yield (practice) (ton/ha)
Ningxia - Xiji	75	0	55	20.2
Ningxia - Yanchi	120	?	76	30
Inner Mongolia - Dalate	326	357	71	40
Heilongjiang - Keshan	44	29	64	52.5
Hebei - Chabei	181	300	82	45
Fujian - Yutian	0	6	24	35

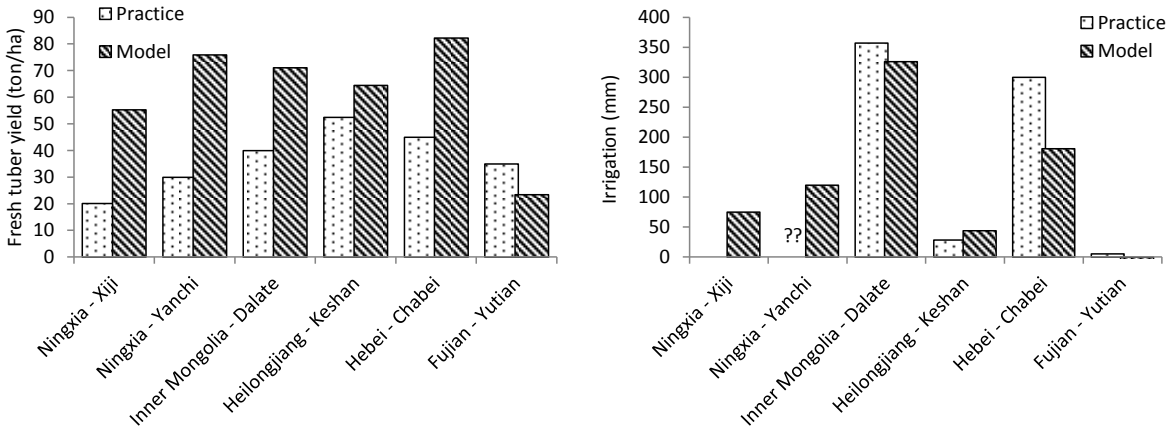

Figure 2. Comparison of model results with data from farming practice. Fresh tuber yield (ton fresh ha^{-1}; left) and irrigation (mm season^{-1}; right).

COOL FARM TOOL CALCULATIONS

Calculations of greenhouse gas (GHG) emissions were carried out with the Cool Farm Tool (CFT; Haverkort & Hillier, 2011) using data from the questionnaire responses (Appendix 1 and "Questionnaire responses - 20121130.xlsx"). Results are presented as absolute values and relative values, both per unit area and unit product (Figures 3 to 6).

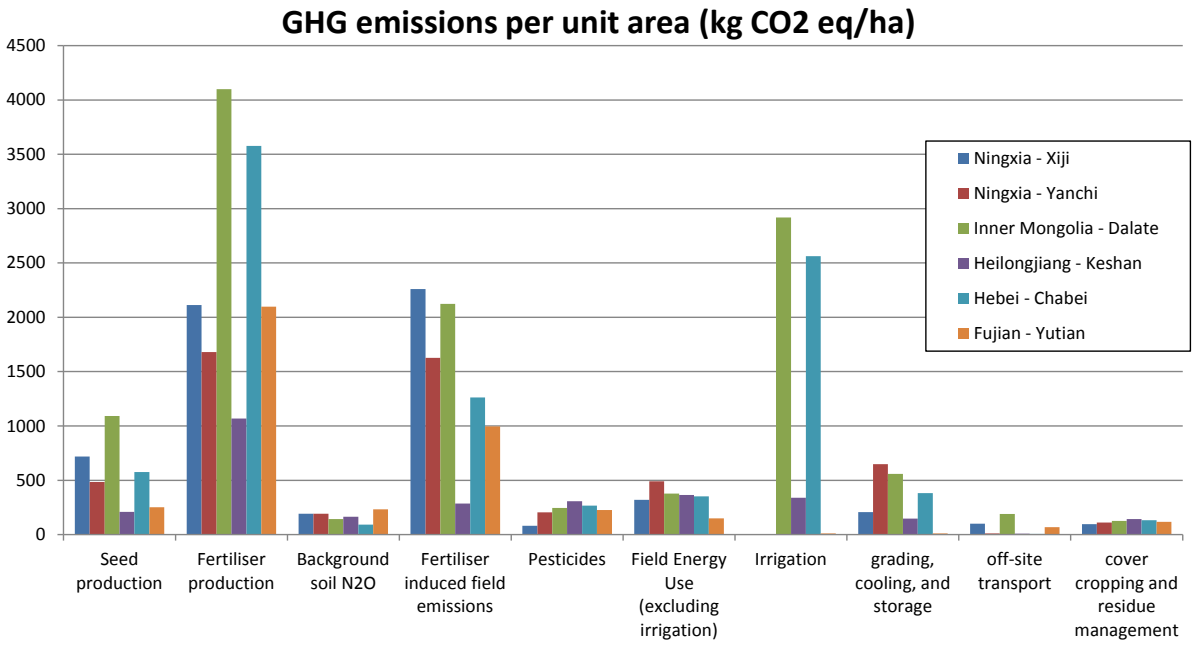

Figure 3. GHG emissions per unit area (kg CO_2-eq ha^{-1}) for different aspects of crop production and six locations in China.

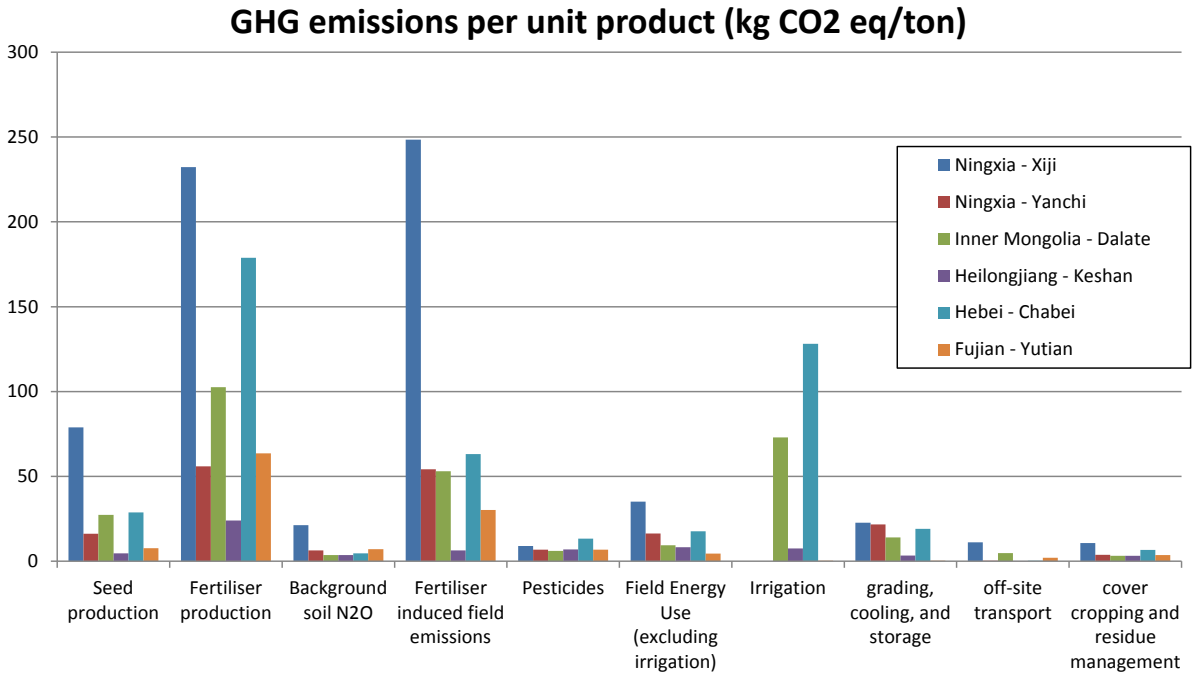

Figure 4. GHG emissions per unit product (kg CO_2-eq ton^{-1}) for different aspects of crop production and six locations in China.

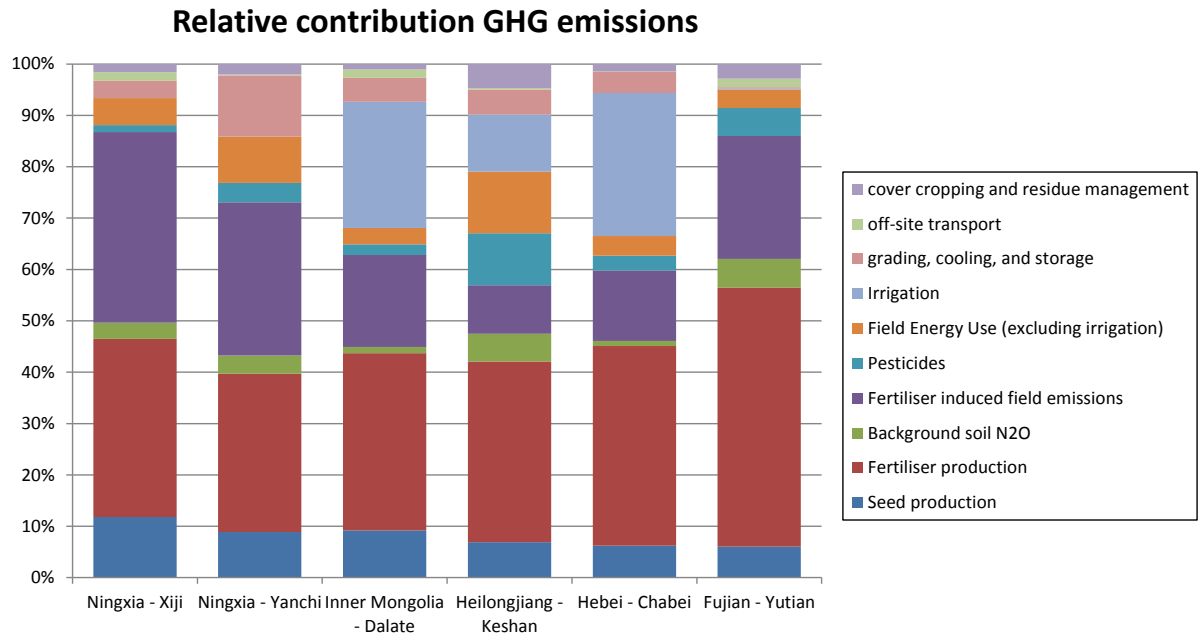

Figure 5. Relative contribution of various aspects of crop production to total GHG emission per location.

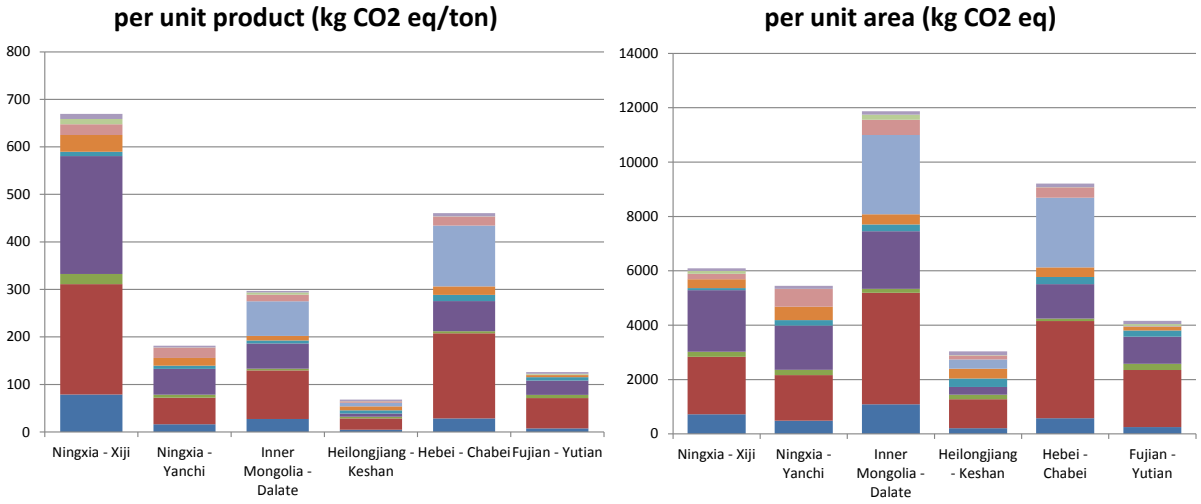

Figure 6. Total GHG emission (kg CO_2-eq) per ton product (left) and per hectare (right) for six locations in China.

Comparison between locations differs when total GHG-emission is expressed per ton of potatoes produced or per hectare. In Ningxia, GHG emission per hectare has an average value compared to the other locations. Expressed per ton of produce, GHG emission is highest in Ningxia. This difference is caused by the low yields in Ningxia.

Largest emissions are related to fertilization. Fertilizer induced field emissions are emissions of N_2O. The sum of emissions from fertilizer production and fertilizer induced field emissions (expressed in CO_2-eq) amounts between 45% (Heilongjiang) and 74% (Fujian) of the total emission. Irrigation may also give a substantial contribution: 25% in Inner Mongolia and 28% in Hebei.

Appendix 1. Questionnaire

In the questionnaires sent to Ningxia, Inner Mongolia, Heilongjiang, Hebei and Fujian, the following topics were missing:

- *altitude*
- *harvest date*

Altitude can be derived from google earth and the coordinates of the location.
Harvest date was asked in a separate email.

Questionnaire for data on potato production in China - version 30-Nov-2012
For questions, contact: Frank de Ruijter, frank.deruijter@wur.nl

This questionnaire is on production of ware potatoes and potatoes for processing.

The aim of collecting these data is to make an evaluation of Chinese potato production in important regions. In this evaluation we calculate the options for yield improvement, and the footprints of potato production such as of land, water, energy and minerals. See also a previous email message that was sent by Corne Kempenaar and Anton Haverkort.

The required data are on averages: average production, average use of inputs in a region and average over several years (average weather conditions).

Together with this document, an example is sent of a completed questionnaire for a potato production area on sandy soil in the southeast of the Netherlands.

Choosing options
For some questions, different options are given. Please mark the box near the most appropriate option, as shown in the example below:

Soil Texture	class		fine (clay)	Choose one of the options
		x	medium	
			course (sand)	

Parameter	Unit	Data	Explanation
Location		Give the name of the region/city or village where the potatoes are produced, together with a latitude and longitude. As example, the latitude and longitude of Beijing is given.	
Name			Name of region/city/village where potatoes are produced.
Latitude	xx°xx'xx"N		39°54'50"N (example for Beijing)
Longitude	xx°xx'xx"E		116°23'30"E (example for Beijing)
Altitude	m		

Soil properties				
Soil Texture	class		fine (clay)	Choose one of the options (by marking the box before the appropriate option)
			medium	
			course (sand)	
Clay and silt content	%			% of weight. Clay and silt are all particles < 0.05 mm. Give an average value for the region
Soil Organic Matter (SOM)	%		SOM ≤ 1.7	Choose one of the options
			1.7 < SOM ≤ 5.2	
			5.2 < SOM ≤ 10.3	
			SOM > 10.3	
Drainage	class		Poor	Choose one of the options
			Good	
Soil pH	class		pH <= 5.5	Choose one of the options
			5.5 < pH <= 7.3	
			7.3 < pH <= 8.5	
			pH > 8.5	
Rooting depth	cm			Give the rooting depth of potato on this soil

Growing period			
Date of planting	day/month		Fill in the date on which potatoes are generally planted (for example: 1 May)
Date of harvest	day/month		Fill in the date on which potatoes are generally harvested

Seed and harvest			
Seed rate	t/ha		Kg of seed potatoes planted per ha
Planting depth	cm		Depth of seed tuber below soil surface
Seed transported	km		Distance from seed grower to potato producer

Fertilizer input		*Calculate the pure nutrients that are applied with chemical fertilizers.* *Example: 100 kg/ha NPK-(15:5:20) = 15 kg N, 5 kg P_2O_5 and 20 kg K_2O*	
N from fertilizer	kg/ha		Kg pure N applied per ha
P_2O_5 from fertilizer	kg/ha		Kg pure P_2O_5 applied per ha

K_2O from fertilizer	kg/ha		Kg pure K_2O applied per ha

Parameter	Unit	Data	Explanation
Manure and compost		Give name and amount that is on average applied to potato, next to the fertilizer input as given above. Fill in the table below.	

Manure name	Amount applied (t/ha)	Type (slurry or solid)	Indicate from which animal

Crop protection products		Give the number of treatments with a crop protection product before planting and during crop production. For treatments during harvest and storage: see under 'Harvesting and storage'. If mixtures are applied, count each product as a separate application, for example: 1 fungicide + 1 insecticide = 2 treatments	
Seed treatments	number		
Herbicides (weeds)	number		Herbicides against weeds
Herbicides (haulm killing)	number		Herbicides used for haulm killing
Insecticides	number		
Fungicides	number		

Parameter	Unit	Data		Explanation
Field operations, mechanically powered				
Fuel type for tractor			diesel	Indicate the type of fuel that is used by your tractor
			petrol	

Ploughing (Indicate the number of operations: how often is it done? 1, 2 or 3x ….)			
Moldboard ploughing	number		This turns the topsoil almost completely over
Chisel ploughing	number		This does not invert the soil
Subsoiling	number		Deeper than chisel ploughing

Harrowing (Indicate the number of operations: how often is it done? 1, 2 or 3x ….)			
Power harrow	number		
Tine harrow	number		Tine or spike harrow
Disk harrow	number		
Roller harrow	number		
Chain harrow	number		

Other treatments (Indicate the number of operations: how often is it done? 1, 2 or 3x ….)			
Planting	number		Mechanical planting
Ridging	number		
De-stoning	number		Mechanical removal of stones
Mechanical weeding	number		

Fertilizer and manure - transport and application			
Slurry injection	number		
Slurry transport	km		From animal house to potato field (km)
Manure spreading	number		Manure or compost
Manure transport	km		From animal house to potato field (km)
Fertilizer spraying	number		For liquid fertilizer
Fertilizer spreading	number		For solid fertilizer. Give the number of times a spreader entered the field
Pesticide spraying	number		How often did the spraying machine enter the field with a single chemical or a mixture?

Irrigation			
Irrigation water	mm		How many mm water irrigated during whole season?
Depth irrigation water	m		From how deep the water is pumped up
Horizontal transport distance	m		Distance between water source and field

Type of irrigation equipment				Choose one of the options
			pivot	
			rain gun	
			sprinkler	
			flooding	
			drip irrigation	

Power supply for irrigation				Indicate the type of fuel that is used for irrigation
			electricity	
			diesel or petrol	

Parameter	Unit	Data		Explanation
Foliage destruction (choose one or more of the options below)				
Type of foliage destruction	choose		spraying	Chemical leaves/stems destruction
			haulm flailing	Mechanical leaves/stems destruction
			manual	Manual removal of foliage
Harvesting and storage				
Type of harvest	choose		Fully mechanical	Mechanical lifting and mechanical loading
			Windrowing	Mechanical lifting and handpicking
			Manual	Fully manual harvest
Transport distance	m			Distance between field and farm store
Fresh product harvested	t/ha			Total product harvested from field (1 ton = 1000 kg)
Sold product	t/ha			Amount of product that is delivered to the factory or market
Washing potatoes	%			Percentage of harvested potatoes washed
Fuel type			electricity	Indicate the type of fuel that is used for washing
			diesel or petrol	
Grading potatoes	%			Percentage of harvested potatoes graded
Fuel type			electricity	Indicate the type of fuel that is used for grading
			diesel or petrol	
Storage of potatoes	%			Percentage of harvested potatoes that is stored.
Energy source for loading/unloading the storage			diesel	Choose one of the options
			petrol	
			electricity	
Duration of storage	months			Number of months
Temperature difference	°C			When cooled mechanically: how many degrees cooled by refrigerator (average temperature heap and outside during whole season)
Crop protection treatments	number			Number of treatments with a crop protection product during harvest and storage. If mixtures are applied, count each product as a separate application, for example: 1 fungicide + 1 insecticide = 2 treatments

Comments

Appendix 2. Questionnaire responses

These data can also be found in "Questionnaire responses - 20121130.xlsx" where additional information from the questionnaire is given in comments in individual cells. In yellow data that were adapted by FdR/AH. Description of the changes made is given in the excel file.

	Ningxia - Xiji	Ningxia - Yanchi	Inner Mongolia - Dalate	Heilongjiang - Keshan	Hebei	Fujian - Yutian, Changle
Latitude	35°35' - 36°14'	37 °48'00"	40°45'55" N	47°95'80"N	41°24'51"N	25°87'55"N
Longitude	105°20' - 106°04'	107 °01'56"	109°80'52"E	125°90'20"N	114°55'56"E	119°.45'76"E
Altitude (m)	1900	1500	1000	225	1375	35
Soil Texture	Medium	Medium	course (sand)	medium	medium	course (sand)
Clay and silt content (%)	10	35.6	0	15	20	15
Soil Organic Matter (SOM)	5.2 < SOM < 10.3	5.2 < SOM < 10.3	SOM < 1.7	1.7 < SOM < 5.2	SOM < 1.7	1.7 < SOM < 5.2
Drainage	Good	Good	Good	good	good	good
Soil pH	7.3 < pH <= 8.5	pH > 8.5	pH > 8.5	5.5 < pH <= 7.3	7.3 < pH <= 8.5	pH <= 5.5
Rooting depth (cm)	50	50	40	40	40	50
Seed						
Seed rate (t/ha)	1.8	1.95	2.7	2.6	2	1.5
Date of planting	12-mei	25-apr	28-apr	28-apr	1-mei	15-nov
Date of harvest	1-sep	1-okt	1-okt	23-sep	20-sep	15-mrt
Nr days growing season	112	159	156	148	142	121
Planting depth (cm)	20	15	15	15	9	20
Seed transported (km)	50	3	350	0.5-30	15	2000
Fertilizer input						
N from fertilizer	225	216	444	105	395	230
P_2O_5 from fertilizer	75	120	285	105	270	160
K_2O from fertilizer	300	84	456.75	127.5	360	215

	Ningxia - Xiji	Ningxia - Yanchi	Inner Mongolia - Dalate	Heilongjiang - Keshan	Hebei	Fujian - Yutian, Changle
Manure and compost (t/ha)						
1	30	22.5	-	-	-	1.5
2	27	1.2				
3	26					
Crop protection products						
Seed treatments	1	1	1	1	2	0
Herbicides (weeds)	1	2	1	1	1	2
Herbicides (haulm killing)	1	1	0	0	0	0
Insecticides	0	2	1	5	2	3
Fungicides	1	4	9	8	8	6
Field operations, mechanically powered						
Fuel type for tractor	Diesel	diesel	diesel	diesel	diesel	diesel
Moldboard ploughing	2	2	1	0	1	1
Chisel ploughing	2	1	2	2	0	0
Subsoiling	1	0	3	3	1	1
Power harrow	1	0	1	0	0	1
Tine harrow	1	0	0	1	1	0
Disk harrow	0	0	1	0	0	0
Roller harrow	0	0	0	0	0	0
Chain harrow	0	0	0	0	0	0
Planting (mechanical)	1	1	1	1	1	1
Ridging	1	2	3	1	1	1
De-stoning (mechanical removal of stones)	0	0	0	0	0	0
Mechanical weeding	1	3	0	1	1	0

	Ningxia - Xiji	Ningxia - Yanchi	Inner Mongolia - Dalate	Heilongjiang - Keshan	Hebei	Fujian - Yutian, Changle
Slurry injection	0	0	0	0	0	0
Slurry transport	0	0	0	0	0	20
Manure spreading	1	2	0	0	0	0
Manure transport	5	2	0	0	0	0
Fertilizer spraying	1	2	5	0	15	0
Fertilizer spreading	3	2	1	1	2	1
Pesticide spraying	1	2	1	5	2	4
Irrigation						
Irrigation water (mm)		?	357	29	300	6
Depth irrigation water (m)		0.1-0.25	80	130	80	5
Horizontal transport distance (m)		1000	0	0	500	20
Type of irrigation equipment	none	Drip irrigation	Pivot	Pivot	Pivot	Flooding
Power supply for irrigation		Electricity	Electricity	Electricity	Electricity	Electricity
Foliage destruction						
Type of foliage destruction	Manual	haulm flailing	haulm flailing	haulm flailing	haulm flailing	manual
Harvesting and storage						
Type of harvest	Manual	Fully mechanical	Fully mechanical	Windrowing	Windrowing	manual
Transport distance (m)	1500	3000	350	15000	15000	300
Fresh product harvested (t/ha)	20.2	30	40	52.5	45	35
Sold product	9.1	30	40	44.6	20	33
Washing potatoes (%)	30	0	0	0	0	100
Fuel type	Electricity				Electricity	Electricity

	Ningxia - Xiji	Ningxia - Yanchi	Inner Mongolia - Dalate	Heilongjiang - Keshan	Hebei	Fujian - Yutian, Changle
Grading potatoes (%)		85	100	85	0	80
Fuel type		electricity	electricity	electricity		electricity
Storage of potatoes (%)	55	100	100	15	55	15
Energy source for loading/unloading the storage	Electricity	Diesel	Diesel	Petrol	Electricity	??
Duration of storage (months)	6	7	4.5	6	5	0
Temperature difference (°C - cooling)	0	0	0	0	0	0
Crop protection treatments	0	0	0	0	0	0
Comments			see comment 1	see comment 2	see comment 3	
			Cv Burbank	Seed tuber company	Average over varieties	
			Soil is very sandy	Product sold to south China	food, seed, french fries	
				Irrigation only once in 2012		

Storage temperature: All storage under cool conditions: no difference in temperature with outside assumed. In Fujian no storage.

Transport off-site: only for seed potatoes and slurry/manure. Not for harvested product.

Comment 1: The farm belongs to a local potato product company whose processing site is 300km away. The variety described is Burbank; they also have Shapody planted but the fertilize usage is different so we chose one as sample. Soil in Dalate is completely sand. And the average wind speed is about 3 m/second. So they make ridge for 3 times because wind will destroy the ridge in the early stage of the plant. Irrigation water is 100,000t in total life period for a 28 ha pivot irrigation circle

Comment 2: This site is run by a local seed tuber production company, 85% of its harvest was sold to south China as seed tuber, while 15% leftover for self-reproduction. The pivot irrigation was used only once (6000 ton for 21 ha) in the whole planting life in year 2012, for precipitation was enough in summer.

Comment 3: This questionnaire was interviewed from the Snowvalley company, whose farms in Chabei district, Zhangjiakou city, Hebei province. The data was averaged from 530 ha land. Variety were Shapody (for food process), Atlantic (Seed tuber use), Favorita (seed use), Innovator (French Fries use).