Database documentation

GHG-DB-Thuenen

Database

Janine Mallast, Heinz Stichnothe, Yvonne Anders

Thünen - Institute of Agricultural Technology

Roland Fuß

Thünen-Institute of Climate Smart Agriculture

Ulrike Hagemann

Leibniz Centre for Agricultural Landscape Research (ZALF)

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Introduction

The GHG-DB-Thuenen is a relational database in which data of two by the Agency for Renewable Resources (FNR) e.V. and the Federal Ministry for Food and Agriculture (BMEL) funded projects i) " Mitigation of greenhouse gas emissions in oilseed rape cropping with particular consideration of nitrogen fertilization" (short: OSR project) as well as ii) "Potential to mitigate the release of climate-relevant trace gases in the cultivation of energy crops for biogas production" (short: BGD project) are stored. The GHG-DB-Thuenen was developed with Microsoft Access Database 2007-2016.

All measuring campaigns were conducted at different sites in order to investigate site-specific variability of greenhouse gas emissions depending on management activities. The experimental sites of both projects are shown in Figure 1 and Figure 4.

After the report release by the Agency for Renewable Resources (FNR) e.V. and the Federal Ministry for Food and Agriculture (BMEL), the final report of both cooperating projects will provide at the technical information library (TIB).

Biogase digestate project

The project "Potentials to mitigate the release of climate-relevant trace gases in the cultivation of energy crops for biogas production" was carried out in cooperation with the joint project EVA II and III "Development and comparison of optimized cultivation systems for agricultural production of energy crops under the different site conditions in Germany" (http://www.eva-verbund.de/home.html) during the period from 09/01/2010 until 31/12/2015, both funded by FNR and BmEL.

I. Sites

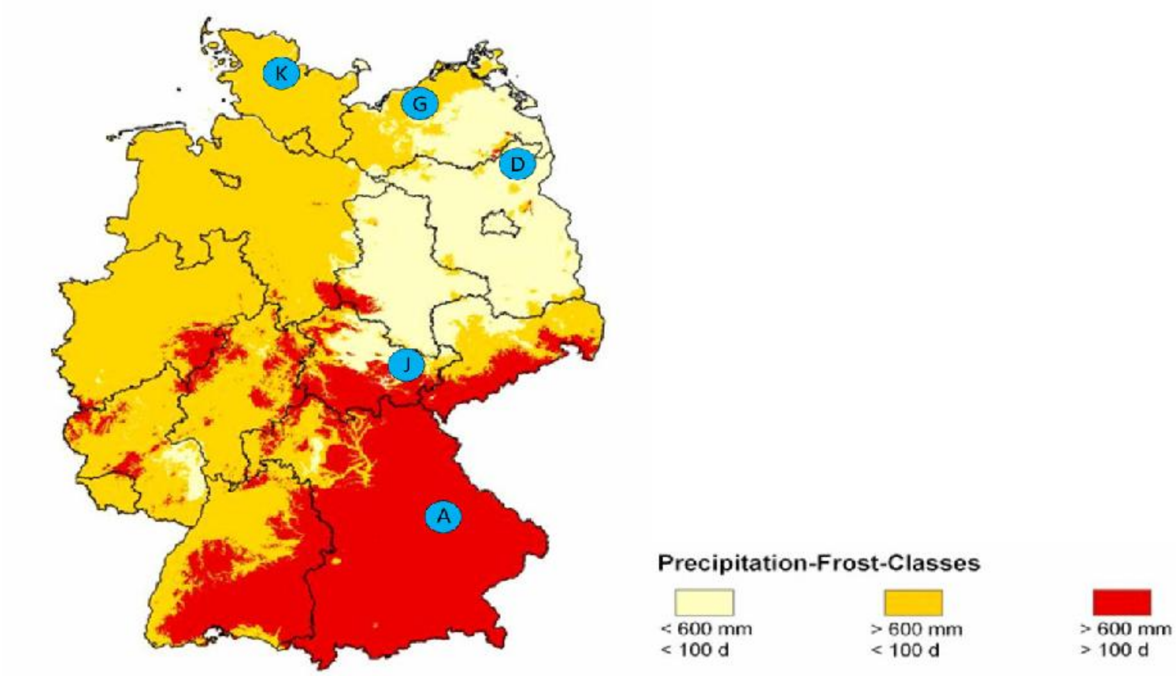

Figure 1: Experimental sites of the BGD project - Kiel (K), Gülzow (G), Dedelow (D), Jena - Dornburg (J), Ascha (A) modified according to Jungkunst et al. 2006

II. *Experimental design*

1. Small digestate experiment (KleinG):

The research aim of the Small digestate experiment (KleinG) is the determination of the influence of the core crop rotation 3 of the EVA project [energy maize – winter rye (GPS - whole plant used as silage) - Sudan grass (GPS) - winter triticale (GPS) - ryegrass (opt.) - winter wheat (grain)] and the application of mineral fertilizer and digestate on the net CO_2-, CH_4- and N_2O- exchange, the NH_3 emission, the resulting impact on climate and the change in the soil carbon stock (system-C-balance).

In doing so, the crop rotation has been replicated, that is, with a time offset of 1 year, created twice, so that the factor "crop rotation year" displays two factor levels:

- 1. Cultivation
- 2. Cultivation

The factor "fertilization" was created with 3 factor levels in the experimental design:

- 100% mineral fertilization (MIN)
- 50% digestate/ fermentation residue (FR) + 50% mineral fertilization (MIN)
- 100% digestate fertilization

This results in 6 KleinG-measuring plots in total at each investigation site, on which the analyses for gas exchange were carried out throughout the year. The measuring plots remained in place throughout the study period.

The absolute N-fertilizer quantity was always oriented on the site-specific fertilizer quantity common for specific crops. The digestate amount to be applied was determined based on the N content of the present digestate of the respective site and of a mineral fertilizer equivalent of 70%. As mineral N fertilizer, calcium ammonium nitrate (CAN) was used. At all sites, the digestate originated from co-fermentation of maize silage and cow-manure, if necessary with small additions of grass silage and barley/rye grist.

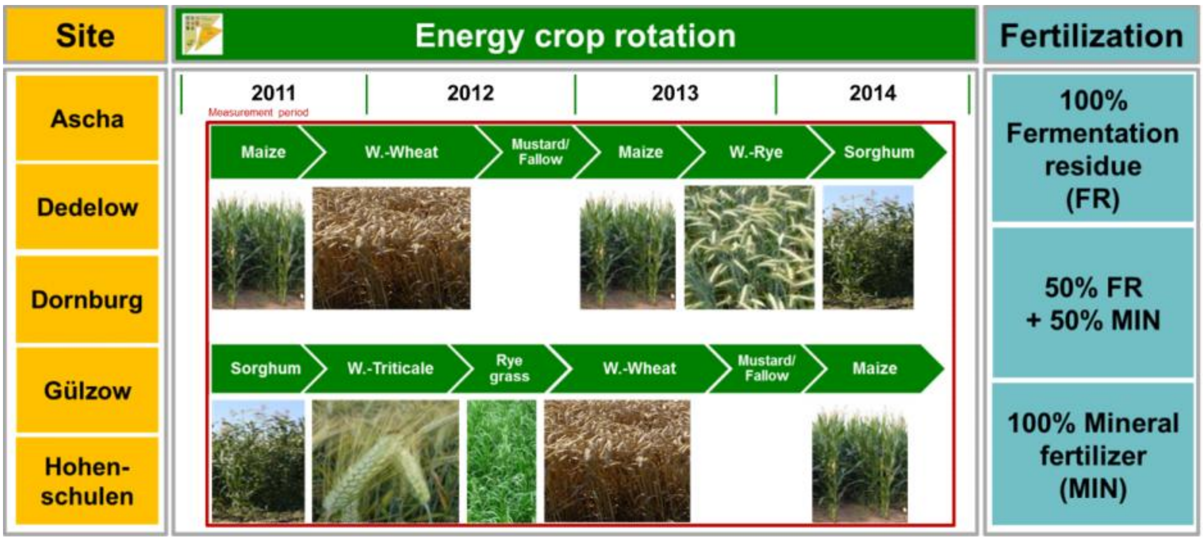

Figure 2: Experimental design of the Small digestate experiment (KleinG) – Cultivation 1 above, cultivation 2 below

2. Large digestate experiment (GroßG): N_2O exchange for maize

The research aim of the Large digestate experiment (GroßG) is the determination of the influence of a wide spectrum of graded digestate additions on the N_2O exchange and derived N_2O emission factors for the cultivation of energy maize.

The factor "fertilization" has been created in the GroßG with 7 factor levels:

- 100% mineral fertilization (MIN)
- 0 % digestate fertilization (FR)
- 50 % digestate fertilization (FR)
- 75 % digestate fertilization (FR)
- 100 % digestate fertilization (FR)
- 125 % digestate fertilization (FR)
- 200 % digestate fertilization (FR)

These result in seven measuring plots at each site of investigation, on which the tests for N_2O exchange were carried out year long. Unlike the Small digestate experiment, the measuring plots changed their location every year, in order to exclude artefacts of N_2O exchange by N-after-effects from the previous year.

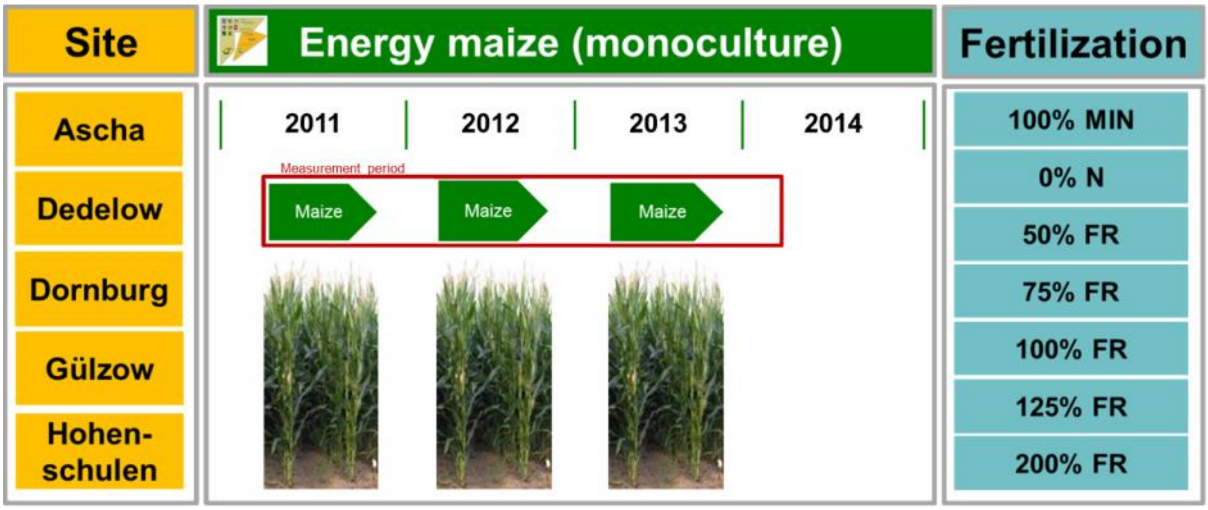

Figure 3: Experimental design of the Large digestate experiment (GroßG)

In addition, in selected years and at selected sites - amongst others, for the synchronization with the EVA III project - other special fertilising variations have been created and tested:

- 100 % mineral fertilization (MIN) + Entec (nitrification inhibitor)
- 100 % digestate fertilization (FR) + Piadin (nitrification inhibitor)
- 100 % digestate fertilization (FR) in stock (fertilized to BBCH-stage 33)

The absolute N-fertilizer quantity was always oriented on the site-specific fertilizer quantity common for specific crops. The digestate amount to be applied was determined based on the N content of the, present digestate of the respective site and of a mineral fertilizer equivalent of 70%. As mineral N fertilizer, calcium ammonium nitrate (KAS) was used. At all sites, the digestate originated from co-fermentation of maize silage and cow-manure, if necessary with small additions of grass silage and barley/rye grist.

As part of the large digestate experiment, there were also two additional trials that were performed in parallel on all experimental sites, but only in a limited time:

1. He- incubation experiment - measuring period: 2012 (see Table Incubation)

As part of this experiment, soil samples from the top soil were taken, directly after the fertilization with digestate at all experimental sites of the 100% MIN and 100% FR-plots of the Large digestate experiment, which were examined subsequently, using the so-called helium-incubation method by Butterbach-Bahl et al. (2002) in the laboratory for release of N_2, N_2O, CO_2 and CH_4.

2. Chloride tracer experiment - measuring period: 2012 - 2013 (see Tables Tracer; Tracer_factor; NO3leaching)

The experiment was created in 2012 within the GroßG to quantify the relocation of NO_3^- in soil and the NO_3^- leaching via the use of chloride as tracer (by Schlüter et al. 1996). On 2 calibrated tracer plots (each 2 m x 2 m), in spring 2012 in all locations of the 100% FR-plots of the GroßG, a salt fertilization was performed, coinciding with the spreading of digestate (equivalent to approximately 2.5 t / ha). This chloride front moved deeper into the ground during the year and has been detected via soil samples both in autumn 2012 and the following spring. Using the N_{min} values, the NO_3^- leaching potential of all other plots of the GroßG was quantified.

III. Data and measuring periods

Parameter	Specification	Period	Location	KleinG	GroßG
Meteorological data					
Air temperature	half-hour values in 0.2 and 2 m in height	Apr. 2011 – Oct. 2014	X		
Air pressure	half-hour values	Apr. 2011 – Oct. 2014	X		
Humidity	half-hour values	Apr. 2011 – Oct. 2014	X		
Photosynthetic active radiation (PAR)	half-hour values	Apr. 2011 – Oct. 2014	X		
Precipitation	half-hour values	Apr. 2011 – Oct. 2014	X		
Wind speed	half-hour values	Apr. 2011 – Oct. 2014	X		
Wind direction	half-hour values	Apr. 2011 – Oct. 2014	X		
Soil temperature	half-hour values in 2, 5, 10 cm depth	Apr. 2011 – Oct. 2014		X	
Soil moisture (TDR)	half-hour values	Apr. 2011 – Oct. 2014		X	
Soil data					
N_{min} (NO_3 + NH_4)	Periodically in 0-10, 0-30, 30-60, 60-90 cm	Apr. 2011 – Oct. 2014		X	X
Soil moisture (gravimetric)	Periodically in 0-10, 0-30, 30-60, 60-90 cm	Apr. 2011 – Oct. 2014		X	X
Bulk density	Periodically in 0-10, 0-30, 30-60, 60-90 cm	Apr. 2011 – Oct. 2014		X	X
C_{org}, C_{anorg}, pH and bulk density	onetime at start and end of the experiments in 0-30, 30-60, 60-90 cm	Spring 2011, autumn 2014		X	
Management and plant data					
Management data	Sowing, fertilization, plant protection, harvest, tillage, damage	Apr. 2011 – Oct. 2014		X	X
Fertilization	Type, dates, quantity, C and N contents, N-fractions and P, K, Mg, Ca contents of the digestate fertilizer	Apr. 2011 – Oct. 2014		X	X
Biomass	Fresh and dry matter for plots and frames of intermediate and final harvest	Apr. 2011 – Oct. 2014		X	X
Biomass-C- and N-content	of final harvest, optional of intermediate harvest	Apr. 2011 – Oct. 2014		X	X
Crop residues above ground	Dry matter of final harvest	Apr. 2011 – Oct. 2014			X
Crop development	Plant height, BBCH, LAI (optional)	Apr. 2011 – Oct. 2014		X	X
Gas flux measurements					

N_2O- and CH_4-flow rates	Periodic and event-related measurements, measured and interpolated flow rates	May 2011 – Mar. 2014 (GroßG) / Oct. 2014 (KleinG)		X	X
CO_2-exchange	Periodic and event-related measurements, measured and empirical modelled flow rates	May 2011 – Sep. 2014		X	
NH_3-flow rates	Event-related measurements directly after fertilization with digestate	April 2011 – May 2014		X	X
Additional tests					
Chloride tracer test	Cl und N_{min} (NO_3 + NH_4)-content in soil, N_{min}-N until 90 and 200 cm or until maximum sampling depth	Spring 2012 – Spring 2013			X
He-Incubation test	Fertilizer-N amount and application, soil parameters, gas flow rates	Spring 2012			

Oilseed rape project

The research project "Reduction of greenhouse gas emissions in oilseed rape cultivation with special reference to nitrogen fertilization" runs from 01/07/2012 to 31/08/2017.

IV. Sites

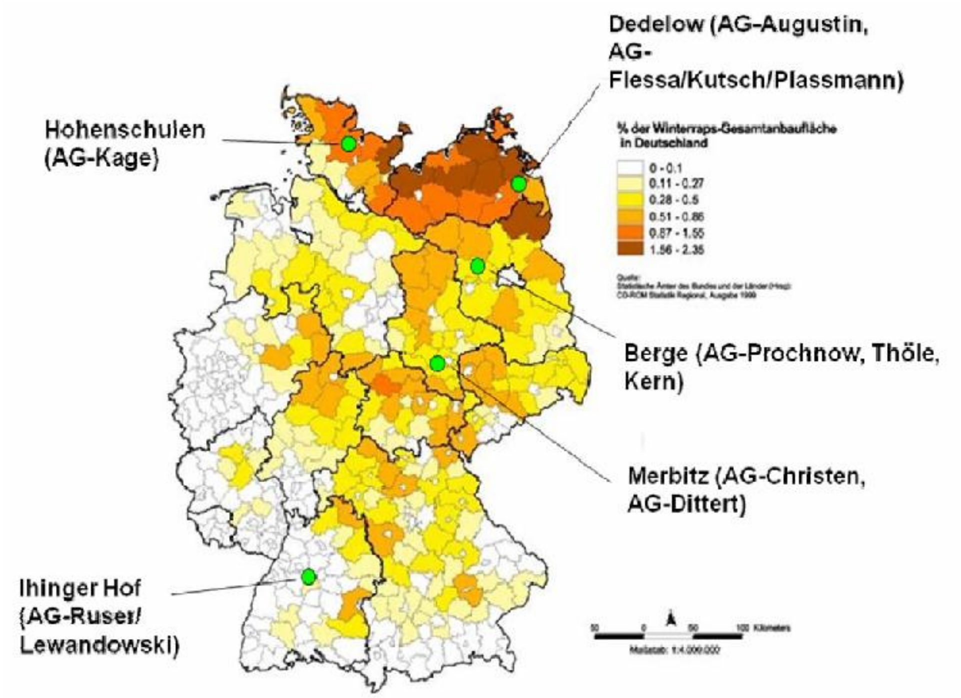

Figure 4: Experimental sites of the OSR project

V. Experimental test design

The following five variations (four oilseed rape climate protection variations and one control variation) are to be analysed and evaluated in context of the joint intensive monitoring program:

N4: N-mineral fertilization 180 kg to oilseed rape (90 + 90) (= 180-min variation); in winter wheat (WW) and winter barley (WG), site specific N-fertilization.

N3: Reduced N-mineral fertilization to oilseed rape, 120 kg N (60 + 60) (= 120-min variation); in winter wheat (WW) and winter barley (WG), site specific N-fertilization.

N6: Full replacement of N-fertilizer in oilseed rape by digestate without nitrification inhibitor, 180 kg NH_4-N to oilseed rape in two applications (= 180-org variation); in winter wheat (WW) and winter barley (WG), site specific N-fertilization.

N7: Full replacement of N-fertilizer in oilseed rape by digestate with nitrification inhibitor (Piadin), 180 kg NH_4-N to oilseed rape in two applications (= 180-org variation+NI variation); in winter wheat (WW) and winter barley (WG), site specific N-fertilization.

G0: Control without management-related increase in N-turnover and thereby induced emission of N_2O. This variation is a long-term grassland without nitrogen fertilization (= G-0 variation) (2 sections with removal of the clippings).

The following three additional variations (three levels of mineral N to oilseed rape) are not part of the intensive monitoring program. They are used together with the mineral N-levels of the intensive monitoring program for determining the site-specific fertilization optimum for the yield (agronomic and economic) as well as for the yield-related climate protection performance.

N1: No N-fertilization to oilseed rape (= 0-min variation), in winter wheat (WW) and winter barley (WG), site specific N-fertilization.
N2: Reduced N-mineral fertilization to oilseed rape, 60 kg N (30 + 30) (= 60-min variation); in winter wheat (WW) and winter barley (WG), site specific N-fertilization.
N5: High N-mineral fertilization to oilseed rape, 240 kg N (120 + 120) (= 240-min variation); in winter wheat (WW) and winter barley (WG), site specific N-fertilization.

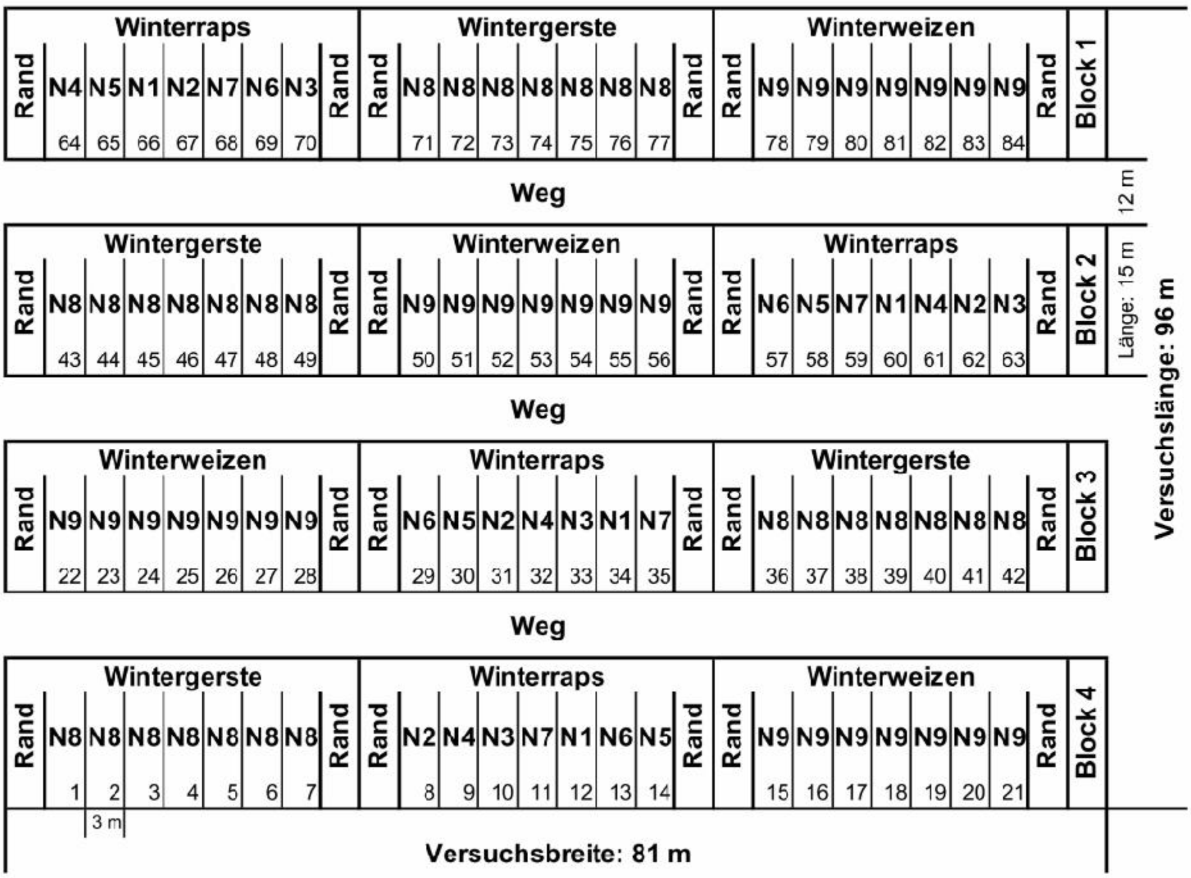

Figure 5: Experimental design for the intensive monitoring program (mineral variations: N1 - 0/0 kg N/ha (partial application 1 /partial application 2 in spring); N2 - 30/30 kg N/ha (partial application 1 /partial application 2 in spring); N3 - 60/60 kg N/ha (partial application 1/partial application 2 in spring); N4 - 90/90 kg N/ha (partial application 1/partial application 2 in spring); N5 - 120/120 kg N/ha (partial application 1 / partial application 2 in spring) --- organic variations (N-rate based on the ammonium content of the digestate residue); N6 - 90/90 kg N/ha (without nitrification inhibitor); N7 - 90/90 kg N/ha (with nitrification inhibitor); N8 - site-specific N-fertilization for winter barley; N9 - site-specific N-fertilization for winter wheat)

VI. Data and measuring periods

Data	Specification	Measurement period
1. Meteorological data		
Air temperature	Hourly values in 2 m	Jan. 2013 – Dec. 2015
Humidity	Hourly values	Jan. 2013 – Dec. 2015
Precipitation	Daily values (24 h)	Jan. 2013 – Dec. 2015
Wind speed	Hourly values	Jan. 2013 – Dec. 2015
Wind direction	Hourly values	Jan. 2013 – Dec. 2015
Radiation	Hourly values	Jan. 2013 – Dec. 2015
Soil temperature	Hourly values in 5, 10 und 20 cm	Jan. 2013 – Dec. 2015
Soil/air temperature	Parallel to emission measurements in 5, 10, 20 cm / 5 cm, 200 cm	Jan. 2013 – Dec. 2015
2. Soil data		
N_{min} ($NO_3 + NH_4$)	Parallel to the N_2O emission measurement in 0-30 cm	Jan. 2013 - Jan. 2016
N_{min} ($NO_3 + NH_4$)	After harvest and in spring before fertilization in 0-30, 30-60, 60-90 cm	2013, 2014, 2015
Grav. soil moisture	Together with N_{min}	2013, 2014, 2015
Volumetric soil moisture	Parallel with each N_2O measurement (mobile probe) in 0-30 cm	Jan. 2013 - Jan. 2016
C_{org} , Nt, pH, texture	One-time at beginning of the trial in 0-30, 30-60 cm	2013
Bulk density	One-time in 30-60, 60-90 cm	2013
Bulk density	Event related (tillage) in 0-30 cm	summer/autumn 2013, 2014, 2015
3. Emission measurements		
N_2O- emission	Weekly and event related	Jan. 2013 - Jan. 2016
CH_4- exchange	Weekly and event related	Jan. 2013 - Jan. 2016
CO_2- exchange (NEE bzw. RECO and GPP)	Repeated measurement campaigns	Okt. 2012 - Jul. 2014
NH_3- emission	Event related (after spreading of digestate)	2013, 2014, 2015
4. Management and plant data		
Management data	Seed, fertilizer, crop protection, harvesting, soil tillage – per culture	Aug. 2012 - Nov. 2015
Crop yield and quality	Dry matter, C / N ratio, oil content	2013 - 2015
Crop residues above ground	Dry matter	2013 - 2015
C / N of crop residues		2013 - 2015
Development of crop	Bi-weekly	Jan. 2013 - Nov. 2015

Data model

In the following sections, all tables and how they are related are explained and partly illustrated by means of brief examples. Figure 6 serves as first illustration of the data structure. The entire graphical data model is located in the appendix (Figure 26).

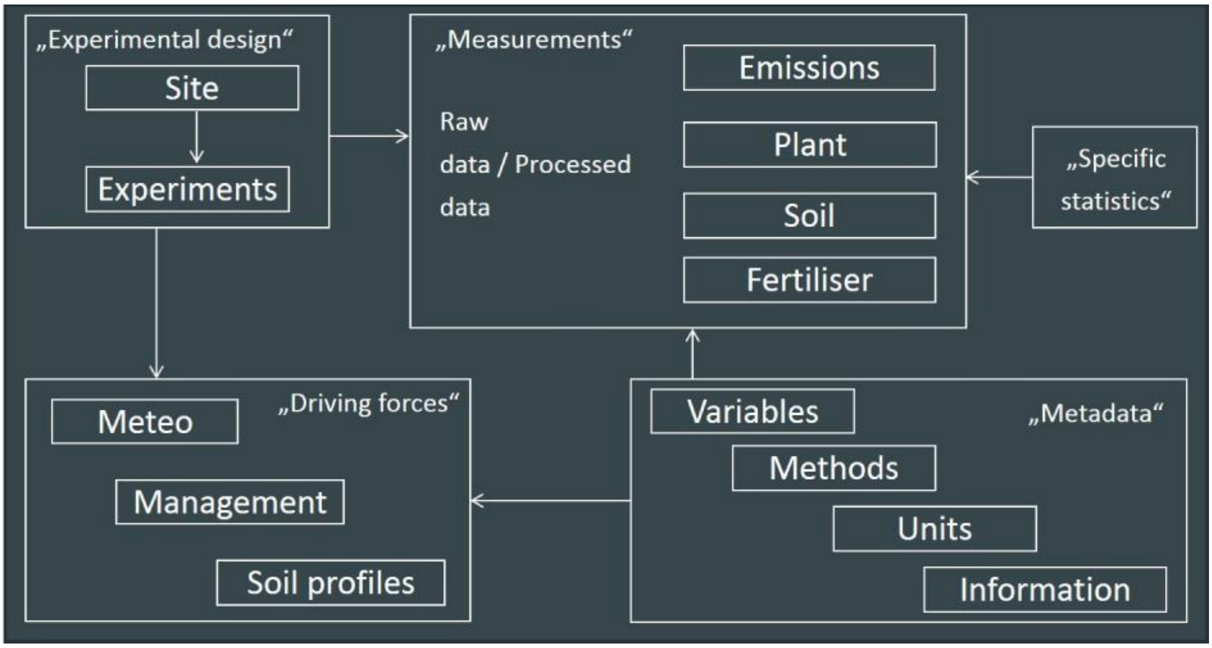

Figure 6: Simplified data structure of the database

From **Fehler! Verweisquelle konnte nicht gefunden werden.** it can be seen that the data of the GHG-DB-Thuenen is divided into six categories:

Category 1: Experimental design (E)

Category 2: Measurements

Subcategory 1: Raw data (R)

Subcategory 2: Processed data (P)

Category 3: Driving forces (D)

Category 4: Specific statistics (S)

Category 5: Metadata (M)

For simplification, the beginning of each table name includes the respective category in abbreviated form.

I. *Experimental design*

The category Experimental design contains the following tables and represents the basic information or the key of the DB (Figure 7).

A special importance is placed on the table **Plot** (information about to which block, treatment, project a study plot belongs). It represents the **organising principle of the database** and thus the central table. By means of the primary key Plot_ID, the unique positioning or affiliation of each measured value and the associated information of the database is created. For each measurement table in the GHG-DB-Thuenen (with the exception of the tables Meteo and Soil profile) a 1:n relation to the table Plot exists. This means, that the tables are thus linked by the foreign key Plot_ID (exemplified in Figure 7). The project index specifies project affiliation and is necessary to manage access privileges of the database.

> Primary key Plot_ID, foreign key Block_ID, Treatment_ID, Variation_ID

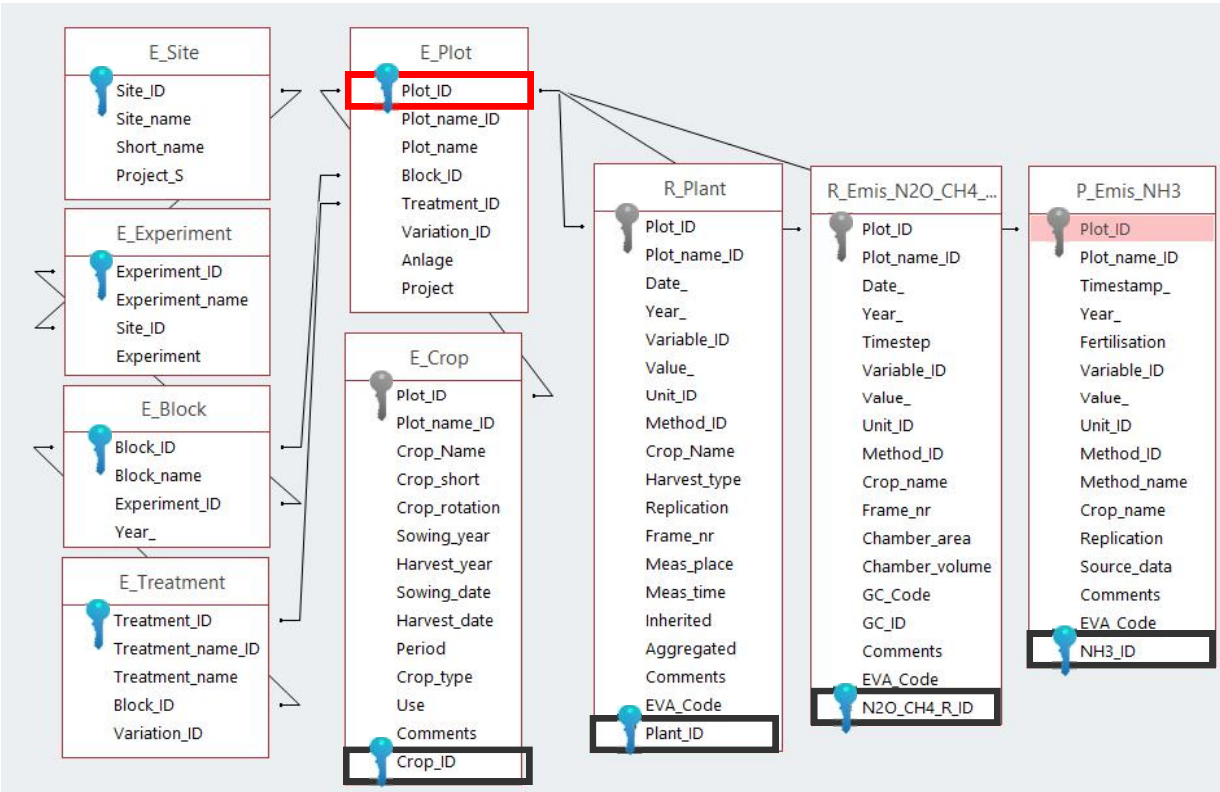

Figure 7: Database design - Tables of the category Experimental design with three sample tables for measured values (blue keys symbolise primary keys, grey keys symbolise foreign keys)

Site (information about sites, such as name, short name, etc..): Each site is represented by a dataset in the table **Site**. Several experiments can be present per site. Therefore, there is a 1:n (one-to-many) relation to the table **Experiment** (example: KleinG, GroßG). Site_ID is the primary key of the table **Site**. The data definition table of both Driving forces-tables - **Meteo** and **Soilprofile** and the data definition table of the metadata-tables **Site_info**, **Digestate_info**, **Fertilisation_info**, **BelowLOQ_info** and **Soilprofile_info** are linked to the table **Site** via the Site_ID as a foreign key. The Projekt_S_Index is required for specification according the project affiliation and thus for the illustration / creation of access rights to the database.

> Primary key Site_ID

Experiment (Information on experiments): Each experiment is represented by an entry in the table **Experiment**. Per experiment, several blocks can be present (1:n relationship to block).

> Primary key Experiment_ID; Foreign key Site_ID

Block (Information on blocks to which the study plots are located): Each block is represented by an entry in the table **Block**. Per block, several treatments and trial plots can be present (1:n relationship to treatment and to plot).

> Primary key Block_ID; Foreign key Experiment_ID

Treatment (information on treatments of the study plots): Each experimental treatment will have an entry in **Treatment**. Per Treatment, several study plots can be present (1:n relationship to plot).

> Primary key Treatment_ID; Foreign key Block_ID, Variation_ID

Variation (Information regarding same treatments): A variation is the summary of replications of a treatment. Per Variation, several study plots can be present (1:n relationship to plot). This table is only relevant for the OSR project.

> Primary key Variation_ID

Crop (Information on crops, year of cultivation, year of harvest, etc.): compilation of various information regarding crop cultivation.

> Primary key Crop_ID; Foreign key Plot_ID

The detailed description of each column of each table of the category Experimental design can be found in the appendix (Table 15).

II. Measurements - Raw data

The category Raw data contains the following tables and represents the first part of possible results of the field measurements (raw data) (Table 14). The detailed description of each column of each table can be found in the appendix (Table 15).

Each table in the sub-categories Raw data (measurements) and Processed data (measurements) (see paragraph III) follows a similar structure. The following eight columns are always present and be complemented by more if necessary. Further table columns will be called in the following description for each data base tables. Detailed descriptions of the individual columns for each data base table are in the appendix (Table 15**Fehler! Verweisquelle konnte nicht gefunden werden.**).

Plot_ID:	Unique spatial positioning / affiliation of the measured value;
Date_ or Timestamp_:	Point in time of the measured value as date (dd.mm.yyyy) or timestamp (dd.mm.yyyy hh:mm:ss);
Variable_ID:	Index of the measured variable
Value_:	the measured value
Unit_ID:	Index of the unit in which the measured value was recorded

Method_ID: Index of the applied methods for the quantified measured value
Comments: Comment(s)
ID: Unique counter / index of the table

Soil_periodic (Data on periodically recorded soil data like N_{min}, C_{org}, etc.): Each measured value, which was collected periodically regarding the soil, is described here, by its location, measurement time as date, measured variable as index, measured value, unit as index, soil depth from, soil depth to, number of replication, relation to fertilization, crop name, method as index, comment, EVA code (only BGD project) and a table-specific counter / index described.

This table is additionally equipped with three Boolean columns (switching variable). The Boolean column "Aggregated" indicates whether a measured value was aggregated out of several values or not. Through the column "Inherited" it is traceable whether a measured value was adopted by another plot or not. If a value was adopted, a comment is displayed stating from which plot. In addition, a further Boolean "Below_LOQ" was introduced. This switching variable indicates whether a measured value is below the limit of quantification (LOQ) or not (see Figure 8). Comments or the metadata table BelowLOQ_info could contain further information about LOQ.

> Primary key Soil_P_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID, EVA_Code

Year_	Variable_	Value_	Unit_	Depth_from	Depth_to	Replication	Inherited	Aggregated	Below_LOQ
2015	NH4_N_soil	0,205	mg/kg	0	30	1	0	-1	0
2014	NH4_N_soil	0,051	mg/kg	30	60	1	0	0	-1
2014	NH4_N_soil	0,536	mg/kg	0	30	1	0	0	0
2015	NH4_N_soil	0,48	mg/kg	0	30	1	0	-1	0
2015	NH4_N_soil	0,05	mg/kg	0	30	1	0	0	-1
2015	NH4_N_soil	0,051	mg/kg	0	30	1	0	0	-1

Figure 8: Example for "Below LOQ"

Soil_continuous (Data on continuously recorded soil data such as soil temperatures – only OSR project): Each measured soil value which was collected continuously, is described here by its location, measurement time as time stamp (dd.mm.yyyy hh:mm: ss), measured variable as index, measured value, unit as index, soil depth, crop name, method as index, comment and a table-specific counter / index.

> Primary key Soil_C_ID; Foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID

Plant (Data on plant-related measured values like yield, ontogenesis, etc.): Each measured plant value is described here by its location, measurement time as date, measured variable as index, measured value, unit as index, number of replication, type of harvest, crop name, method as index, comment, the EVA code (only BGD project) and a table-specific counter / index.

This table is additionally equipped with two Boolean columns (switching variable). The Boolean column "Aggregated" indicates whether a measured value was aggregated out of several values or not. Through the column "Inherited" it is traceable whether a measured value was adopted by another plot or not. If a value was adopted, a comment states from which plot.

In the BGD project, gas measurements were carried out using frames (which means, at specific measurement points), which were constructed in the respective plots. The end harvest of the biomass was therefore carried out both on the plot, as well as directly within these frames. Due to the frames, there is an accurate link between gas- and biomass measurements which is directly available at the measurement point (frame). Therefore, this table also displays the column number of frame, which appoints a number to the frames for the gas flow measurements per parcel (1-3).

> Primary key Plant_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID, EVA_Code

Digestate (Data on digestate properties – only BGD project): Each measured digestate value is described here by its location, measurement time as date, measured variable as index, measured value, unit as index, number of replication, method as index, comment, EVA code (only BGD project) and a table-specific counter / index.

> Primary key Digestate_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID, EVA_Code

Emis_N_2O_CH_4_CO_2_conc (Data for N_2O, CH_4 and CO_2 concentration measurements): Each measured value obtained through gas chromatography in the laboratory, given as specific concentration of a gas for the quantification of the flux is described here by its location, measurement time as time stamp, measured variable as index, measured value, unit as index, method as index, crop name (only OSR project), chamber area, chamber volume, comment, EVA code (only BGD project) and a table-specific counter / index.

In the BGD project, the gas measurements were carried out using frames (i.e. at specific measurement points) which were constructed in respective plots. Due to the frames flux- and biomass measurements at the specific measurement points (table **Plant**) are directly linked. Therefore, this table also displays the column number of frame, which appoints a number to the frames for the gas flux measurements per plot (1-3). Additionally, the column GD_ID records a site-specific unique continuous index for the gas chromatograph measurements. GC_Code describes an error code of the gas chromatograph (only BGD project).

> Primary key N_2O_ CH_4_R_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID, EVA_Code

Emis_CO_2_conc (Data for CO_2 concentration measurements – only BGD project): Each measured value obtained through an infrared gas analyser in the field, given as concentration to quantify the CO_2 exchange, is described here by its location, measurement time as time stamp, measured variable as index, measured value, unit as index, method as index, chamber area, chamber volume, type of chamber, air pressure, comment, EVA code (only BGD project) and a table-specific counter / index.

The gas measurements were carried out using frames (i.e. at specific measurement points). Therefore, this table also displays the column number of frame, which appoints a number to the frames for the gas flux measurements per plot (1-3).

The Record-index describes a continuous index / counter within a CO_2 measurement for each time step (which means, index for each single concentration determination). Measurement_ID represents a continuous ID for all measurements at a single site. Campaign_ID also describes a continuous index / counter for all CO_2 measuring campaigns. This table is linked by the Campaign_ID as primary key to the table **Parameter_ CO_2** via a n:1 relationship, which means an empirical model and its parameters can be calculated from several measuring campaigns. The linking of the parameters to the modelled CO_2 values is accomplished with the column reference to modelling.

> Primary key CO_2_ID; Foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID

Incubation (Data on an incubation experiment – only BGD project): Each measured value obtained through an incubation experiment, is described here by its location, measurement time as date, measured variable as index, measured value, unit as index, number of replication, type of application, amount of liquid fertilizer, amount of N-fertilizer, amount of plant-available fertilizer, soil depth from, soil depth to, crop name, method as index, internal lab index, comment, EVA code (only BGD project) and a table-specific counter / index.

> Primary key Incubation_ID; Foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID, EVA_Code

Cl_Tracer (Data for a chloride tracer experiment – only BGD project): Each measured value obtained through a tracer experiment, is described here by its location, measurement time as date, measured variable as index, measured value, unit as index, number of replication, soil depth from, soil depth to, method as index, comment and a table-specific counter / index.

> Primary key Tracer_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID

Tracer_factor (Factors on a chloride tracer experiment – only BGD project): Each factor was calculated by the measured values of the tracer experiment and is described here by its location, measured variable as index, measured value, unit as index, method as index, crop name, comment and a table-specific counter / index.

> Primary key Cl_Tracer_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID

III. Measurements - Processed data

The category Processed data contains the following tables and represents the second part of the possible results of the field measurements (processed data) (Figure 9). The detailed description of each column of each table can be found in the appendix.

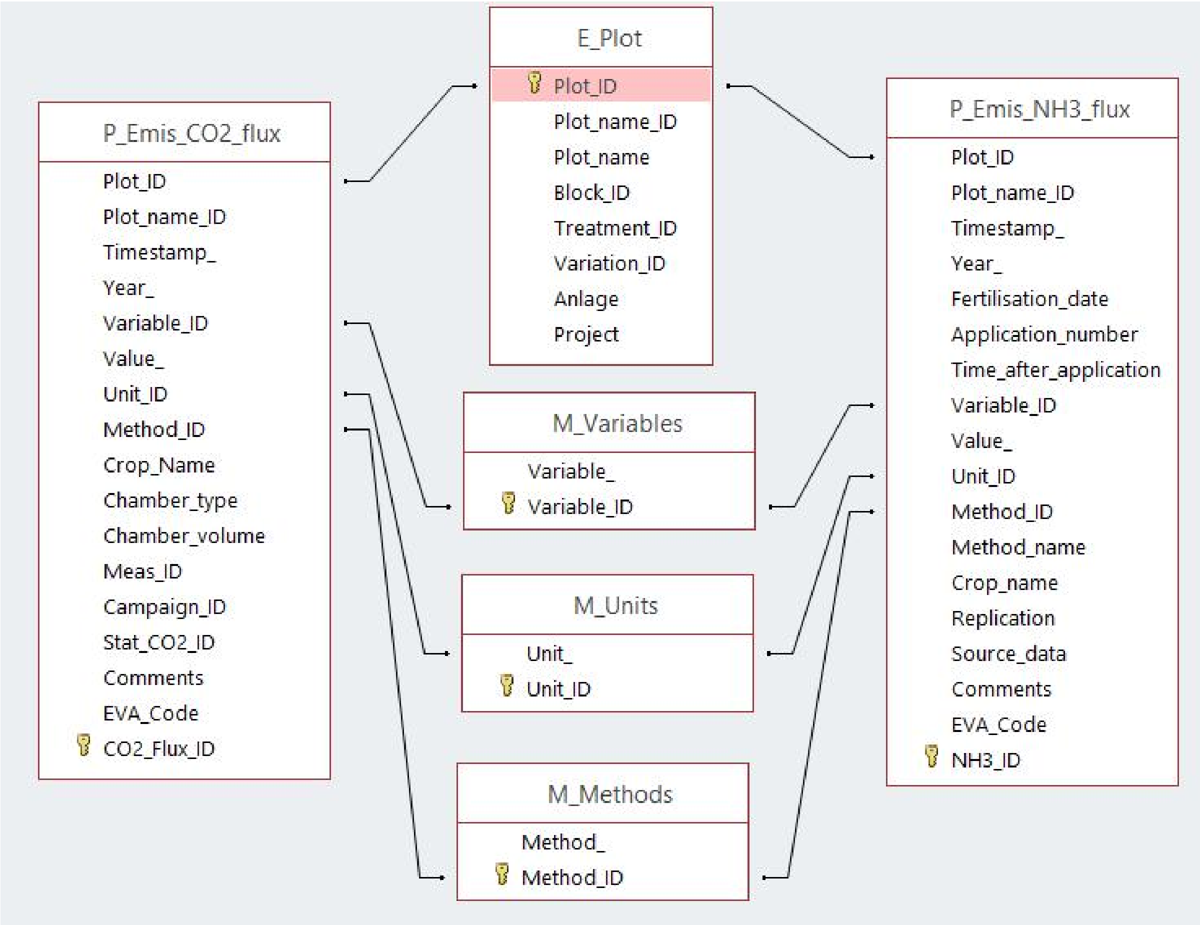

Figure 9: Database design - Sample tables for category Processed data with the three most important metadata tables

Balances (Data on C and N balances – only BGD project): Each measured value was calculated as a component of a C- or N-balance and is described here by its location, accounting period with start and end date as well as the duration in days, measured variable as index, measured value, unit as index, method as index, crop name, comment, EVA code (only for BGD project), statistics index and a table-specific counter / index.

> Primary key Balances_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID, Stat_Balances_ID, EVA_Code

Emis_CO_2_flux (Data on CO_2 fluxes and associated data such as soil temperature, air temperature inside and outside the chamber, etc. – (only BGD project) and also gross primary production (GPP), net ecosystem exchange (NEE), ecosystem respiration (R_{eco}) by eddy covariance (only OSR project): Each measured value was calculated as CO_2 flux on the basis of the infrared analyzer-CO_2-concentration data by linear regression and also each measured value of the above mentioned CO_2-measures determined by eddy covariance is described here by its location, measurement time as time stamp, measured variable as index, measured value, unit as index, method as index, crop name, type of chamber (only for BGD project), chamber volume (only for BGD project), comment, EVA code (only for BGD project), statistics index (only for BGD project) and a table-specific counter / index.

In addition, the Meas_ID represents a continuous index for all measurements at each site. The campaign_P_ID describes also a continuous index / counter for all CO_2 measuring campaigns.

> Primary key CO_2_Flux_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID, Campaign_P_ID, Stat_ CO_2_ID

Emis_N_2O_CH_4_daily (Data on daily interpolated N_2O and CH_4 fluxes – only BGD project): Each measured value was calculated as daily N_2O and CH_4 flux on the basis of N_2O and CH_4 flux by linear interpolation and is described here by its location, measurement time as date, measured variable as index, measured value, unit as index, method as index, comment, EVA code (only for BGD project) and a table-specific counter / index.

> Primary key N_2O_CH_4_D_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID, EVA_Code

Emis_N_2O_CH_4_flux (Data on N_2O and CH_4 fluxes and associated data such as soil temperature, air temperature inside and outside the chamber, etc.): Each measured value was calculated as N_2O and CH_4 fluxes on the basis of chromatography-concentration data and is described here by its location, measurement time as time stamp, measured variable as index, measured value, unit as index, method as index, crop name, number of the frame (only for BGD project), comment, EVA code (only for BGD project), two statistics indexes and a table-specific counter / index.

This table also displays the column number of frame (1-3, gas flux measurements per plot) as the gas measurements were carried out in frames (i.e. at specific measurement points) (see table Emis_N_2O_CH_4_CO_2_conc).

> Primary key N_2O_CH_4_F_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID, EVA_Code, Stat_N_2O_CH_4_ID (only BGD project), Stat_N_2O_ID (only OSR project)

Emis_NH_3_flux (Data on NH_3 fluxes and associated data such as soil temperature, air temperature, etc.): Each measured value was determined as NH_3 fluxes and is described here by its location, measurement in time as time stamp, measured variable as index, measured value, unit as index, number of replication, date of fertilization, time after application, number of application, source of data, crop name, method as index, comment, EVA code (only for BGD project) and a table-specific counter / index.

> Primary key NH_3_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID

Modelled_NO_3 (Modelled data on NO3 leaching): Each measured value represents data from an empirical modelling of soil water and nitrogen dynamic and is described here by its location, measurement time as date, measured variable as index, measured value, unit as index, soil depth from, soil depth to, method as index, modelling period and a table-specific counter / index. Detailed descriptions about the modelling provide further information about the modelled data (Modellbeschreibung_Mais.pdf and Modellbeschreibung_Raps.pdf).

> Primary key NO3_M_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID

Modelled_CO_2 (Modelled data on Gross Primary Production - GPP, Net Ecosystem Exchange - NEE, Ecosystem Respiration - R_{eco} and associated data such as soil temperature, air temperature, etc. – only BGD project): Each measured value represents data from the empirical CO_2 modelling and is described here by its location, measurement time as time stamp, measured variable as index, measured value, unit as index, a 95% confidence interval, status, crop name, quality of data, method as index, comment and a table-specific counter / index.

The column Status displays whether the values relate to the period between two measurement campaigns (indicated by "0") or the modelled data are within the period of one measurement campaign (indicated by "1"). The column data quality displays whether there are reliable site-specific CO_2 model data (indicated by "0") or there are reliable site-specific CO_2 model data with underlying assumptions for site-specific models (indicated by "1") or perhaps, there is limited data quality due to individual problems (indicated by "2"). In the column Comments, further explanations are given.

> Primary data CO_2_M_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID

Parameter_CO_2 (Parameters of empirical GPP, NEE- and R_{eco}-modelling – only BGD project): Each measured value represents a parameter of the empirical CO_2 models and is described here by its location, measurement time as start and end time stamp, measured variable as index, measured value, p-value, best fit, parameter type, crop name, method as index, comment and a table-specific counter / index. The parameters in this table are without units. Campaign_P_ID links the parameters with the measured values in table **Emis_CO_2_conc**. A model parameter can be based on data from several measuring campaigns.

> Primary data Parameter_ID; foreign key Plot_ID, Variable_ID, Method_ID, Campaign_P_ID

NO_3leaching (Data on NO_3 leaching – only BGD project): Each measured value obtained through the chloride tracer experiment for the determination of the potential nitrate leaching and is described here by its location, measurement time as date, measured variable as index, measured value, unit as index, number of replication, crop name, soil depth to, method as index, comment and a table-specific counter / index.

> Primary data NO_3leaching_ID; foreign key Plot_ID, Variable_ID, Unit_ID, Method_ID

IV. Driving forces

The category Driving forces contains three tables. These represent the site properties of GHG-DB-Thuenen (Figure 10). The detailed description of each column of each table can be found in the appendix. The in Figure 10 displayed tables **Management**, **Meteo** and **Soilprofile** are described in the following text.

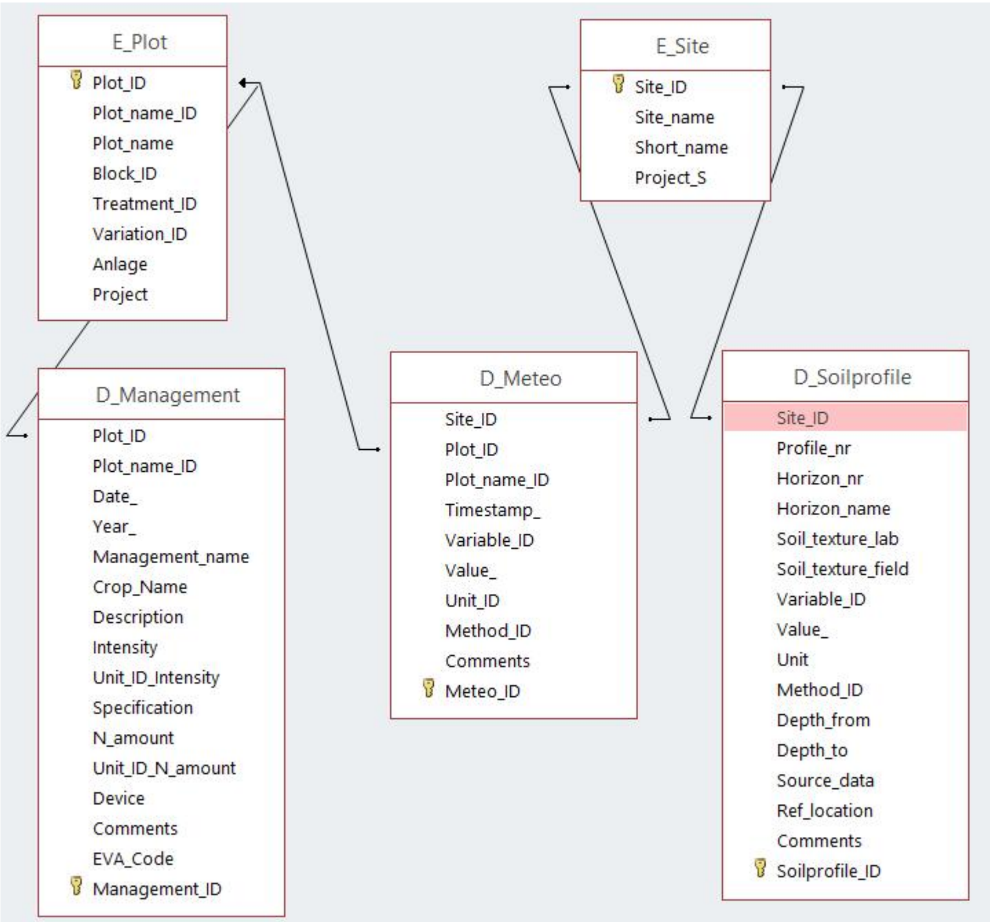

Figure 10: Database design - Tables of the category Drivers / Driving forces, the localisation of the soil profile data is selected only via site (right), the management data, however, are located plot precise (left), meteorological data is located via site or plot precise (central)

Meteo (Meteorological data): Each measured value which was collected continuously regarding the weather at a site and is described here by its location (site related, also partly plot related), measurement time as timestamp, measured variable as index, measured value, unit as index, method as index, comment and a table-specific counter / index. The metadata table **Variables** contains the description about the used meteorological elements.

> Primary key Meteo_ID; Foreign key Site_ID, Plot_ID, Variable_ID, Unit_ID, Method_ID

Soilprofile (Soil physical measured values for profile description (Profile_nr) such as soil texture, humus content, etc.): The table **Soilprofile** describes the composition of a soil profile at a site (location) consisting of horizons (Horizont_nr, Horizont_name) and their physical soil parameters (soil texture, measured value, unit as index, soil depth from, soil depth to, method as index, source of data, comment and a table-specific counter / index). The metadata table **Variables** includes also the description about all the physical soil properties. In the BGD project, the spatial localisation of the soil profiles with respect to the location of the trial plots is only possible via the PDF maps. You can find these maps for each project site under DB documents /Soilprofile).

> Primary key Soilprofile_ID; foreign key Site_ID, Variable_ID, Unit_ID, Method_ID

Management (Data on the management of the experiment area, such as sowing, harvesting, tillage, fertilization, etc.): A dataset in the management table describes what event or what activity (Management_Name) was performed on a specific study plot (location) for a particular crop, at a given time (as date) with a certain intensity (Intensity) and with a certain specification (Specification). Partly, an event is additionally described by a description and the amount of N. The columns Intensity and N_amount are separately complemented by a unit as index.

> Primary key Management_ID; foreign key Plot_ID, Unit_ID, EVA_Code

V. Specific statistics

The category Specific statistics contains four tables (Figure 11). The detailed description of each column of each table can be found in the appendix. The, in Figure 11 displayed tables, **Statistics_N_2O_CH_4_flux**, **Statistics_N_2O_flux**, **Statistics_CO_2_flux** and **Statistics_Balances**, are described in the following text.

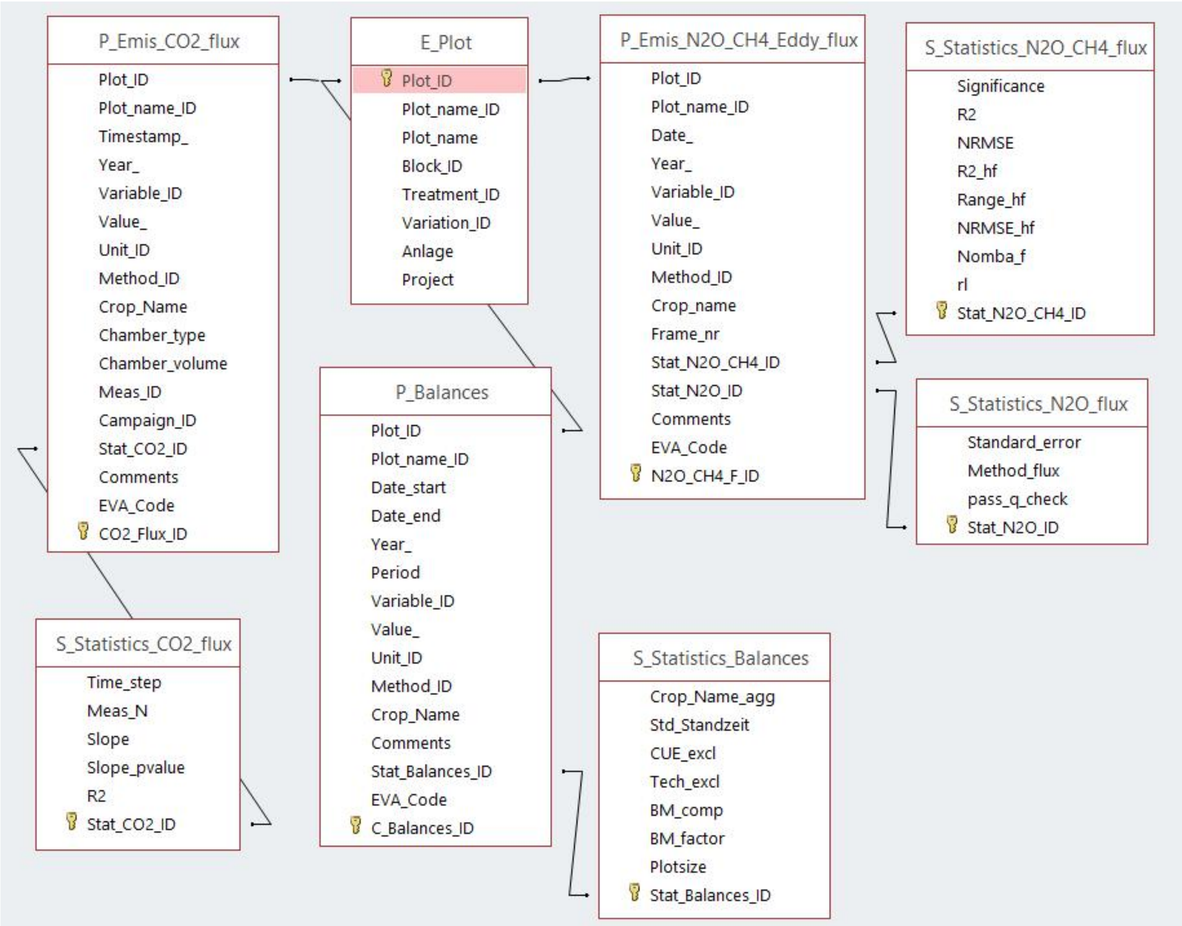

Figure 11: Database design - Tables category specific statistics with associated tables and plot table

Statistics_N_2O_CH_4_flux (statistical parameters on N_2O and CH_4 fluxes – only BGD project): The table contains various statistical parameters of linear regression such as R2, NRMSE, etc for each calculated N_2O and CH_4 fluxes from the table **Emis_N_2O_CH_4_flux**. Therefore, there is a 1:n relationship between the mentioned tables.

> Primary key Stat_N_2O_CH_4_ID

Statistics_N_2O_flux (statistical parameters on N_2O fluxes – only OSR project): The table contains the standard error for each calculated N_2O fluxes from the table **Emis_N_2O_CH_4_flux**, the applied method for flux calculation and pass_q_check. Therefore, there is a 1:n relationship between the mentioned tables.

> Primary key Stat_N_2O_ID

Statistics_CO_2_flux (statistical parameters on CO_2 fluxes – only BGD project): The table contains various statistical parameters of linear regression such as Slope, R2, etc for each calculated flux from the table **Emis_CO_2_flux**. Therefore, there is a 1:n relationship between the mentioned tables.

> Primary key Stat_CO_2_ID

Statistics_Balances (statistical parameters on C balances – only BGD project): The table contains various parameters und information of C balance calculation for each calculated variable of C balances from the table Balances. Therefore, there is a 1:n relationship between the mentioned tables.

> Primary key Stat_Balances_ID

VI. Metadata

This category contains the following tables and thus provides information on the characteristics of the, in the GHG-DB-Thuenen, used data (Figure 12). The detailed description of each column of each table can be found in the appendix. The tables shown in Figure 12 will be described in the following text.

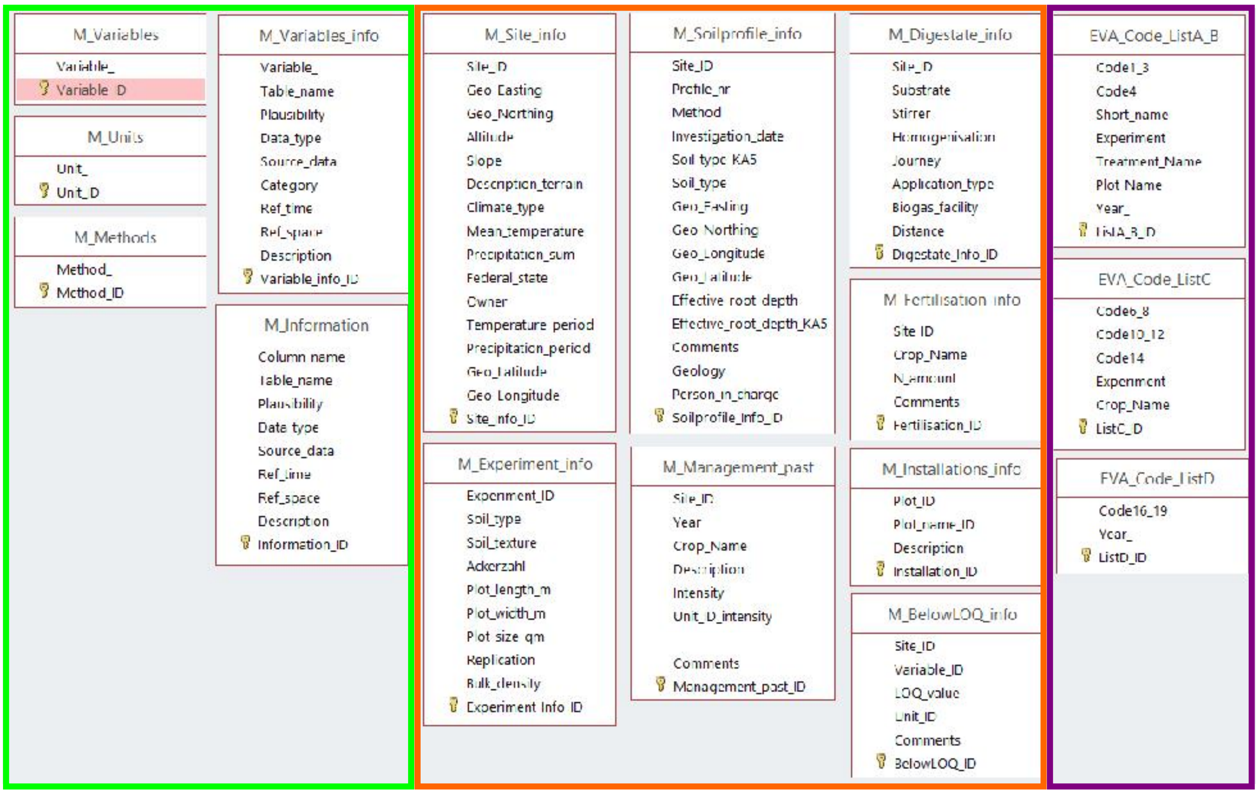

Figure 12: Database design - all tables of the category Metadata (green frame: general metadata, orange frame: specific metadata, purple frame: project-specific metadata of the BGD project (see explanation of the EVA-Code)

Variables (Information on all measured variables): This table lists all used variables (Variable_) with an index.

> Primary key Variable_ID

Variables_info (further Information on all measured variables): This table lists all information about the variables used (Variable_). The variables are described by the plausibility of the variable value (measured value), the source of the variable and its reference to space and time. The table **Variables_info** also defines the data type of the variable, that is, whether it is raw, processed or general data.

> Primary key Variable_info_ID

Methods (Information on all methods): The table Methods contains the description of the methods, by which the measured value were collected in this database. The table **Methods** also gives information, whether there is a detection limit for this method.

> Primary key Method_ID

Units (Information on all units): All units of the variables are stored in the table **Units**.

> Primary key Unit_ID

Information (Descriptive information): This table lists all the descriptive information which means, all columns of the GHG-DB-Thuenen, except for the column "Variable_", are explained here. The descriptive information is also described by the source of the information, the reference to space and time and the plausibility. The plausibility has been checked and described by both projects respectively. This column, for example, gives information on whether the value includes number or text. In case of a number, details regarding minimum and maximum values as well as number of decimal places, can follow. In case of a text box, if necessary, the possible or permissible elements are displayed. Also, here the term "non-empty" may be noted.

> Primary key Information_ID

Experiment_info (further information on experiment): This table lists other general information about the experiment, such as soil type, soil texture, plot size, etc.

> Primary key Experiment_info_ID; foreign key Experiment_ID

Site_info (further information on site): This table lists other general information about the site, such as coordinates, altitude above NN, slope, climate type (USDA Plant Hardiness Zones), mean annual temperature, etc.

> Primary key Site_info_ID; foreign key Site_ID

Management_past (further Information about management of the trial area in the past – only OSR project): This table lists which crop was cultivated in the past (before the current experiments). Partly the applied fertilizer is also mentioned.

> Primary key Management_past_ID; foreign key Site_ID

Soilprofile_info (further information on soil – only BGD project): This table contains, also based on the Site_ID (also site-related), other general information for the characterisation of the soil at the site.

> Primary key Soilprofile_info_ID; foreign key Site_ID

Installations_info (Information on installed sensors): The table describes the installed sensors and their positioning at the study plots.

> Primary key Installation_ID, foreign key Plot_ID

Fertilisation_info (Information on the site-specific fertilization – only BGD project): The table describes, based on the Site_ID (also site-related) and the crop, the site-specific fertilization.

> Primary key Fertilization_ID; foreign key Site_ID.

Digestate_info (further information on digestate – only BGD project): This table contains, based on the Site_ID (also site-related), further information about the fertilization with digestate, especially on the source and composition of the digestate.

> Primary key Digestate_info_ID; foreign key Site_ID

BelowLOQ_info (further information about limits of quantification): This table contains, based on the Site_ID, limits of quantification (LOQ) for different measured variables (e.g. NH4-N).

> Primary key BelowLOQ_ID; foreign key Site_ID

EVA_Code_ListeA+B, _ListeC, _ListeD (Coding of the data in cooperation with the EVA II project – only BGD project): The BGD project was conducted in conjunction with the EVA II project, in which project-specific codes for all measured values were introduced. To ensure the reference to the EVA II project in the data of the BGD project, the project-specific EVA code was thus incorporated also in this database on request of the grantor. The explanations on the composition of the code are stored in the three mentioned tables.

> Primary key ListA_B_ID, ListC_ID, ListD_ID

VII. Literature

Jungkunst HF, Freibauer A, Neufeldt H, Bareth G (2006): Nitrous oxide emissions from agricultural land use in Germany - a synthesis of available annual field data. Journal of Plant Nutrition and Soil Science 169: 341-351

Butterbach-Bahl, K., Willibald, G., and Papen, H. (2002): Soil core method for direct simultaneous determination of N2 and N_2O emissions from forest soils, Plant and Soil, 240, 105–116.

Schlüter, Wilhelm, Achim Hennig, and Gerhard W. Brümmer (1996): Verlagerung und Dispersion von Chlorid-, Bromid-, Nitrat-und SulfatTracern in zwei typischen Auenböden. Zeitschrift für Pflanzenernährung und Bodenkunde 159.6: 591-598.

VIII. *Default queries for GHG-DB-Thuenen*

The following text will explain all default queries which are stored in the GHG-DB-Thuenen. These simplify the application of the database. The queries could use as a template for individual creating of queries. An available query should open in the Query Design to change something in a query. Double-clicking on an available query will consequently run the query. The following explanations will show how queries about different themes could be independently created in the GHG-DB-Thuenen.

Further information is given e.g. https://www.tutorialspoint.com/ms_access/ms_access_tutorial.pdf.

Format query:

Due to database structure, all data and information are stored in different tables. The "format" query join all required information in one table.

How do I create a "user-friendly" table using the table of digestate properties? That means indexes of sites, plots, variables, units, etc. will translate into text.

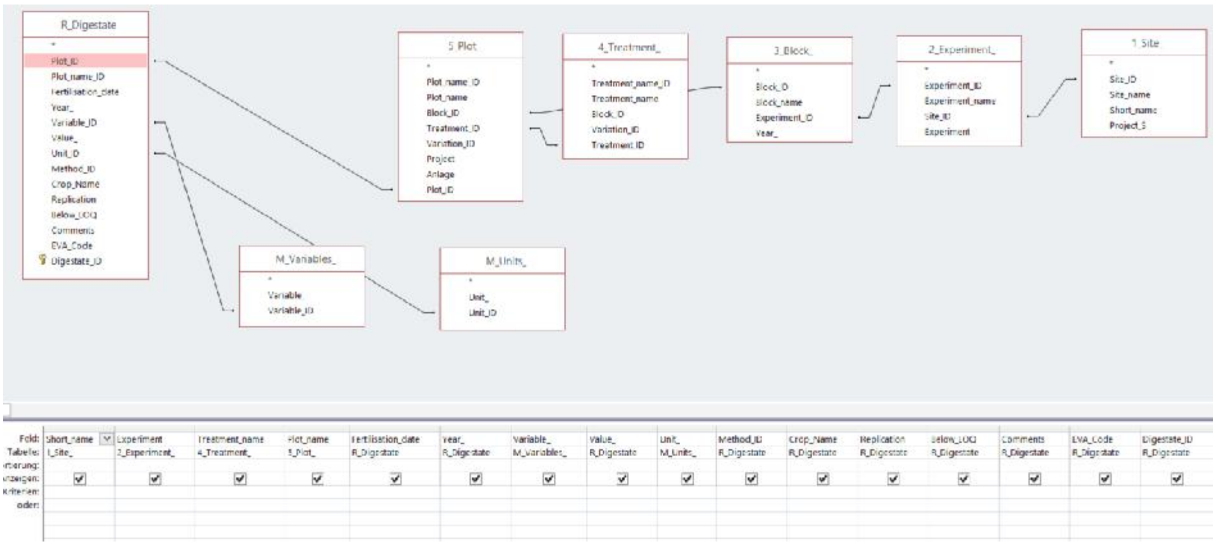

Figure 13: Query setup of the „user-friendly" table (Feld = Field, Tabelle = Table, Sortierung = Sort, Anzeigen = Show, Kriterien = Criteria, Oder = Or)

Detailed descriptions of the table columns are listed in Appendix (see Table 15).

1. Identify your required tables depending on the task.
2. Open your database.
3. Go to the Create tab and click on Query Design.
4. In the Tables tab on Show Table dialog box, double-click on the required tables and then close the dialog box. Which information from which table are required, will be shown in detail in section 6.
5. Double-click on the field you want to be displayed. You can add new tables and/or queries to the query at any time by clicking on Show tables in the "Query Tools".
6. In the query design, all tables with their field names are now displayed (see Figure 13). Double-click on the field name will add a column into the query grid (lower part of the window). The query setup contains the following columns in the query grid:

With	from table	results in
„Site_name“	„1_Site“	site name,
„Experiment“	„2_Experiment“	name of experiment,
„Treatment_name“	„4_Treatment“	name of treatment,
„Plot_name“	„5_Plot“	name of investigation plot,
„Fertilisation_date“	„R_Digestate“	date of fertilisation,
„Year_“	„R_Digestate“	year,
„Variable_“	„M_Variables“	name of variable,
„Value_“	„R_Digestate“	measured value,
„Unit_“	„M_Units“	unit of variable,
„Method_ID“	„R_Digestate“	index of method,
„Crop_name“	„R_Digestate“	name of crop,
„Replication“	„R_Digestate“	number of replication,
„BelowLOQ“	„R_Digestate“	Boolean of LOQ[1],
„Comments“	„R_Digestate“	comments,
„EVA_Code“	„R_Digestate“	code of the EVA project,
„Digestate_ID“	„R_Digestate“	table-specific index.

[1] limit of quantification

7. Select the Make table button to save the result of the query as a new table (see Table 1). Run your query.

Table 1: Part of the result table of the format query

Short_name	Experiment	Treatment_name	Plot_name	Fertilisation_date	Year_	Variable_	Value_	Unit_	Method_ID	Crop_Name
ASA	KleinG	100% GÄR	FFA 3-100	27.04.2012	2012	NH4_N_digestate	0,24	%FM	32	Winterweizen
ASA	KleinG	100% GÄR	FFA 3-100	27.04.2012	2012	TC_digestate	3,35	%FM	20	Winterweizen
DED	KleinG	100% GÄR	D18	27.03.2012	2012	TC_digestate	2,1	%FM	5	Wintertriticale
DED	KleinG	100% GÄR	D15	27.03.2012	2012	TC_digestate	2,1	%FM	5	Winterweizen
DOR	KleinG	100% GÄR	JK6	26.06.2012	2012	TC_digestate	1,96	%FM	5	Weidelgras
DOR	KleinG	100% GÄR	JK6	26.06.2012	2012	NH4_N_digestate	0,19	%FM	34	Weidelgras
HOH	GroßG	100% GÄR	HS_G_3	19.04.2012	2012	NH4_N_digestate	0,28	%FM	32	Mais
HOH	GroßG	100% GÄR	HS_G_3	19.04.2012	2012	TC_digestate	2,98	%FM	5	Mais

Template R script - How do I create a template for the flux calculation using R?

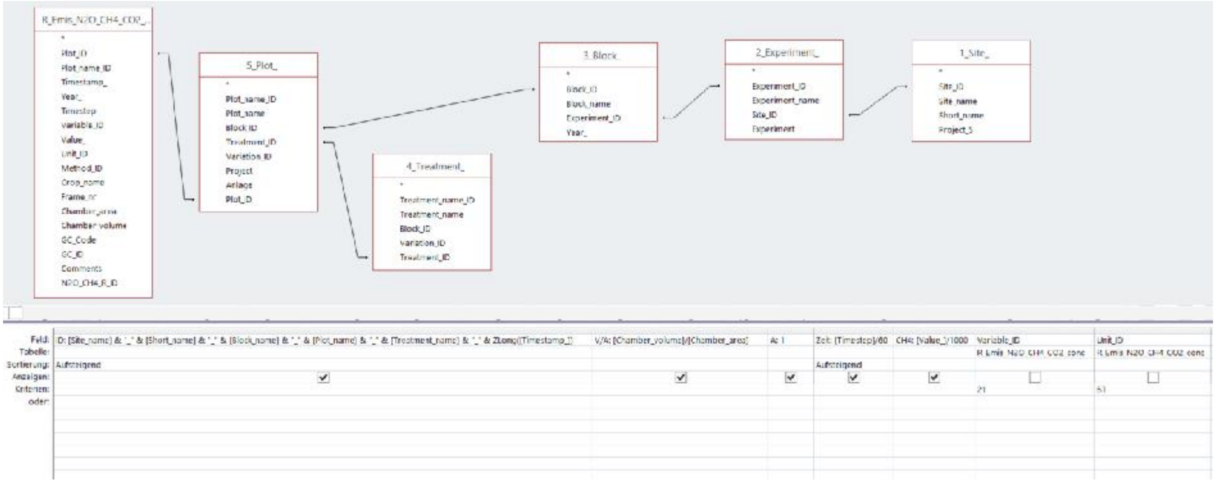

Figure 14: Query setup – query to create a R template (Zeit = Time, Feld = Field, Tabelle = Table, Sortierung = Sort, Anzeigen = Show, Kriterien = Criteria, Oder = Or, Aufsteigend = Ascending)

Detailed descriptions of the table columns are listed in Appendix (see Table 15).

1. Identify your required tables depending on the task.
2. Open your database.
3. Go to the Create tab and click on Query Design.
4. In the Tables tab on Show Table dialog box, double-click on the required tables and then close the dialog box. Which information from which table are required, will be shown in detail in section 6.
5. Double-click on the field you want to be displayed. You can add new tables and/or queries to the query at any time by clicking on Show tables in the "Query Tools".
6. In the query design, all tables with their field names are now displayed (see Figure 14Figure 13). Double-click on the field name will add a column into the query grid (lower part of the window). The query setup contains the following columns in the query grid:

With	from table	results in
„ID: [Site_name] & "_" & [Short_name] & "_" & [Block_name] & "_" & [Plot_name] & "_" & [Treatment_name] & "_" & ZLong([Timestamp_])“	„1_Site“ „1_Site“ „3_Block“ „5_Plot“ „4_Treatment“ „R_ Emis_N2O_CH4_CO2_conc“	the column „ID“ as an unique index (by chaining the site name with the short name of site, with the block name, with the plot name, with the treatment name and with the date as integer extract from timestamp with the function Zlong()),
„V/A: [Chamber_ volume]/[Chamber_area]“	„R_ Emis_N2O_CH4_CO2_conc“	the column “V/A” with the applied chamber height (division of chamber volume and chamber area)
„A: "1"“		the column “A” with the specified content,
„Time: [Timestep]/60“	„R_ Emis_N2O_CH4_CO2_conc“	The column “Time” with the recalculated timestep,
„CH4: [Value]/1000“	„R_ Emis_N2O_CH4_CO2_conc“	the column “CH4” with the recalculated measures value,

„Variable_ID“	„M_Variables“	no column is shown as the check box is cleared,
„Unit_ID“	„M_Units“	no column is shown as the check box is cleared.

7. Enter “21” in the criteria row of the Variable field and “63” in the criteria row of the Unit_ID field. The query will extract matching record only for the variable CH4_onc with the unit µgC/m³.
8. Select the Make table button to save the result of the query as a new table (see Table 2Table 1). Run your query.

Table 2: Part of the result table of the query “R template”

ID	V/A	A	Zeit	CH4
Bornim_ATB_Block1a_64_N4_N9_N8_41254	0,094	1	0	1,053952954
Bornim_ATB_Block1a_64_N4_N9_N8_41254	0,094	1	0,333333333333333	1,05718693
Bornim_ATB_Block1a_64_N4_N9_N8_41254	0,094	1	0,666666666666667	1,053777994
Bornim_ATB_Block1a_64_N4_N9_N8_41254	0,094	1	1	1,05264412
Bornim_ATB_Block1a_64_N4_N9_N8_41261	0,184	1	0	1,120768377
Bornim_ATB_Block1a_64_N4_N9_N8_41261	0,184	1	0,333333333333333	1,125048789
Bornim_ATB_Block1a_64_N4_N9_N8_41261	0,184	1	0,683333333333333	1,131201993
Bornim_ATB_Block1a_64_N4_N9_N8_41261	0,184	1	1,01666666666667	1,136033109

Queries without calculations (applicable for raw and processed data):

Yields - How does the biomass yield of maize at site X vary depending on the fertilisation treatment YZ?

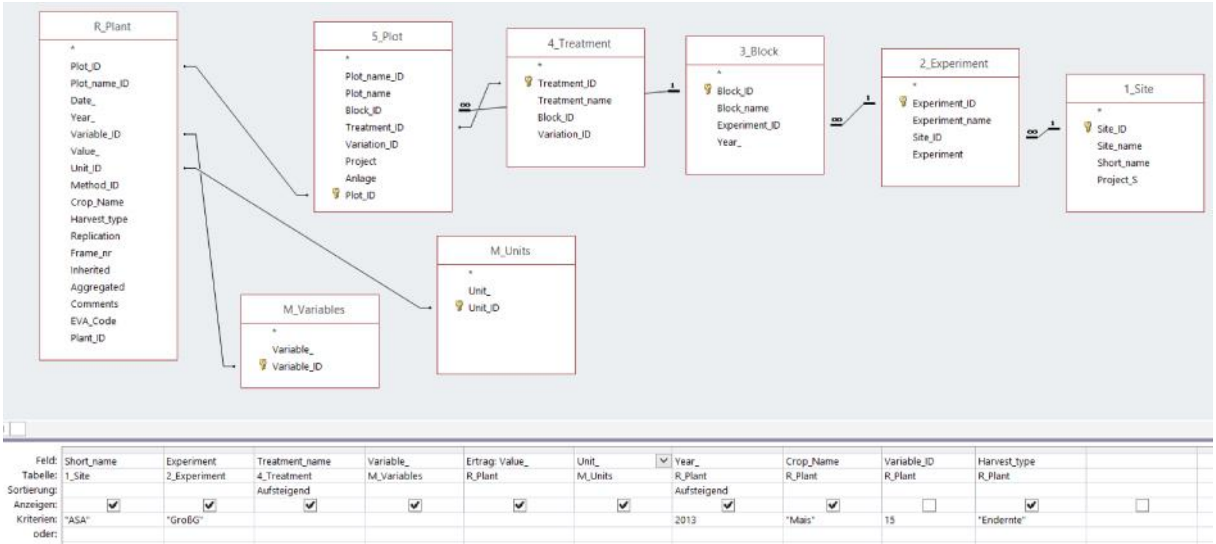

Figure 15: Query setup without calculation – Yields (Ertrag = Yield, Feld = Field, Tabelle = Table, Sortierung = Sort, Anzeigen = Show, Kriterien = Criteria, Oder = Or, Aufsteigend = Ascending, Endernte = Main harvest)

Detailed descriptions of the table columns are listed in Appendix (see Table 15).

1. Identify your required tables depending on the task.
2. Open your database.
3. Go to the Create tab and click on Query Design.
4. In the Tables tab on Show Table dialog box, double-click on the required tables and then close the dialog box. Which information from which table are required, will be shown in detail in section 6.
5. Double-click on the field you want to be displayed. You can add new tables and/or queries to the query at any time by clicking on Show tables in the "Query Tools".
6. In the query design, all tables with their field names are now displayed (see Figure 15). Double-click on the field name will add a column into the query grid (lower part of the window). The query setup contains the following columns in the query grid:

With	from table	results in
"Project"	„5_Plot"	project affiliation,
„Site_name"	„1_Site"	site name,
„Experiment"	„2_Experiment"	name of experiment,
„Treatment_name"	„4_Treatment"	name of treatment,
„Year_"	„R_Plant"	year,
„Variable_"	„M_Variables"	name of variable,
„Yield: Value_"	„R_Plant"	measured value,
„Unit_"	„M_Units"	unit of variable,
„Crop_name"	„R_Plant"	name of crop,
„Variable_ID"	„R_Plant"	no column is shown as the check box is cleared,
„Harvest_type"	„R_Plant"	time of harvest "main harvest".

7. Enter “1” in the criteria row of the Project field, “ASA” in the criteria row of the Short_name field, “GroßG” in the criteria row of the Experiment field, “2013” in the criteria row of the Year_ field, “15” in the criteria row of the Variable_ID field and “Endernte” in the criteria row of the Harvest_type field. The query will extract matching record for the 2013 dry matter biomass yield of maize at the site Ascha and the Small digestate experiment in the BGD project.
8. Select the Make table button to save the result of the query as a new table (see Table 3Table 1). Run your query.

Table 3: Result table of the query without calculation – yields

Project	Short_name	Experiment	Treatment_name	Variable_	Ertrag	Unit_	Year_	Crop_Name	Harvest_type
1	ASA	GroßG	100% GÄR	Biomass_total_drymatter	1,11	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	100% GÄR	Biomass_total_drymatter	1,28	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	100% GÄR	Biomass_total_drymatter	1,48	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	100% GÄR	Biomass_total_drymatter	1,26	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	100% MIN	Biomass_total_drymatter	1,06	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	100% MIN	Biomass_total_drymatter	1,24	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	100% MIN	Biomass_total_drymatter	1,21	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	100% MIN	Biomass_total_drymatter	0,96	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	200% GÄR	Biomass_total_drymatter	1,43	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	200% GÄR	Biomass_total_drymatter	1	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	200% GÄR	Biomass_total_drymatter	1,29	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	200% GÄR	Biomass_total_drymatter	1,28	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	Ohne Düngung	Biomass_total_drymatter	1,1	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	Ohne Düngung	Biomass_total_drymatter	1,07	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	Ohne Düngung	Biomass_total_drymatter	1,06	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	Ohne Düngung	Biomass_total_drymatter	1,12	kgTM/m²	2013	Mais	Endernte

<u>Query with Calculation - How do I get calculated data from the database?</u>

Variability - How is the variability of the biomass yield of maize at site X as a function of the fertilisation treatments YZ?

a) **Year 2013**

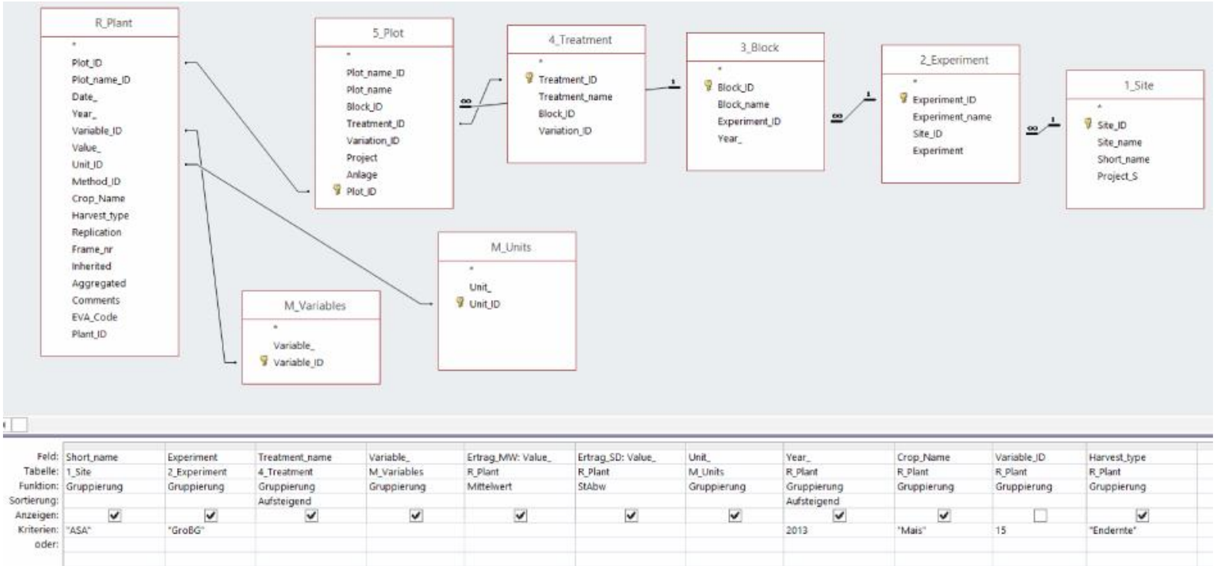

Figure 16: Query setup with calculation - Yield variability (Ertrag_MW = Yield average, Ertrag_SD = Yield standard deviation, Feld = Field, Tabelle = Table, Funktion = Total, Sortierung = Sort, Anzeigen = Show, Kriterien = Criteria, Oder = Or, Aufsteigend = Ascending, Endernte = Main harvest)

The following changes at the query setup Yields (see above) were made to calculate the yield variability:

6. The column "Value_" are required twice. All other columns remain unchanged (see Figure 16).

With	from table	results in
„Yield_avg: Value_"	„R_Plant"	the column „Yield_avg" with the average of the measured values,
„Yield_SD: Value_"	„R_Plant"	the column „Yield_SD" with the standard deviation of the measured values.

7. Click the sigma symbol (totals button) in the Design tab to get the results in the described columns. It will open another row underneath called "Total" with "Group by".
8. Choose the "Avg" and "StDev" for the two Value_ fields. An average value and standard deviation are calculated for each aggregation of the measured values.
9. and 10. Remain unchanged like the query setup Yields (see Table 4).

Table 4: Result table of the query with calculation – yield variability

Project	Short_name	Experiment	Treatment_name	Variable_	Ertrag_MW	Ertrag_SD	Unit_	Year_	Crop_name	Harvest_type
1	ASA	GroßG	100% GÄR	Biomass_total_drymatter	1,2825	0,1519	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	100% MIN	Biomass_total_drymatter	1,1175	0,1312	kgTM/m²	2013	Mais	Endernte

Project	Short_name	Experiment	Treatment_name	Variable_	Ertrag_MW	Ertrag_SD	Unit_	Year_	Crop_name	Harvest_type
1	ASA	GroßG	200% GÄR	Biomass_total_drymatter	1,25	0,1801	kgTM/m²	2013	Mais	Endernte
1	ASA	GroßG	Ohne Düngung	Biomass_total_drymatter	1,0875	2,7537E-02	kgTM/m²	2013	Mais	Endernte

b) during time period 2011 – 2015

See section a) 1. to 10., only one change in 9. is necessary:

9. “>= 2011 and <=2013” in the criteria row of the Year_ field.

Aggregated fluxes - How high are the annual N_2O fluxes of the various fertiliser treatments in the large digestate experiment in 2011?

a) during the growing season (from soil tillage/sowing to harvest/soil tillage)

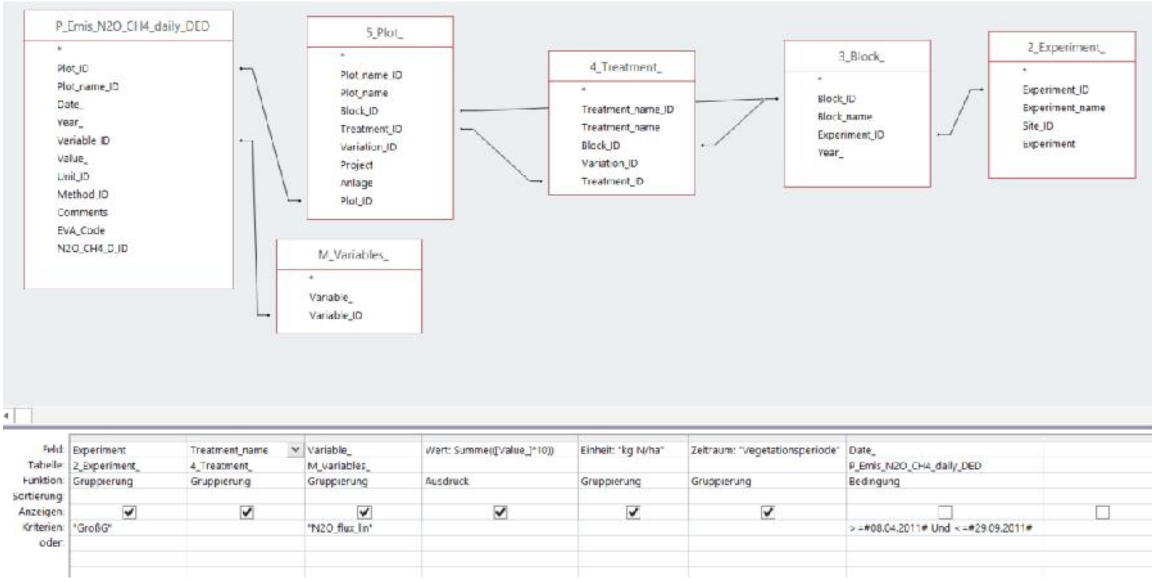

Figure 17: Query setup with calculation – aggregated fluxes (Wert = Value, Einheit = Unit, Zeitraum = time period, Vegetationsperiode = growing season, Feld = Field, Tabelle = Table, Funktion = Total, Sortierung = Sort, Anzeigen = Show, Kriterien = Criteria, Oder = Or, Gruppierung = Group by, Aufsteigend = Ascending, Ausdruck = Expression, Bedingung = Where)

Detailed descriptions of the table columns are listed in Appendix (see Table 15).

1. Identify your required tables depending on the task.
2. Open your database.
3. Go to the Create tab and click on Query Design.
4. In the Tables tab on Show Table dialog box, double-click on the required tables and then close the dialog box. Which information from which table are required, will be shown in detail in section 6.
5. Double-click on the field you want to be displayed. You can add new tables and/or queries to the query at any time by clicking on Show tables in the "Query Tools".
6. In the query design, all tables with their field names are now displayed (see Figure 15). Double-click on the field name will add a column into the query grid (lower part of the window). The query setup contains the following columns in the query grid:

With	from table	results in
„Short_name“	„1_Site“	site name,
„Experiment“	„2_Experiment“	name of experiment,
„Treatment_name“	„4_Treatment“	name of treatment,
„Variable_“	„M_Variables“	name of variable,
„Value: Sum([Value_]*10)“	„R_ Emis_N2O_CH4_daily “	the column „Value“ with the sum of the measured values multiplied by 10,
„Unit: "kg N/ha"“		the column “Unit” with the specified con-

		tent,
„Time_period: "Vegetationsperiode"“		the column “Time_period” with the specified content,
„Date_“	„R_Emis_N2O_CH4_daily“	no column is shown as the check box is cleared.

7. Click the sigma symbol (totals button) in the Design tab to get the results in the described columns. It will open another row underneath called “Total” with “Group by”.
8. Choose the “Sum” for the Value_ field. A sum value is calculated for each aggregation of the measured values. The multiplication by 10 results in the values for the unit kg N/ha.
9. Enter “GroßG” in the criteria row of the Experiment field, “N2O_flux_lin” in the criteria row of the Variable_ field and “>= #08.04.2011# und <=#29.09.2011#“ in the criteria row of the Date_ field. The group by query will extract matching record for the 2011 during the growing season at the site DED and the Large digestate experiment in the BGD project.
10. Select the Make table button to save the result of the query as a new table (see Table 5Table 1). Run your query.

Table 5: Result table of the query – aggregated fluxes

Short_name	Experiment	Treatment_name	Variable_	Wert	Einheit	Zeitraum
DED	KleinG	100% GÄR	N2O_flux_lin	6,07805	kg N/ha	Vegetationsperiode
DED	KleinG	100% MIN	N2O_flux_lin	5,59253	kg N/ha	Vegetationsperiode
DED	KleinG	50% MIN + 50% GÄR	N2O_flux_lin	3,84272	kg N/ha	Vegetationsperiode

b) During the after-harvest period (from harvest/soil tillage to soil tillage/sowing)

See section a) 1. to 10., only two changes in 6. and 9. are necessary:

6. Change the content of the column “time_period” in “after-harvest period”.
9. “>= 29.09.2011 und <=05.03.2012” in the criteria row of the Year_ field.

Crosstab query

How do I get a temporal and spatial overview of several measured variables - that means - what was measured when and where on the field?

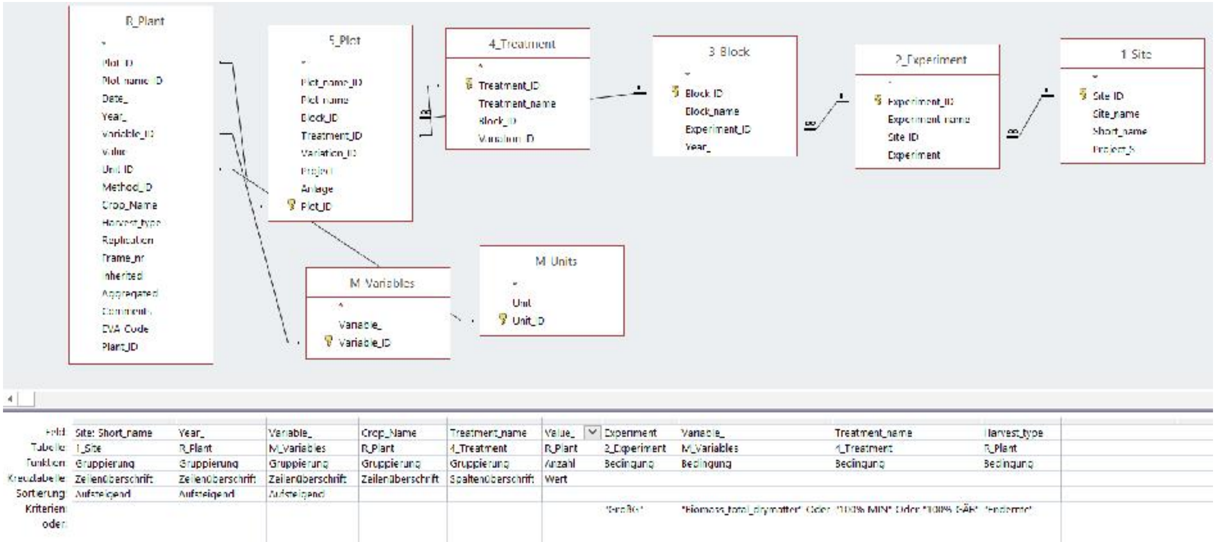

Figure 18: Query setup – overview table (Feld = Field, Tabelle = Table, Funktion = Total, Kreuztabelle = Cross-tab, Sortierung = Sort, Anzeigen = Show, Kriterien = Criteria, Oder = Or, Gruppierung = Group by, Anzahl = Count, Bedingung = Where, Zeilenüberschrift = Row heading, Spaltenüberschrift = Column heading, Wert = Value, Aufsteigend = Ascending)

Detailed descriptions of the table columns are listed in Appendix (see Table 15).

1. Identify your required tables depending on the task.
2. Open your database.
3. Go to the Create tab and click on Query Design.
4. In the Tables tab on Show Table dialog box, double-click on the required tables and then close the dialog box. Which information from which table are required, will be shown in detail in section 7.
5. Double-click on the field you want to be displayed. You can add new tables and/or queries to the query at any time by clicking on Show tables in the "Query Tools".
6. Select the Crosstab button in the Design tab to get a crosstab query. It will open two other rows underneath called “Total” and “Crosstab”.
7. In the query design, all tables with their field names are now displayed (see Figure 18Figure 15). Double-click on the field name will add a column into the query grid (lower part of the window). The query setup contains the following columns in the query grid. To get a two-dimensional statistical data evaluation from the crosstab query, in addition to group by, row and column headings are used.

With	from table	results in	as
„Site: Short_name“	„1_Site“	site name	row heading,
„Year_“	„R_Plant“	year	row heading,
„Variable_“	„M_Variables“	name of variable	row heading,
„Crop_name“	„R_Plant“	name of crop	row heading,
„Treatment_name“	„4_Treatment“	name of treatment	column heading,

„Value_“	„R_Plant“	measured value	value,
„Experiment“	„2_Experiment“	name of experiment,	
„Harvest_type“	„R_Plant“	time of harvest “main harvest”.	

8. Choose the “Count” for the Value_ field. A count value is calculated for each aggregation of the measured values. For the Experiment field and Harvest_type field the check boxes are cleared that means both fields will not occur in the cross table, but the selection “Where” for these fields will considers both for the group by.
9. Enter “GroßG” in the criteria row of the Experiment field, ““Biomass_total_drymatter” or “TC_biomass”” in the criteria row of the Variable_ field and “”100% MIN“ or “100% GÄR” or “50% GÄR” or “75% GÄR”” in the criteria row of the treatment_name field as well as “Endernte” in the criteria row of the Harvest_type field. The cross tab query will aggregate for two variables and four treatments at all sites and the Large digestate experiment in the BGD project.
10. Run your query (see Table 6).

Table 6: Result cross table – Overview table

Site	Year_	Variable_	Crop_Name	100% MIN	100% GÄR	50% GÄR	75% GÄR
ASA	2011	Biomass_total_drymatter	Mais	3	4	4	4
ASA	2011	TC_biomass	Mais	3	4	4	4
ASA	2012	Biomass_total_drymatter	Mais	4	4	4	4
ASA	2012	TC_biomass	Mais	4	4	4	4
ASA	2013	Biomass_total_drymatter	Mais	4	4		
DED	2011	Biomass_total_drymatter	Mais	4	4	4	4
DED	2011	TC_biomass	Mais	2	2	2	2
DED	2012	Biomass_total_drymatter	Mais	4	4	4	4
DED	2013	Biomass_total_drymatter	Mais	4	4	4	4
DED	2013	TC_biomass	Mais	4	4	4	4
DOR	2011	Biomass_total_drymatter	Mais	1	1	1	1
DOR	2011	TC_biomass	Mais	1	1	1	1
DOR	2012	Biomass_total_drymatter	Mais	6	6	6	6
DOR	2012	TC_biomass	Mais	6	6	6	6
DOR	2013	Biomass_total_drymatter	Mais	5	5		
DOR	2013	TC_biomass	Mais	5	5		
GUE	2011	Biomass_total_drymatter	Mais	1	1	1	1
GUE	2011	TC_biomass	Mais	1	1	1	1
GUE	2012	Biomass_total_drymatter	Mais	4	4	4	4
GUE	2012	TC_biomass	Mais	4	4	4	4
GUE	2013	Biomass_total_drymatter	Mais	4	4		
GUE	2013	TC_biomass	Mais	4	4		
HOH	2011	Biomass_total_drymatter	Mais	3	3	3	3
HOH	2011	TC_biomass	Mais	3	3	3	3
HOH	2012	Biomass_total_drymatter	Mais	4	4	4	4
HOH	2012	TC_biomass	Mais	3	3	3	3
HOH	2013	Biomass_total_drymatter	Mais	4	4	4	4
HOH	2013	TC_biomass	Mais	4	4	4	4

Complex, build upon queries for data calculation:

Balance (Difference between N input and N output) - How does the N balance for winter oilseed rape at the site Merbitz of the OSR project in 2013?

Query 1: Yield_N Balance

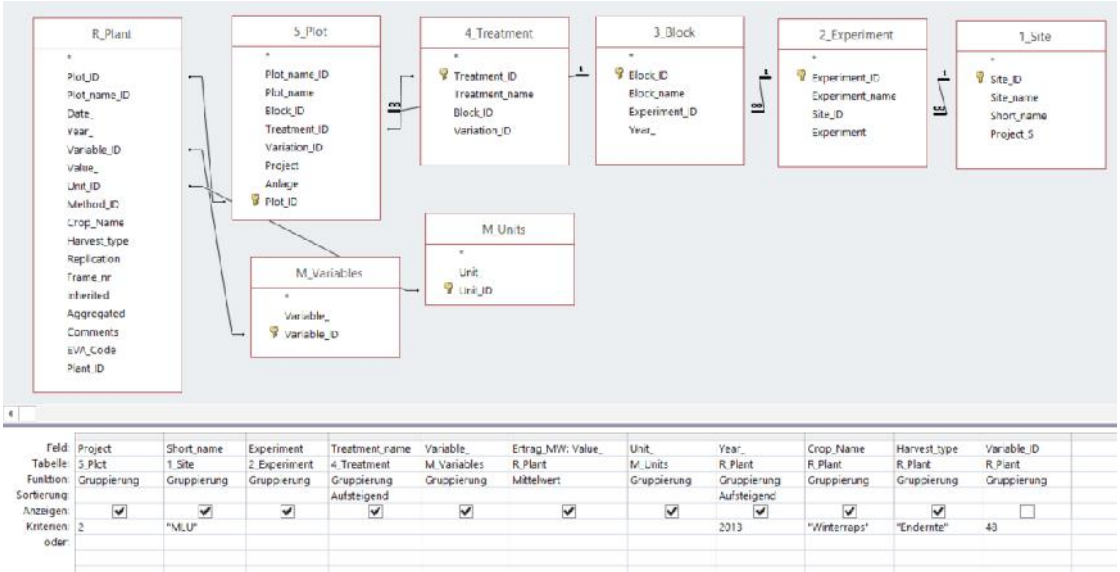

Figure 19: Query setup – Yield_N balance (Feld = Field, Tabelle = Table, Sortierung = Sort, Anzeigen = Show, Kriterien = Criteria, Oder = Or, Aufsteigend = Ascending, Mais = Maize, Endernte = Main harvest)

Detailed descriptions of the table columns are listed in Appendix (see Table 15).

1. Identify your required tables depending on the task.
2. Open your database.
3. Go to the Create tab and click on Query Design.
4. In the Tables tab on Show Table dialog box, double-click on the required tables and then close the dialog box. Which information from which table are required, will be shown in detail in section 6.
5. Double-click on the field you want to be displayed. You can add new tables and/or queries to the query at any time by clicking on Show tables in the "Query Tools".
6. In the query design, all tables with their field names are now displayed (see Figure 19). Double-click on the field name will add a column into the query grid (lower part of the window). The query setup contains the following columns in the query grid:

With	from table	results in
"Project"	„5_Plot“	project affiliation,
„Site_name“	„1_Site“	site name,
„Experiment“	„2_Experiment“	name of experiment,
„Treatment_name“	„4_Treatment“	name of treatment,
„Year_“	„R_Plant“	year,
„Variable_“	„M_Variables“	name of variable,
„Yield_avg: Value_“	„R_Plant“	the average of the measured values,
„Unit_“	„M_Units“	unit of variable,

„Crop_name“ „R_Plant“ name of crop,
„Variable_ID“ „R_Plant“ no column is shown as the check box is cleared,
„Harvest_type“ „R_Plant“ time of harvest “main harvest”.

7. Click the sigma symbol (totals button) in the Design tab to get the results in the described columns. It will open another row underneath called “Total” with “Group by”.
8. Choose the “Avg” for the Value_ field. An average value is calculated for each aggregation of the measured values.
9. Enter “2” in the criteria row of the Project field, “MLU” in the criteria row of the Short_name field, “2013” in the criteria row of the Year_ field and “Endernte” in the criteria row of the Harvest_type field. The group by query will extract matching record for grain yield in 2013 at the site MLU in the OSR project.
10. Click the Select button, run your query (see Table 7) and save it as “Yields-N_balance”.

Table 7: Result of the select query – Yields_N balance

Project	Short_name	Experiment	Treatment_name	Variable_	Ertrag_MW	Unit_	Year_	Crop_Name	Harvest_type
2	MLU	IMPr	N1_N9_N8	Grain_dry_matter	32,575	dt/ha	2013	Winterraps	Endernte
2	MLU	IMPr	N2_N9_N8	Grain_dry_matter	35,975	dt/ha	2013	Winterraps	Endernte
2	MLU	IMPr	N3_N9_N8	Grain_dry_matter	39,475	dt/ha	2013	Winterraps	Endernte
2	MLU	IMPr	N4_N9_N8	Grain_dry_matter	41,35	dt/ha	2013	Winterraps	Endernte
2	MLU	IMPr	N5_N9_N8	Grain_dry_matter	43,3	dt/ha	2013	Winterraps	Endernte
2	MLU	IMPr	N6_N9_N8	Grain_dry_matter	40,475	dt/ha	2013	Winterraps	Endernte
2	MLU	IMPr	N7_N9_N8	Grain_dry_matter	39,3	dt/ha	2013	Winterraps	Endernte

Query 2: N input

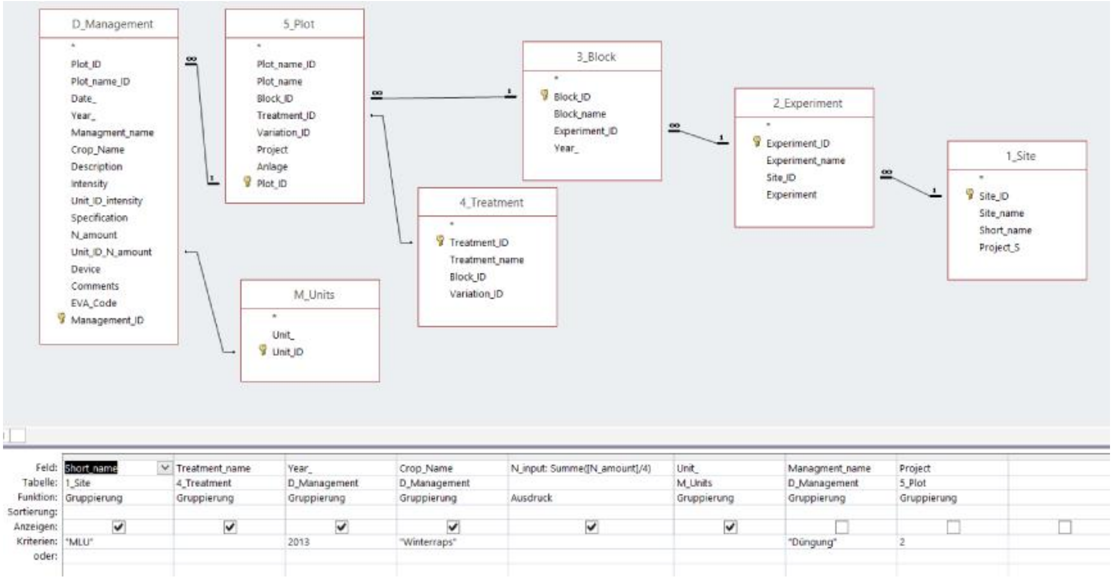

Figure 20: Query setup – N input (Feld = Field, Tabelle = Table, Funktion = Total, Sortierung = Sort, Anzeigen = Show, Kriterien = Criteria, Oder = Or, Gruppierung = Group by, Ausdruck = Expression, Winterraps = winter oilseed rape, Düngung = Fertilisation)

1. Go to the Create tab and click on Query Design.
2. In the Tables tab on Show Table dialog box, double-click on the required tables and then close the dialog box. Which information from which table are required, will be shown in detail in section 4.
3. Double-click on the field you want to be displayed. You can add new tables and/or queries to the query at any time by clicking on Show tables in the "Query Tools".
4. In the query design, all tables with their field names are now displayed (see Figure 20). Double-click on the field name will add a column into the query grid (lower part of the window). The query setup contains the following columns in the query grid:

With	from table	results in
„Short_name“	„1_Site“	site name,
„Treatment_name“	„4_Treatment“	name of treatment,
„Year_“	„D_Management“	year,
„Crop_name“	„D_Management“	name of crop,
„N_input: Sum([N_amount]/4)“	„D_Management“	the sum of the measured values divided by 4,
„Unit_“	„M_Units“	unit of variable,
„Management_name“	„D_Management“	name of management activity,
„Project“	„5_Plot“	no column is shown as the check box is cleared.

5. Click the sigma symbol (totals button) in the Design tab to get the results in the described columns. It will open another row underneath called “Total” with “Group by”.
6. Choose the “Sum” for the N_amount field. A sum value is calculated for each aggregation of the measured values. The division by 4 is necessary as each treatment has four replications.

7. Enter “2” in the criteria row of the Project field, “MLU” in the criteria row of the Short_name field, “2013” in the criteria row of the Year_ field, “Winterraps” in the criteria row of the Crop_name field and “Düngung” in the criteria row of the Management_name field. The group by query will extract matching record for fertilisation of winter oilseed rape in 2013 at the site MLU in the OSR project.
8. Click the Select button, run your query (see Table 8) and save it as “N-input”.

Table 8: Result of the select query – N input

Short_name	Treatment_name	Year_	Crop_Name	N_input	Unit_
MLU	N1_N9_N8	2013	Winterraps	0	kg N/ha
MLU	N2_N9_N8	2013	Winterraps	60	kg N/ha
MLU	N3_N9_N8	2013	Winterraps	120	kg N/ha
MLU	N4_N9_N8	2013	Winterraps	180	kg N/ha
MLU	N5_N9_N8	2013	Winterraps	240	kg N/ha
MLU	N6_N9_N8	2013	Winterraps	180	kg NH4-N/ha
MLU	N7_N9_N8	2013	Winterraps	180	kg NH4-N/ha

Query 3: N content

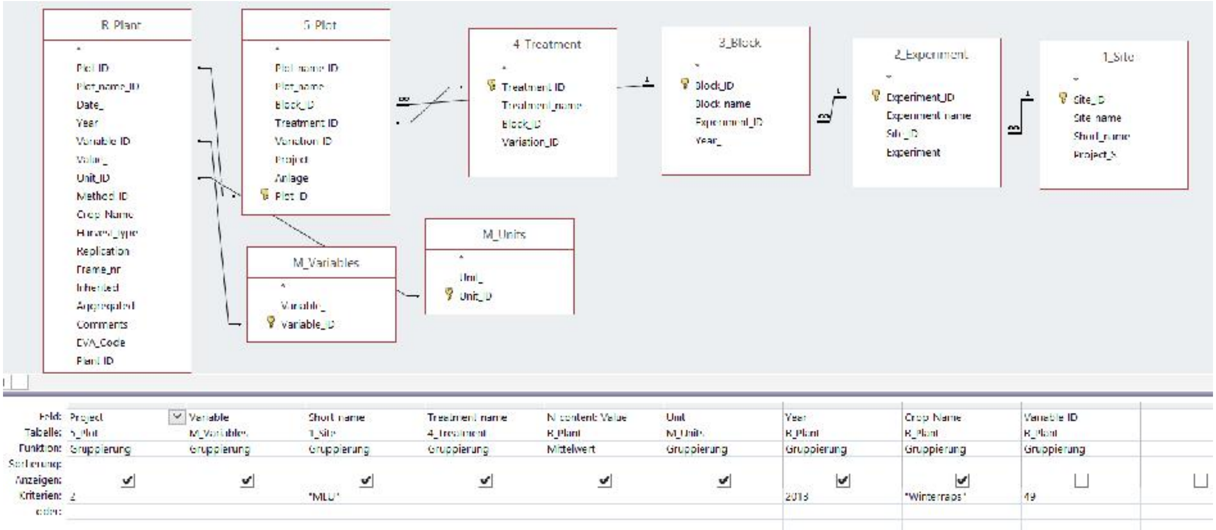

Figure 21: Query setup – N content (Feld = Field, Tabelle = Table, Funktion = Total, Sortierung = Sort, Anzeigen = Show, Kriterien = Criteria, Oder = Or, Gruppierung = Group by, Mittelwert = Average, Winterraps = winter oilseed rape)

1. Go to the Create tab and click on Query Design.
2. In the Tables tab on Show Table dialog box, double-click on the required tables and then close the dialog box. Which information from which table are required, will be shown in detail in section 4.
3. Double-click on the field you want to be displayed. You can add new tables and/or queries to the query at any time by clicking on Show tables in the "Query Tools".
4. In the query design, all tables with their field names are now displayed (see Figure 21). Double-click on the field name will add a column into the query grid (lower part of the window). The query setup contains the following columns in the query grid:

With	from table	results in
"Project"	„5_Plot“	project affiliation,
„Variable_“	„M_Variables“	name of variable,
„Short_name“	„1_Site“	site name,
„Treatment_name“	„4_Treatment“	name of treatment,
„N_content: Value_“	„R_Plant“	the measured values of N content,
„Unit_“	„M_Units“	unit of variable,
„Year_“	„R_Plant“	year,
„Crop_name“	„R_Plant“	name of crop,
„Variable_ID“	„R_Plant“	no column is shown as the check box is cleared.

5. Click the sigma symbol (totals button) in the Design tab to get the results in the described columns. It will open another row underneath called "Total" with "Group by".
6. Choose the "Avg" for the Value_ field. An average value is calculated for each aggregation of the measured values.
7. Enter "2" in the criteria row of the Project field, "MLU" in the criteria row of the Short_name field, "2013" in the criteria row of the Year_ field, "Winterraps" in the criteria row of the Crop_name field and "49" in the criteria row of the Variable_ID field. The group by query will

extract matching record for N content of winter oilseed rape in 2013 at the site MLU in the OSR project.

8. Click the Select button, run your query (see Table 9) and save it as “N-content”.

Table 9: Result of the select query – N content

Project	Variable_	Short_name	Treatment_name	N_content	Unit_	Year_	Crop_Name
2	Grain_N_content	MLU	N1_N9_N8	2,8375	%TM	2013	Winterraps
2	Grain_N_content	MLU	N2_N9_N8	3,12	%TM	2013	Winterraps
2	Grain_N_content	MLU	N3_N9_N8	3,285	%TM	2013	Winterraps
2	Grain_N_content	MLU	N4_N9_N8	3,375	%TM	2013	Winterraps
2	Grain_N_content	MLU	N5_N9_N8	3,6225	%TM	2013	Winterraps
2	Grain_N_content	MLU	N6_N9_N8	3,3625	%TM	2013	Winterraps
2	Grain_N_content	MLU	N7_N9_N8	3,265	%TM	2013	Winterraps

Query 4: N output

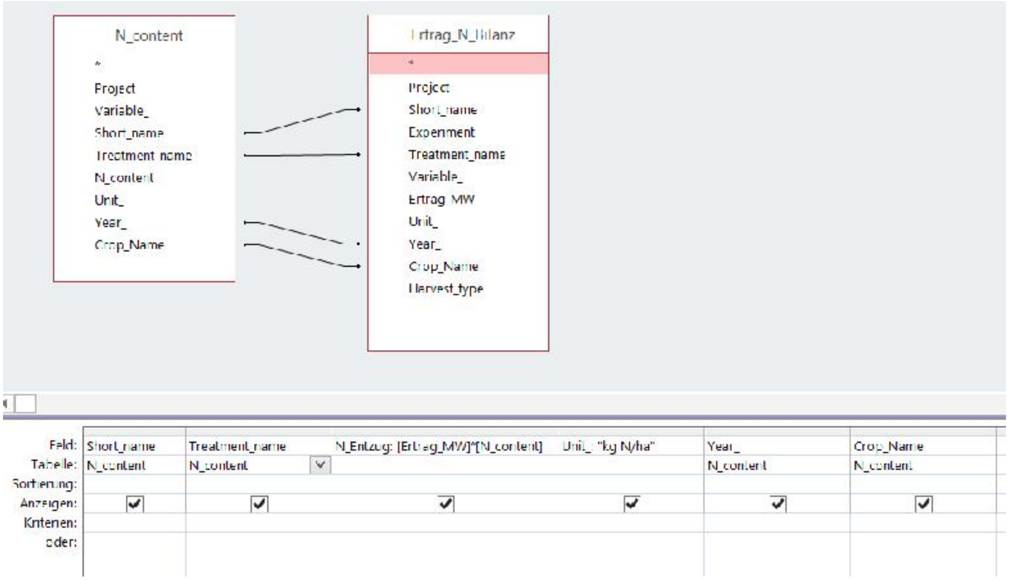

Figure 22: Query setup - N output (Feld = Field, Tabelle = Table, Sortierung = Sort, Anzeigen = Show, Kriterien = Criteria, Oder = Or, N-Entzug = N uptake, Ertrag_MW = Average of yield)

1. Go to the Create tab and click on Query Design.
2. In the Tables tab on Show Table dialog box, double-click on the required queries and then close the dialog box. Which information from which query are required, will be shown in detail in section 4.
3. Double-click on the field you want to be displayed. You can add new tables and/or queries to the query at any time by clicking on Show tables in the "Query Tools".
4. In the query design, all queries with their field names are now displayed (see Figure 22). Double-click on the field name will add a column into the query grid (lower part of the window). The query setup contains the following columns in the query grid:

With	from query	results in
„Short_name“	„N_content“	site name,
„Treatment_name“	„N_content“	name of treatment,
„N_uptake: ([Yield_avg]*[N_content])“	„Yield_N_balance“	the column “N uptake”,
„Unit_: "kg N/ha"“		the column “Unit” with specified content,
„Year_“	„N_content“	year,
„Crop_name“	„N_content“	name of crop.

5. To create a relationship between both queries, use the mouse, and click and hold the field from the query N content and drag and drop that field on the field from the query Yield_N_balance which will be related. The fields „Short_name“, Treatmemt_name“, „Year_“ and „Crop_name“ need to be related (see Figure 22).
6. Click the Select button, run your query (see Table 10) and save it as “N output”.

Table 10: Result of the select query – N output

Short_name	Treatment_name	N_Entzug	Unit_	Year_	Crop_Name

Short_name	Treatment_name	N_Entzug	Unit_	Year_	Crop_Name
MLU	N1_N9_N8	92,4315625	kg N/ha	2013	Winterraps
MLU	N2_N9_N8	112,242	kg N/ha	2013	Winterraps
MLU	N3_N9_N8	129,675375	kg N/ha	2013	Winterraps
MLU	N4_N9_N8	139,55625	kg N/ha	2013	Winterraps
MLU	N5_N9_N8	156,85425	kg N/ha	2013	Winterraps
MLU	N6_N9_N8	136,0971875	kg N/ha	2013	Winterraps
MLU	N7_N9_N8	128,3145	kg N/ha	2013	Winterraps

Query 5: N balance

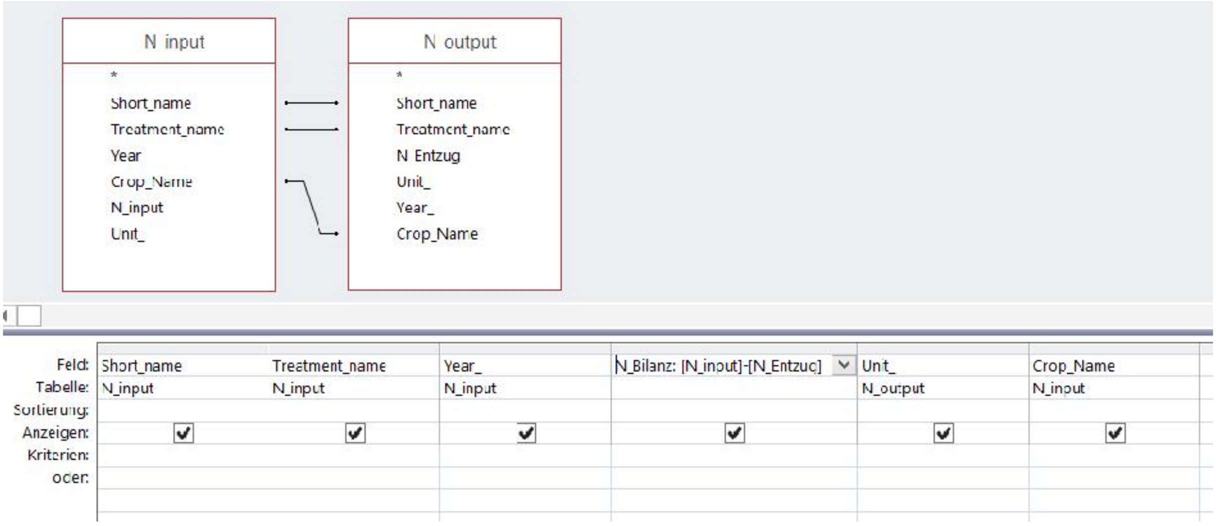

Figure 23: Query setup – N balance (N_Bilanz = N balance, N_Entzug = N uptake, Feld = Field, Tabelle = Table, Funktion = Total, Sortierung = Sort, Anzeigen = Show, Kriterien = Criteria, Oder = Or)

1. Go to the Create tab and click on Query Design.
2. In the Tables tab on Show Table dialog box, double-click on the required queries and then close the dialog box. Which information from which query are required, will be shown in detail in section 4.
3. Double-click on the field you want to be displayed. You can add new tables and/or queries to the query at any time by clicking on Show tables in the "Query Tools".
4. In the query design, all tables with their field names are now displayed (see Figure 23Figure 22). Double-click on the field name will add a column into the query grid (lower part of the window). The query setup contains the following columns in the query grid:

With	from query	results in
„Short_name“	„N_input“	site name,
„Treatment_name“	„N_input“	name of treatment,
„Year_“	„N_input“	year,
„N_balance: [N_input]* [N_uptake]“	„N_input“	the column “N uptake”,
„Unit_“	„N_output“	unit of variable,
„Crop_name“	„N_input“	name of crop.

5. To create a relationship between both queries, use the mouse, and click and hold the field from the query N content and drag and drop that field on the field from the query Yield_N_balance which will be related. The fields „Short_name“, Treatmemt_name“ and „Crop_name“ need to be related (see Figure 23).
6. Click the Select button, run your query (see Table 11) and save it as “N balance”.

Table 11: Result of the select query – N balance

Short_name	Treatment_name	Year_	N_Bilanz	Unit_	Crop_Name
MLU	N1_N9_N8	2013	-92,4315625	kg N/ha	Winterraps
MLU	N2_N9_N8	2013	-52,242	kg N/ha	Winterraps

Short_name	Treatment_name	Year_	N_Bilanz	Unit_	Crop_Name
MLU	N3_N9_N8	2013	-9,675375	kg N/ha	Winterraps
MLU	N4_N9_N8	2013	40,44375	kg N/ha	Winterraps
MLU	N5_N9_N8	2013	83,14575	kg N/ha	Winterraps
MLU	N6_N9_N8	2013	43,9028125	kg N/ha	Winterraps
MLU	N7_N9_N8	2013	51,6855	kg N/ha	Winterraps

Nitrogen efficiency - Which treatment of winter oilseed rape has the best nitrogen efficiency at the site Merbitz in 2013?

The nitrogen efficiency (NUE (%)) was calculated according the final report of the OSR project (page 84). A part of the queries can use from the N balance queries.

Query 1: N output unfertilised

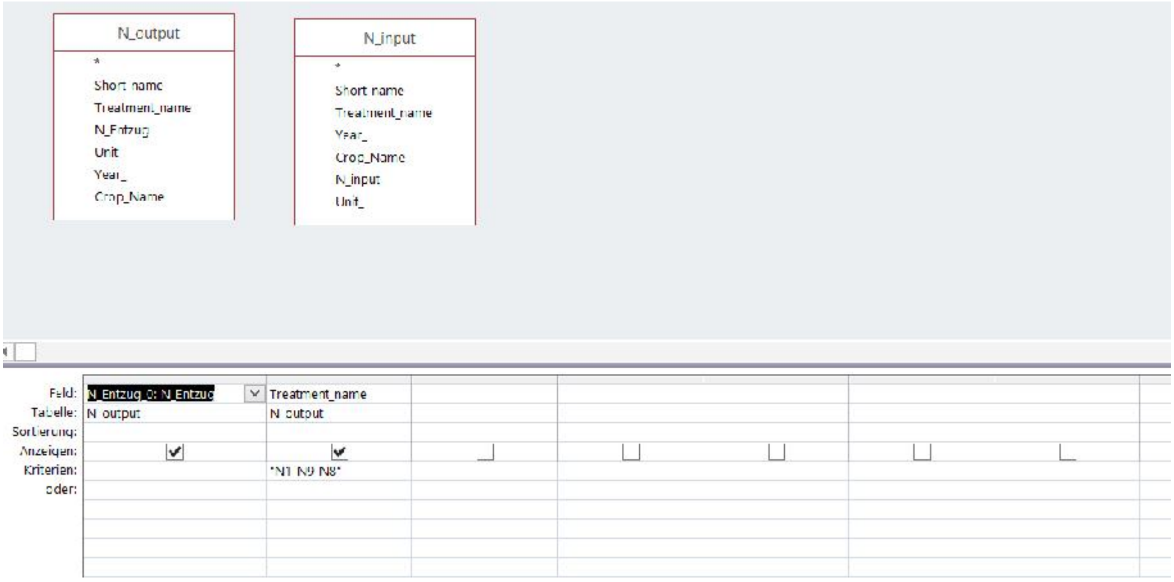

Figure 24: Query setup – N output unfertilised (Feld = Field, Tabelle = Table, Funktion = Total, Sortierung = Sort, Anzeigen = Show, Kriterien = Criteria, Oder = Or)

1. Go to the Create tab and click on Query Design.
2. In the Tables tab on Show Table dialog box, double-click on the required queries and then close the dialog box. Which information from which query are required, will be shown in detail in section 4.
3. Double-click on the field you want to be displayed. You can add new tables and/or queries to the query at any time by clicking on Show tables in the "Query Tools".
4. In the query design, all queries with their field names are now displayed (see Figure 24Figure 22). Double-click on the field name will add a column into the query grid (lower part of the window). The query setup contains the following columns in the query grid:

With	from query	results in
„N_uptake_0: N_uptake“	„N_output“	The column “N_uptake”,
„Treatment_name“	„N_output“	name of treatment.

5. Add the queries “N output” and “N input”. The late one contains all fertilisation treatments. In this case no relationship between same fields will be not established. Enter “N1_N9_N8” (unfertilised treatment) in the criteria row of the Treatment_name field. So, for each fertilisation treatment a row of N uptake from the unfertilised treatment will be produced.
6. Click the Select button, run your query (see Table 12) and save it as “N output unfertilised”.

Table 12: Result of the select query – N output unfertilised

N_Entzug	Treatment_name
92,4315625	N1_N9_N8
92,4315625	N1_N9_N8
92,4315625	N1_N9_N8
92,4315625	N1_N9_N8
92,4315625	N1_N9_N8
92,4315625	N1_N9_N8
92,4315625	N1_N9_N8

Query 2: NUE

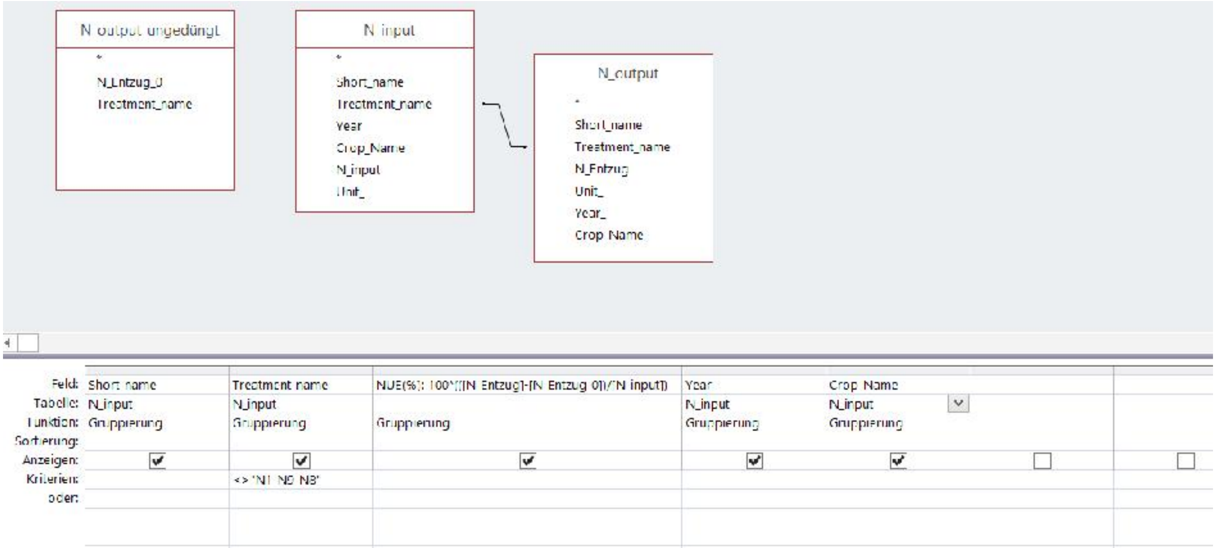

Figure 25: Query setup – NUE (N Entzug = N uptake, Feld = Field, Tabelle = Table, Funktion = Total, Sortierung = Sort, Anzeigen = Show, Kriterien = Criteria, Oder = Or, Gruppierung = Group by)

1. Go to the Create tab and click on Query Design.
2. In the Tables tab on Show Table dialog box, double-click on the required queries and then close the dialog box. Which information from which query are required, will be shown in detail in section 4.
3. Double-click on the field you want to be displayed. You can add new tables and/or queries to the query at any time by clicking on Show tables in the "Query Tools".
4. In the query design, all queries with their field names are now displayed (see Figure 24Figure 22). Double-click on the field name will add a column into the query grid (lower part of the window). The query setup contains the following columns in the query grid:

With	from query	results in
„Short_name“	„N_input“	site name,
„Treatment_name“	„N_input“	name of treatment,
„NUE(%): 100*(([N_uptake]-[N_uptake_0])/[N_input])“	„N_output“ „N_output_unfertilised“ „N_input“	the column “NUE(%)”,
„Year_“	„N_input“	year,
„Crop_name“	„N_input“	name of crop.

5. To create a relationship only between queries (N input and N output), use the mouse, and click and hold the field from the query N input and drag and drop that field on the field from the query N output which will be related. The field Treatmemt_name need to be related (see Figure 25).
6. To get the NUE results from Table 13, click the sigma symbol (totals button) in the Design tab to get the results in the described columns. It will open another row underneath called “Total” with “Group by”. As the query “N output unfertilised” is considered without a relationship, the count of records (n=7) from the two related queries will multiplied by the count of

records from the query “N output unfertilised”. The group by will be added to summarize same items.

7. Enter „not "N1_N9_N8"“ in the criteria row of the Treatment_name field to not consider the unfertilised treatment in the query.
8. Click the Select button, run your query (see Table 13) and save it as “NUE”.

Table 13: Result of the select query – NUE

Short_name	Treatment_name	NUE(%)	Year_	Crop_Name
MLU	N2_N9_N8	33,0173958333333	2013	Winterraps
MLU	N3_N9_N8	31,0365104166667	2013	Winterraps
MLU	N4_N9_N8	26,1803819444444	2013	Winterraps
MLU	N5_N9_N8	26,8427864583333	2013	Winterraps
MLU	N6_N9_N8	24,2586805555556	2013	Winterraps
MLU	N7_N9_N8	19,9349652777778	2013	Winterraps

A. Appendix

Table 14: Overview of all tables (with category) of the GHG-DB-Thuenen

Table name	Category
D_Management	Driving forces
D_Meteo	Driving forces
D_Soilprofile	Driving forces
E_Block	Experimental design
E_Crop	Experimental design
E_Experiment	Experimental design
E_Plot	Experimental design
E_Site	Experimental design
E_Treatment	Experimental design
E_Variation	Experimental design
M_Below_LOQ_info	Metadata
M_Digestate_info	Metadata
M_EVA_Code_ListA_B	Metadata
M_EVA_Code_ListC	Metadata
M_EVA_Code_ListD	Metadata
M_Experiment_info	Metadata
M_Fertilisation	Metadata
M_Information	Metadata
M_Installations	Metadata
M_Management_past	Metadata
M_Methods	Metadata
M_Site_info	Metadata
M_Soilprofile_info	Metadata
M_Units	Metadata
M_Variables	Metadata
M_Variable_info	Metadata
P_Balances	Processed data
P_Emis_CO2_flux	Processed data
P_Emis_N2O_CH4_daily	Processed data
P_Emis_N2O_CH4_flux	Processed data
P_Emis_NH3_flux	Processed data
P_Modelled_CO2	Processed data
P_Modelled_NO3	Processed data
P_NO3leaching	Processed data
P_Parameter_CO2	Processed data
R_Cl_Tracer	Raw data
R_Cl_Tracer_factor	Raw data
R_Digestate	Raw data

R_Emis_CO2_conc	Raw data
R_Emis_N2O_CH4_CO2_conc	Raw data
R_Incubation	Raw data
R_Plant	Raw data
R_Soil_continuous	Raw data
R_Soil_periodic	Raw data
S_Statistics_Balances	Specific statistics
S_Statistics_N2O_flux	Specific statistics
S_Statistics_CO2_flux	Specific statistics
S_Statistics_N2O_CH4_flux	Specific statistics

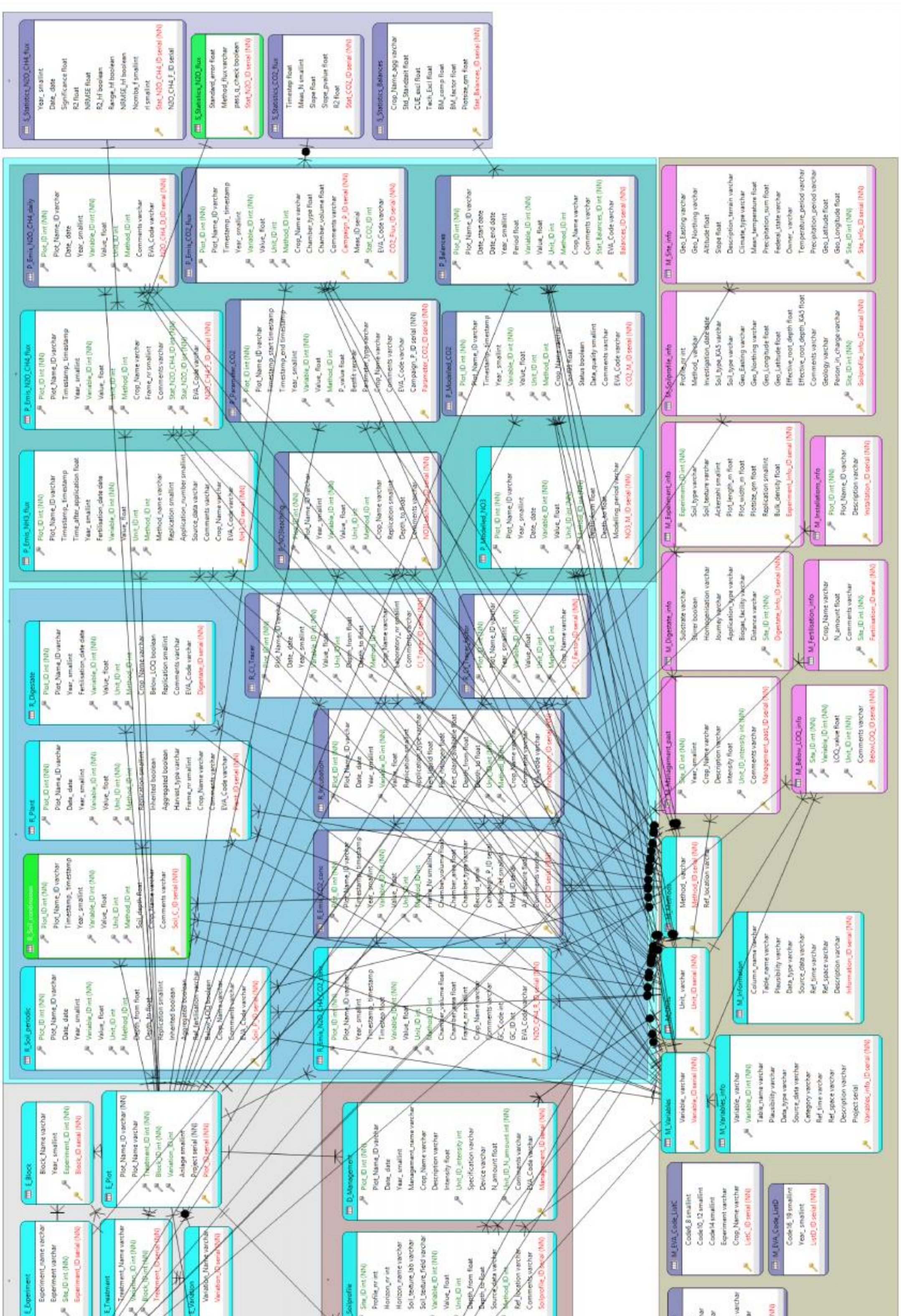

Figure 26: Entire database design

Table 15: Detailed description of the columns of the table

Table name	Column name	Type	PK	NOT NULL	FK	Description
D_Management	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
D_Management	Plot_Name_ID	varchar				Unique name for plots
D_Management	Date_	date				Date of management activity
D_Management	Year_	smallint				Year
D_Management	Management_name	varchar				Name of management activity
D_Management	Crop_Name	varchar				Name of crop
D_Management	Description	varchar				Description
D_Management	Intensity	float				Intensity of management activity
D_Management	Unit_ID_intensity	int		*	-> M_Units.Unit_ID	Index / unique counter of the units
D_Management	Specification	varchar				Additional description (Specification)
D_Management	Device	varchar				Used device
D_Management	N_amount	float				Amount of nitrogen
D_Management	Unit_ID_N_amount	int		*	-> M_Units.Unit_ID	Index / unique counter of the units
D_Management	Comments	varchar				Comments
D_Management	EVA_Code	serial				Code to identify data of the EVA II project
D_Management	Management_ID	serial	*	*		Index / unique counter for management activities
D_Meteo	Site_ID	int		*	-> E_Site.Site_ID	Index / unique counter for sites
D_Meteo	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
D_Meteo	Plot_Name_ID	varchar				Unique name for plots
D_Meteo	Timestamp_	timestamp				Measurement time of measured value (time stamp)
D_Meteo	Variable_ID	int		*	-> M_Variables.Variable_ID	Index / unique counter of measured variables
D_Meteo	Value_	float				Measured value
D_Meteo	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
D_Meteo	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of method
D_Meteo	Comments	varchar				Comments
D_Meteo	Meteo_ID	serial	*	*		Index / unique counter for meteorological data
D_Soilprofile	Site_ID	int		*	-> E_Site.Site_ID	Index / unique counter for sites
D_Soilprofile	Profile_nr	int				Number of profile
D_Soilprofile	Horizon_nr	int				Number of horizon
D_Soilprofile	Horizon_name	varchar				Name of the horizon
D_Soilprofile	Soil_texture_lab	varchar				Soil texture determined in the laboratory
D_Soilprofile	Soil_texture_field	varchar				Soil texture determined in the field
D_Soilprofile	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables

D_Soilprofile	Value_	float				Measured value
D_Soilprofile	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
D_Soilprofile	Depth_from	float				Soil depth from
D_Soilprofile	Depth_to	float				Soil depth to
D_Soilprofile	Source_data	varchar				Source of data
D_Soilprofile	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
D_Soilprofile	Ref_location	varchar				Link to deposited docu-ments
D_Soilprofile	Comments	varchar				Comments
D_Soilprofile	Soilprofile_ID	serial	*	*		Index / unique counter for physical soil measured values
E_Block	Block_Name	varchar				Name of block
E_Block	Year_	smallint				Year
E_Block	Experiment_ID	int		*	-> E_Experiment.Experiment_ID	Index / unique counter for experiments
E_Block	Block_ID	serial	*	*		Index / unique counter for blocks
E_Crop	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
E_Crop	Crop_Name	varchar				Name of crop
E_Crop	Crop_short	varchar				Short name of crop
E_Crop	Crop_rotation	varchar				Crop rotation
E_Crop	Treatment_Project	varchar				Project name of treat-ment
E_Crop	Treatment_Crop	varchar				Treatment related only to crop of year
E_Crop	Sowing_year	smallint				Year of sowing
E_Crop	Harvest_year	smallint				Year of harvest
E_Crop	Sowing_date	date				Date of sowing
E_Crop	Harvest_date	date				Date of harvest
E_Crop	Crop_type	varchar				Kind of crop (winter or summer crop)
E_Crop	Use	varchar				Usage of crop
E_Crop	Period	float				Period of cultivation in days
E_Crop	Comments	varchar				Comments
E_Crop	Crop_ID	serial	*	*		Index / unique counter for crops
E_Experiment	Experiment_name	varchar				Name of experiment
E_Experiment	Experiment	varchar				Short name of experi-ment
E_Experiment	Site_ID	int		*	-> E_Site.Site_ID	Index / unique counter for sites
E_Experiment	Experiment_ID	serial	*	*		Index / unique counter for experiments
E_Plot	Plot_Name_ID	varchar				Unique name for plots
E_Plot	Plot_Name	varchar				Name of trial plots
E_Plot	Treatment_ID	int		*	-> E_Treatment.Treatment_ID	Index / unique counter for treatments

E_Plot	Block_ID	int		*	-> E_Block.Block_ID	Index / unique counter for blocks
E_Plot	Variation_ID	int		*	-> E_Variation.Variation_ID	Index / unique counter for variations
E_Plot	Anlage	smallint				Number of cultivation
E_Plot	Project	serial		*		Index / unique counter for project affiliation
E_Plot	Plot_ID	varchar	*	*		Index / unique counter for plots
E_Site	Site_name	varchar				Name of site
E_Site	Short_name	varchar				Short name of site
E_Site	Project_S	serial		*		Index / unique counter for project affiliation
E_Site	Site_ID	serial	*	*		Index / unique counter for sites
E_Treatment	Treatment_Name_ID	varchar				Index / unique counter for treatments
E_Treatment	Treatment_Name	varchar				Name of treatment
E_Treatment	Variation_ID	int		*	-> E_Variation.Variation_ID	Index / unique counter for variations
E_Treatment	Block_ID	int		*	-> E_Block.Block_ID	Index / unique counter for blocks
E_Treatment	Treatment_ID	serial	*	*		Index / unique counter for treatments
E_Variation	Variation_Name	varchar				Name of variation / summary of equal replica-tions
E_Variation	Variation_ID	serial	*	*		Index / unique counter for variation
M_Below_LOQ_info	Site_ID	int		*	-> E_Site.Site_ID	Index / unique counter for sites
M_Below_LOQ_info	Variable_ID	int		*	-> M_Variables.Variable_ID	Index / unique counter of measured variables
M_Below_LOQ_info	LOQ_value	float				Value / limit of quantifica-tion - LOQ
M_Below_LOQ_info	Unit_ID	int		*	-> M_Units.Unit_ID	Index / unique counter of units
M_Below_LOQ_info	Comments	varchar				Comments
M_Below_LOQ_info	BelowLOQ_ID	serial	*	*		Index / unique counter for information about LOQ
M_Digestate_info	Substrate	varchar				Substrate of digestate
M_Digestate_info	Stirrer	varchar				Stirrer
M_Digestate_info	Homogenisation	varchar				Homogenisation
M_Digestate_info	Journey	varchar				Time of journey
M_Digestate_info	Application_type	varchar				Type of application
M_Digestate_info	Biogas_facility	varchar				Biogas facility
M_Digestate_info	Distance	varchar				Distance
M_Digestate_info	Site_ID	int		*	-> E_Site.Site_ID	Index / unique counter for sites
M_Digestate_info	Digestate_info_ID	serial	*	*		Index / unique counter for information about digestate
M_EVA_Code_ListA_B	Code1_3	smallint				Code position 1 to 3

M_EVA_Code_ListA_B	Short_name	varchar				Short name of sites
M_EVA_Code_ListA_B	Experiment	varchar				Short name of experi-ments
M_EVA_Code_ListA_B	Year_	smallint				Year
M_EVA_Code_ListA_B	Treatment_Name	varchar				Name of treatment
M_EVA_Code_ListA_B	Plot_Name	varchar				Name of trial plots
M_EVA_Code_ListA_B	Code4	smallint				Code position 4
M_EVA_Code_ListA_B	ListA_B_ID	serial	*	*		Index / unique counter for EVA_Code List A+B
M_EVA_Code_ListC	Code6_8	smallint				Code position 6 to 8
M_EVA_Code_ListC	Code10_12	smallint				Code position 10 to 12
M_EVA_Code_ListC	Code14	smallint				Code position 14
M_EVA_Code_ListC	Experiment	varchar				Short name of experi-ment
M_EVA_Code_ListC	Crop_Name	varchar				Name of crop
M_EVA_Code_ListC	ListC_ID	serial	*	*		Index / unique counter for EVA_Code List C
M_EVA_Code_ListD	Code16_19	smallint				Code position 16 to 19
M_EVA_Code_ListD	Year_	smallint				Year
M_EVA_Code_ListD	ListD_ID	serial	*	*		Index / unique counter for EVA_Code List D
M_Experiment_info	Experiment_ID	int		*	-> E_Experiment.Experiment_ID	Index / unique counter for experiments
M_Experiment_info	Soil_type	varchar				Soil type
M_Experiment_info	Soil_texture	varchar				Soil texture
M_Experiment_info	Ackerzahl	smallint				Number of fields
M_Experiment_info	Plot_length_m	float				Length of experimental plot in m
M_Experiment_info	Plot_width_m	float				With of experimental plot in m
M_Experiment_info	Plotsize_qm	float				Plot size in square meter
M_Experiment_info	Replication	smallint				Number of replications
M_Experiment_info	Bulk_density	float				Bulk density of the experiment
M_Experiment_info	Experiment_info_ID	int	*	*		Index / unique counter for information of exper-iments
M_Fertilisation_info	Crop_Name	varchar				Name of crop
M_Fertilisation_info	N_amount	float				Amount of nitrogen
M_Fertilisation_info	Comments	varchar				Comments
M_Fertilisation_info	Site_ID	int		*	-> E_Site.Site_ID	Index / unique counter for sites
M_Fertilisation_info	Fertilisation_ID	serial	*	*		Index / unique counter for information of fertili-sation
M_Information	Column_name	varchar				Column name
M_Information	Table_name	varchar				Table name
M_Information	Plausibility	varchar				Plausibility (number or text, etc., number of decimal places, value range)

M_Information	Data_type	varchar				Data type
M_Information	Source_data	varchar				Source of data
M_Information	Ref_time	varchar				Temporal relation of measured variable
M_Information	Ref_space	varchar				Spatial relation of meas-ured variable
M_Information	Description	varchar				Description
M_Information	Information_ID	serial	*	*		Index / unique counter of descriptive information
M_Installations_info	Plot_ID	varchar		*	-> E_Plot.Plot_ID	Index / unique counter for plots
M_Installations_info	Plot_Name_ID	varchar				Unique name for plots
M_Installations_info	Description	varchar				Description
M_Installations_info	Installation_ID	serial	*	*		Index / unique counter of information for installa-tions
M_Management_past	Site_ID	int		*	-> E_Site.Site_ID	Index / unique counter for sites
M_Management_past	Year_	smallint				Year
M_Management_past	Crop_Name	varchar				Crop name
M_Management_past	Description	varchar				Description
M_Management_past	Intensity	float				Intensity of management activity
M_Management_past	Unit_ID_intensity	int		*	-> M_Units.Unit_ID	Index / unique counter of the units
M_Management_past	Comments	varchar				Comments
M_Management_past	Management_past_ID	serial	*	*		Index / unique counter of information for manage-ment history
M_Methods	Method_	varchar				Description of method
M_Methods	Method_ID	serial	*	*		Index / unique counter of method
M_Methods	Ref_location	varchar				Link to deposited docu-ments
M_Site_info	Geo_Easting	varchar				Easting
M_Site_info	Geo_Northing	varchar				Northing
M_Site_info	Altitude	float				Altitude above NN
M_Site_info	Slope	float				Slope
M_Site_info	Description_terrain	varchar				Description of terrain
M_Site_info	Climate_type	varchar				Climate type
M_Site_info	Mean_temperature	float				Mean annual tempera-ture
M_Site_info	Precipitation_sum	float				Mean annual precipita-tion sum
M_Site_info	Federal_state	varchar				Federal state
M_Site_info	Owner	varchar				Owner of experiment
M_Site_info	Temperature_period	varchar				Period of recording - annual average tempera-ture
M_Site_info	Precipitation_period	varchar				Period of recording - annual average precipita-tion sum
M_Site_info	Geo_Latitude	float				Latitude

M_Site_info	Geo_Longitude	float				Longitude
M_Site_info	Site_ID	int		*	-> E_Site.Site_ID	Index / unique counter for sites
M_Site_info	Site_Info_ID	serial	*	*		Index / unique counter of information for sites
M_Soilprofile_info	Profile_nr	int				Number of profiles
M_Soilprofile_info	Method	varchar				Method
M_Soilprofile_info	Investigation_date	date				Year of investigation
M_Soilprofile_info	Soil_type_KA5	varchar				Soil type according to KA5 (abbreviation)
M_Soilprofile_info	Soil_type	varchar				Soil type
M_Soilprofile_info	Geo_Easting	varchar				Easting
M_Soilprofile_info	Geo_Northing	varchar				Northing
M_Soilprofile_info	Geo_Longitude	float				Longitude
M_Soilprofile_info	Geo_Latitude	float				Latitude
M_Soilprofile_info	Effective_root_depth	float				Effective rooting depth
M_Soilprofile_info	Effective_root_depth_KA5	float				Effective rooting depth according to KA5
M_Soilprofile_info	Comments	varchar				Comments
M_Soilprofile_info	Geology	varchar				Geological description of subsurface
M_Soilprofile_info	Person_in_charge	varchar				Cartographer / person in charge
M_Soilprofile_info	Site_ID	int		*	-> E_Site.Site_ID	Index / unique counter for sites
M_Soilprofile_info	Soilprofile_Info_ID	serial	*	*		Index / unique counter of information for soil profiles
M_Units	Unit	varchar				Description of unit
M_Units	Unit_ID	serial	*	*		Index / unique counter of units
M_Variables	Variable_	varchar				Measured variable
M_Variables	Variable_ID	serial	*	*		Index / unique counter of measured variables
M_Variable_info	Variable_	varchar				Measured variable
M_Variable_info	Variable_ID	int		*	-> M_Variables.Variable_ID	Index / unique counter of measured variables
M_Variable_info	Table_name	varchar				Table name
M_Variable_info	Plausibility	varchar				Plausibility (number or text, etc., number of decimal places, value range)
M_Variable_info	Data_type	varchar				Data type
M_Variable_info	Source_data	varchar				Source of data
M_Variable_info	Category	varchar				Category
M_Variable_info	Ref_time	varchar				Temporal relation of measured variable
M_Variable_info	Ref_space	varchar				Spatial relation of meas-ured variable
M_Variable_info	Description	varchar				Description
M_Variable_info	Variable_info_ID	serial	*	*		Index / unique counter of information about measured variables

P_Balances	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
P_Balances	Plot_Name_ID	varchar				Unique name for plots
P_Balances	Date_start	date				Start date of measured value
P_Balances	Date_end	date				End date of measured value
P_Balances	Year_	smallint				Year
P_Balances	Period	float				Period of cultivation in days
P_Balances	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
P_Balances	Value_	float				Measured value
P_Balances	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
P_Balances	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
P_Balances	Crop_Name	varchar				Name of crop
P_Balances	Stat_Balances_ID	int		*	-> S_Statistics_Balances. Stat_Balances_ID	Index / unique counter of statistical parameters
P_Balances	EVA_Code	varchar				Code to identify data of the EVA II project
P_Balances	Comments	varchar				Comments
P_Balances	Balances_ID	serial	*	*		Index / unique counter of balances
P_Emis_CO_2_flux	Plot_ID	varchar		*	-> E_Plot.Plot_ID	Index / unique counter for plots
P_Emis_CO_2_flux	Plot_Name_ID	varchar				Unique name for plots
P_Emis_CO_2_flux	Timestamp_	timestamp				Measurement time of measured value (time stamp)
P_Emis_CO2_flux	Year_	smallint				Year
P_Emis_CO_2_flux	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
P_Emis_CO_2_flux	Value_	float				Measured value
P_Emis_CO_2_flux	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
P_Emis_CO_2_flux	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
P_Emis_CO_2_flux	Crop_Name	varchar				Name of crop
P_Emis_CO2_flux	Chamber_type	float				Chamber type
P_Emis_CO2_flux	Chamber_volume	float				Chamber volume
P_Emis_CO_2_flux	Comments	varchar				Comments
P_Emis_CO2_flux	Campaign_P_ID	serial	*	*		Index / unique counter for CO_2 measuring campaigns
P_Emis_CO2_flux	Meas_ID	serial				Index / unique counter (continuous) for CO_2 measurements
P_Emis_CO_2_flux	Stat_CO_2_ID	int			-> S_Statistics_CO_2.Stat_CO_2_ID	Index / unique counter of statistical parameters
P_Emis_CO_2_flux	EVA_Code	varchar				Code to identify data of the EVA II project
P_Emis_CO_2_flux	CO_2_Flux_ID	serial	*	*		Index / unique counter of CO_2 fluxes
P_Emis_N_2O_CH_4_daily	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots

P_Emis_N_2O_CH_4_daily	Plot_Name_ID	varchar				Unique name for plots
P_Emis_N_2O_CH_4_daily	Date_	date				Date of measured value
P_Emis_N_2O_CH_4_daily	Year_	smallint				Year
P_Emis_N_2O_CH_4_daily	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
P_Emis_N_2O_CH_4_daily	Value_	float				Measured value
P_Emis_N_2O_CH_4_daily	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
P_Emis_N_2O_CH_4_daily	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
P_Emis_N_2O_CH_4_daily	Comments	varchar				Comments
P_Emis_N_2O_CH_4_daily	EVA_Code	varchar				Code to identify data of the EVA II project
P_Emis_N_2O_CH_4_daily	N_2O_ CH_4_D_ID	serial	*	*		Index / unique counter of daily N_2O fluxes
P_Emis_N_2O_CH_4_flux	Plot_ID	Int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
P_Emis_N_2O_CH_4_flux	Plot_Name_ID	varchar				Unique name for plots
P_Emis_N_2O_CH_4_flux	Timestamp_	timestamp				Measurement time of measured value (time stamp)
P_Emis_N_2O_CH_4_flux	Year_	smallint				Year
P_Emis_N_2O_CH_4_flux	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
P_Emis_N_2O_CH_4_flux	Value_	float				Measured value
P_Emis_N_2O_CH_4_flux	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
P_Emis_N_2O_CH_4_flux	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
P_Emis_N_2O_CH_4_flux	Crop_Name	varchar				Name of crop
P_Emis_N_2O_CH_4_flux	Frame_nr	smallint				Number of frame
P_Emis_N_2O_CH_4_flux	Comments	varchar				Comments
P_Emis_N_2O_CH_4_flux	Stat_N2O_CH4_ID	int		*	-> S_Statistics_N2O_CH4_flux. Stat_N2O_CH4_ID	Index / unique counter of statistical parameters
P_Emis_N_2O_CH_4_flux	Stat_N2O_ID	int		*	-> S_Statistics_N2O_flux. Stat_N2O_ID	Index / unique counter of statistical parameters
P_Emis_N_2O_CH_4_flux	EVA_Code	varchar				Code to identify data of the EVA II project
P_Emis_N_2O_CH_4_flux	N2O_CH4_F_ID	serial	*	*		Index / unique counter for N_2O fluxes
P_Emis_NH_3_flux	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
P_Emis_NH_3_flux	Plot_Name_ID	varchar				Unique name for plots
P_Emis_NH_3_flux	Timestamp_	timestamp				Measurement time of measured value (time stamp)
P_Emis_NH_3_flux	Time_after_application	float				Time after application
P_Emis_NH_3_flux	Year_	smallint				Year
P_Emis_NH_3_flux	Fertilisation_date	date				Measurement time of fertilisation
P_Emis_NH_3_flux	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
P_Emis_NH_3_flux	Value_	float				Measured value
P_Emis_NH_3_flux	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
P_Emis_NH_3_flux	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods

P_Emis_NH_3_flux	Method_name	varchar				Name of method
P_Emis_NH_3_flux	Replication	smallint				Number of replications
P_Emis_NH_3_flux	Application_number	smallint				Number of fertilisation application
P_Emis_NH_3_flux	Source_data	varchar				Source of data
P_Emis_NH_3_flux	Comments	varchar				Comments
P_Emis_NH_3_flux	Crop_Name	varchar				Name of crop
P_Emis_NH_3_flux	EVA_Code	varchar				Code to identify data of the EVA II project
P_Emis_NH_3_flux	NH3_ID	serial	*	*		Index / unique counter of NH_3 fluxes
P_Modelled_CO_2	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
P_Modelled_CO_2	Plot_Name_ID	varchar				Unique name for plots
P_Modelled_CO_2	Timestamp_	timestamp				Measurement time of measured value (time stamp)
P_Modelled_CO_2	Year_	smallint				Year
P_Modelled_CO_2	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
P_Modelled_CO_2	Value_	float				Measured value
P_Modelled_CO_2	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
P_Modelled_CO_2	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
P_Modelled_CO_2	Crop_Name	varchar				Name of crop
P_Modelled_CO_2	Conf95	float				95% confidence interval
P_Modelled_CO_2	Status	boolean				Status of NEE, Reco or GPP values
P_Modelled_CO_2	Data_quality	smallint				Data quality
P_Modelled_CO_2	Comments	varchar				Comments
P_Modelled_CO_2	EVA_Code	varchar				Code to identify data of the EVA II project
P_Modelled_CO_2	CO_2_M_ID	serial	*	*		Index / unique counter for modelled CO_2 values
P_Modelled_NO3	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
P_Modelled_NO3	Plot_Name_ID	varchar				Unique name for plots
P_Modelled_NO3	Year_	smallint				Year
P_Modelled_NO3	Date_	date				Date of measured value
P_Modelled_NO3	Variable_ID	int		*	-> M_Variables.Variable_ID	Index / unique counter of measured variables
P_Modelled_NO3	Value_	float				Measured value
P_Modelled_NO3	Unit_ID	int		*	-> M_Units.Unit_ID	Index / unique counter of units
P_Modelled_NO3	Method_ID	int		*	-> M_Methods.Method_ID	Index / unique counter of methods
P_Modelled_NO3	Depth_from	float				Soil depth from
P_Modelled_NO3	Depth_to	float				Soil depth to
P_Modelled_NO3	Modelling_period	varchar				Description of modelling period
P_Modelled_NO3	NO3_M_ID	serial	*	*		Index / unique counter for modelled soil water and NO3 values

P_NO3leaching	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
P_NO3leaching	Plot_Name_ID	varchar				Unique name for plots
P_NO3leaching	Year_	smallint				Year
P_NO3leaching	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
P_NO3leaching	Value_	float				Measured value
P_NO3leaching	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
P_NO3leaching	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
P_NO3leaching	Crop_Name	varchar				Name of crop
P_NO3leaching	Replication	smallint				Number of replications
P_NO3leaching	Depth_to	float				Soil depth to
P_NO3leaching	Comments	varchar				Comments
P_NO3leaching	NO3Leaching_ID	serial	*	*		Index / unique counter for values of NO_3 leaching
P_Parameter_CO_2	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
P_Parameter_CO_2	Plot_Name_ID	varchar				Unique name for plots
P_Parameter_CO_2	Timestamp_start	timestamp				Start of point in time of measured value (time stamp)
P_Parameter_CO_2	Timestamp_end	timestamp				End of point in time of measured value (time stamp)
P_Parameter_CO_2	Year_	smallint				Year
P_Parameter_CO_2	Variable_ID	int		*	-> M_Variables.Variable_ID	Index / unique counter of measured variables
P_Parameter_CO_2	Value_	float				Measured value
P_Parameter_CO_2	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
P_Parameter_CO_2	P_value	float				P-value (significance level)
P_Parameter_CO_2	Bestfit	varchar				
P_Parameter_CO_2	Parameter_type	varchar				Parameter type
P_Parameter_CO_2	Crop_Name	varchar				Name of crop
P_Parameter_CO_2	Comments	varchar				Comments
P_Parameter_CO_2	EVA_Code	varchar				Code to identify data of the EVA II project
P_Parameter_CO_2	Campaign_P_ID	int				Index / unique counter for measuring campaign
P_Parameter_CO_2	Parameter_CO2_ID	serial	*	*		Index / unique counter for CO_2 parameter values
R_Cl_Tracer	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
R_Cl_Tracer	Plot_Name_ID	varchar				Unique mane for plots
R_Cl_Tracer	Date_	date				Date of measured value
R_Cl_Tracer	Year_	smallint				Year
R_Cl_Tracer	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
R_Cl_Tracer	Value_	float				Measured value
R_Cl_Tracer	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
R_Cl_Tracer	Depth_from	float				Soil depth from

R_Cl_Tracer	Depth_to	float				Soil depth to
R_Cl_Tracer	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
R_Cl_Tracer	Crop_Name	varchar				Name of crop
R_Cl_Tracer	Laboratory_nr	smallint				Laboratory number
R_Cl_Tracer	Comments	varchar				Comments
R_Cl_Tracer	Cl_Tracer_ID	serial	*	*		Index / unique counter for measured values of tracer experiment
R_CL_Tracer_factor	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
R_CL_Tracer_factor	Plot_Name_ID	varchar				Unique name for plots
R_Cl_Tracer_factor	Year_	smallint				Year
R_CL_Tracer_factor	Variable_ID	int		*	-> M_Variables.Variable_ID	Index / unique counter of measured variables
R_CL_Tracer_factor	Value_	float				Measured value
R_CL_Tracer_factor	Unit_ID	int		*	-> M_Units.Unit_ID	Index / unique counter of units
R_CL_Tracer_factor	Method_ID	int		*	-> M_Methods.Method_ID	Index / unique counter of methods
R_Cl_Tracer_factor	Crop_Name	varchar				Name of crop
R_CL_Tracer_factor	Cl_Factor_ID		*	*		Index / unique counter for factors of tracer experiment
R_Digestate	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
R_Digestate	Plot_Name_ID	varchar				Unique name for plots
R_Digestate	Year_	smallint				Year
R_Digestate	Fertilisation_date	date				Measurement time of fertilization
R_Digestate	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
R_Digestate	Value_	float				Measured value
R_Digestate	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
R_Digestate	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
R_Digestate	Crop_Name	varchar				Name of crop
R_Digestate	Below_LOQ	boolean				Switching variable, whether a measured value is below the limit of quantification (LOQ)
R_Digestate	Replication	smallint				Number of replications
R_Digestate	Comments	varchar				Comments
R_Digestate	EVA_Code	varchar				Code to identify data of the EVA II project
R_Digestate	Digestate_ID	serial	*	*		Index / unique counter for digestate values
R_Emis_CO_2_conc	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
R_Emis_CO_2_conc	Plot_Name_ID	varchar				Unique name for plots
R_Emis_CO_2_conc	Timestamp_	timestamp				Measurement time of measured value (time stamp)
R_Emis_CO_2_conc	Year_	smallint				Year

R_Emis_CO_2_conc	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
R_Emis_CO_2_conc	Value_	float				Measured value
R_Emis_CO_2_conc	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
R_Emis_CO_2_conc	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
R_Emis_CO_2_conc	Frame_Nr	smallint				Frame number
R_Emis_CO_2_conc	Chamber_volume	float				Chamber volume
R_Emis_CO_2_conc	Chamber_area	float				Chamber area
R_Emis_CO_2_conc	Chamber_type	float				Type of chamber
R_Emis_CO_2_conc	Comments	varchar				Comments
R_Emis_CO_2_conc	Record_	serial				Index within one meas-urement for each time step
R_Emis_CO_2_conc	Campaign_P_ID	serial	*	*		Index / unique counter for CO_2 measuring campaign
R_Emis_CO_2_conc	Model_ref	smallint				Reference to modelling
R_Emis_CO_2_conc	Meas_ID	serial				Index / unique counter (continuous) for CO_2 measurements
R_Emis_CO_2_conc	Air pressure	float				Air pressure
R_Emis_CO_2_conc	Comments	varchar				Comments
R_Emis_CO_2_conc	CO_2_ID	serial	*	*		Index / unique counter for CO_2 concentration
R_Emis_N_2O_CH_4_CO_2_conc	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
R_Emis_N_2O_CH_4_CO_2_conc	Plot_Name_ID	varchar				Unique name for plots
R_Emis_N_2O_CH_4_CO_2_conc	Timestamp_	time				Point in time of measured value (time stamp)
R_Emis_N_2O_CH_4_CO_2_conc	Timestep	float				Time step
R_Emis_N_2O_CH_4_CO_2_conc	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
R_Emis_N_2O_CH_4_CO_2_conc	Value_	float				Measured value
R_Emis_N_2O_CH_4_CO_2_conc	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
R_Emis_N_2O_CH_4_CO_2_conc	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
R_Emis_N_2O_CH_4_CO_2_conc	Chamber_volume	float				Chamber volume
R_Emis_N_2O_CH_4_CO_2_conc	Chamber_area	float				Chamber area
R_Emis_N_2O_CH_4_CO_2_conc	Frame_Nr	smallint				Frame number
R_Emis_N_2O_CH_4_CO_2_conc	Crop_Name	varchar				Name of crop
R_Emis_N_2O_CH_4_CO_2_conc	Comments	varchar				Comments
R_Emis_N_2O_CH_4_CO_2_conc	GC_Code	int				Error code for the GC
R_Emis_N_2O_CH_4_CO_2_conc	GC_Code	int				Site-specific unique index of GC measurements
R_Emis_N_2O_CH_4_CO_2_conc	N_2O_CH_4_R_ID	serial	*	*		Index / unique counter for N_2O concentrations
R_Incubation	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots

R_Incubation	Plot_Name_ID	varchar				Unique name for plots
R_Incubation	Date_	date				Date of measured value
R_Incubation	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
R_Incubation	Value_	float				Measured value
R_Incubation	Replication	smallint				Number of replications
R_Incubation	Application_type	varchar				Type of application
R_Incubation	Fert_liquid	float				Amount of liquid fertilizer
R_Incubation	Fert_nitrogen	float				Amount of N-fertilizer
R_Incubation	Fert_plant_available	float				Amount of plant available fertilizer
R_Incubation	Depth_from	float				Soil depth from
R_Incubation	Depth_to	float				Soil depth to
R_Incubation	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
R_Incubation	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
R_Incubation	Comments	varchar				Comments
R_Incubation	EVA_Code	varchar				Code to identify data of the EVA II project
R_Incubation	Incubation_ID	serial	*	*		Index / unique counter for measured values of incubation experiment
R_Plant	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
R_Plant	Plot_Name_ID	varchar				Unique name for plots
R_Plant	Date_	date				Date of the measured value
R_Plant	Year_	smallint				Year
R_Plant	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
R_Plant	Value_	float				Measured value
R_Plant	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
R_Plant	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
R_Plant	Replication	smallint				Number of replications
R_Plant	Inherited	boolean				Switching variable, whether a measured value have been taken over by another plot
R_Plant	Aggregated	boolean				Switching variable, whether a measured value was aggregated from multiple measure-ments
R_Plant	Harvest_type	varchar				Type of harvest (parcel or frame)
R_Plant	Frame_nr	smallint				Frame number
R_Plant	Crop_Name	varchar				Name of crop
R_Plant	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
R_Plant	Comments	varchar				Comments
R_Plant	EVA_Code	varchar				Code to identify data of the EVA II project
R_Plant	Plant_ID	serial	*	*		Index / unique counter for plant relevant meas-

						ured values
R_Soil_continuous	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
R_Soil_continuous	Plot_Name_ID	varchar				Unique name for plots
R_Soil_continuous	Timestamp_	timestamp				Measurement time of measured value (time stamp)
R_Soil_continuous	Year_	smallint				Year
R_Soil_continuous	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
R_Soil_continuous	Value_	float				Measured value
R_Soil_continuous	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
R_Soil_continuous	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
R_Soil_continuous	Soil_depth	float				Soil depth
R_Soil_continuous	Crop_Name	varchar				Name of crop
R_Soil_continuous	Comments	varchar				Comments
R_Soil_continuous	Soil_C_ID	serial	*	*		Index / unique counter for continuously recorded soil data
R_Soil_periodic	Plot_ID	int		*	-> E_Plot.Plot_ID	Index / unique counter for plots
R_Soil_periodic	Plot_Name_ID	varchar				Unique name for plots
R_Soil_periodic	Date_	date				Date of measured value
R_Soil_periodic	Year_	smallint				Year
R_Soil_periodic	Variable_ID	int			-> M_Variables.Variable_ID	Index / unique counter of measured variables
R_Soil_periodic	Value_	float				Measured value
R_Soil_periodic	Unit_ID	int			-> M_Units.Unit_ID	Index / unique counter of units
R_Soil_periodic	Method_ID	int			-> M_Methods.Method_ID	Index / unique counter of methods
R_Soil_periodic	Depth_from	float				Soil depth from
R_Soil_periodic	Depth_to	float				Soil depth to
R_Soil_periodic	Replication	smallint				Number of replications
R_Soil_periodic	Inherited	boolean				Switching variable, whether a measured value has been taken over by another plot
R_Soil_periodic	Aggregated	boolean				Switching variable, whether a measured value was aggregated from multiple measure-ments
R_Soil_periodic	Ref_fertilisation	varchar				Reference to fertilisation
R_Soil_periodic	Below_LOQ	boolean				Switching variable, whether a measured data is below the limit of quantification (LOQ)
R_Soil_periodic	Crop_Name	varchar				Name of crop
R_Soil_periodic	Comments	varchar				Comments
R_Soil_periodic	EVA_Code	varchar				Code to identify data of the EVA II project
R_Soil_periodic	Soil_P_ID	serial	*	*		Index / unique counter for periodically recorded

						soil data
S_Statistics_Balances	Crop_Name_agg	varchar				Aggregated name of crop
S_Statistics_Balances	Std_Standzeit	float				Standard balance period
S_Statistics_Balances	CUE_excl	float				Check of plausibility
S_Statistics_Balances	Tech_Excl	float				Technical check
S_Statistics_Balances	BM_comp	float				Comparison value for plot and frame biomass
S_Statistics_Balances	BM_factor	float				Biomass correction factor
S_Statistics_Balances	Plotsize_qm	float				Plot size in square meter
S_Statistics_Balances	Stat_Balances_ID	serial	*	*		Index / unique counter for statistical parameters
S_Statistics_CO_2_flux	Timestep	float				Time step
S_Statistics_CO_2_flux	Meas_N	smallint				Number of used data points
S_Statistics_CO_2_flux	Slope	float				Slope of linear regression analysis
S_Statistics_CO_2_flux	Slope_pvalue	float				p-value (significance level)
S_Statistics_CO_2_flux	R_2	float				Regression coefficient
S_Statistics_CO_2_flux	Stat_CO_2_ID	serial	*	*		Index / unique counter for statistical parameters
S_Statistics_N_2O_CH_4_flux	Year_	smallint				Year
S_Statistics_N_2O_CH_4_flux	Date_	date				Date of measured value
S_Statistics_N_2O_CH_4_flux	Significance	float				Significance level
S_Statistics_N_2O_CH_4_flux	R^2	float				Coefficient of determina-tion
S_Statistics_N_2O_CH_4_flux	NRMSE	float				Normalized root-mean-square-error
S_Statistics_N_2O_CH_4_flux	R^2_hf	boolean				Hardflag R^2
S_Statistics_N_2O_CH_4_flux	Range_hf	boolean				Hardflag RANGE
S_Statistics_N_2O_CH_4_flux	NRMSE_hf	boolean				Hardflag NRMSE
S_Statistics_N_2O_CH_4_flux	Nomba_f	smallint				Number of measuring points
S_Statistics_N_2O_CH_4_flux	rl	smallint				GC error
S_Statistics_N_2O_CH_4_flux	Stat_N_2O_CH_4_ID	serial	*	*		Index / unique counter for statistical parameters
S_Statistics_N_2O_CH_4_flux	N2O_CH4_F_ID	serial				Index / unique counter for N_2O fluxes
S_Statistics_N2O_flux	Standard_error	float				Standard error
S_Statistics_N2O_flux	Method_flux	varchar				Used method for flux calculation
S_Statistics_N2O_flux	pass_q_check	boolean				Check
S_Statistics_N2O_flux	Stat_N2O_ID	serial	*	*		Index / unique counter for statistical parameters