



Long-term Field Experiments in Germany: Classification and spatial Representation

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Abstract. The collective analysis of long-term field experiments (LTFE) can be used for detecting changes in soil properties and yield such as induced by climate change. However, information about existing LTFEs is scattered, and the research data are not easily accessible. In this study, meta-information on LTFEs in Germany is compiled and their spatial representation is analysed. The study is conducted within the framework of the BonaRes project, which, *inter alia*, has established a central 10 access point for LTFE information and research data. A total of 205 LTFEs is identified with a minimum duration of twenty years and research in the context of soil and yield. Of these, 140 LTFEs are ongoing. LTFEs are categorized into fertilization, tillage, and crop rotation experiments. The spatial representation is analysed according to the climatic water balance (CWB) and the Müncheberger Soil Quality Rating (MSQR). The results show that, in general, the LTFEs well represent the area shares of both the CWB and the MSQR classes. 89% of the arable land and 65% of the grassland in Germany is covered by the three 15 driest CWB classes, hosting 89% and 71% of the arable and grassland LTFE, respectively. LTFE cover all six MSQR classes, however with a bias towards the high and very high soil quality classes. The results confirm the very high potential of LTFE data for spatially differentiated analyses and modelling. However, reuse is restricted by the difficult access to LTFE research data. The common database is an important step in overcoming this restriction.

1 Introduction

20 Agricultural long-term field experiments (LTFEs) are a valuable research infrastructure for terrestrial research in general and agricultural research in particular. Changes in soil properties tend to occur slowly; thus, for the identification of long-term trends, experiments with a long duration are needed. However, a single LTFE allows the drawing of conclusions only for its specific site. The collective analysis of research data from different LTFEs at different locations leads to more generalizable results. On the one hand, similar experiments on similar sites will lead to better validated conclusions when analysed in 25 combination. On the other hand, LTFEs in different experimental conditions may lead to broader implementable results by their collective analysis. Furthermore, LTFEs are expensive; a comprehensive and coordinated evaluation is also required to prove that they are worth the expense (Körschens, 2006; Berti et al., 2016). Historically, LTFEs were mainly established to answer questions regarding plant nutrition (Merbach and Deubel, 2008). Later, they were used to reveal the effects of agricultural management practices (e.g., fertilization, tillage, crop rotation) on crop yield and soil characteristics. LTFEs have



30 been very helpful for research on soil organic carbon content or composition (Ellerbrock and Gerke, 2016; Kaiser et al., 2014; Körschens et al., 2014). LTFEs are further important for research related to questions regarding the inter annual variability of crop yield (i.e., yield stability) that can be associated with climate change (Berti et al., 2016; Reckling et al., 2018; Macholdt et al., 2019) and respective adaptation options (Hamidov et al., 2018). Valuable data can also be delivered for the validation of models (Franko et al., 2011; Ellerbrock et al., 2005) and for concepts used to evaluate soil functions (Vogel et al., 2019; 35 Techen et al., 2020).

The common analysis of LTFEs can go beyond the original research question of each LTFE, e.g., to answer questions about climate change, ecosystem services, nutrient cycles, or yield stability. This research could be done through the common assessment of the so-called ‘control’ treatment of each LTFE, irrespective of its original research theme. The control treatment is here defined as a treatment with customary tillage and fertilization and is present in most LTFEs. A meta-analysis of control 40 treatments would allow us to reveal changes in soil properties independently of the original questions for which the experiments were set up, e.g., overall trends in carbon content development. In addition, meta-analyses of similar experiments are reasonable, e.g., of fertilizer experiments with similar factors (e.g., with/without organic manure) or tillage experiments (e.g., conventional tillage vs. reduced tillage). The analysis of similar experiments has the opportunity to make use of the original 45 research question of the LTFE. The effects and sustainability of measures can be revealed in a broader context and in different landscapes. This can be done with pairwise comparisons of alternative and reference management practices, such as that by Bai (2018) and Sandén et al. (2018). However, because of the site specificity of soil-plant interactions and their responses to agricultural management practices, the upscaling and generalization of results requires information about the spatial representation of LTFE sites.

Important compilations of German LTFEs have been performed by Körschens (1994, 1997) and Debreczeni and Körschens 50 (2003). In Körschens (1994), 97 German LTFEs with a duration of more than 20 years were listed. The starting year, the kind of factors, the cultivated crops, the size of the plots and experiments, the soil texture, the average annual air temperature and the average annual precipitation of the site are presented if available. In Körschens (1997), 50 German LTFEs with a duration of more than 30 years are listed, and similar information is presented. In Debreczeni and Körschens (2003), 94 German LTFEs with a duration of more than 20 years are listed, and information about the start, experimental aspects, cropping system and 55 soil is provided. Körschens (1994, 1997) indicates the following constraints for the compilation of a complete overview of all LTFEs in Germany: the multitude of experiments, discontinued experiments, new experiments, or experiments not at all documented in the literature. In Debreczeni and Körschens (2003), restricted resources for data collection are also mentioned. In addition, the heterogeneous setup and the scattered distribution of LTFEs make comparisons of data difficult or impossible (Bai, 2018). No information is yet available regarding the spatial representation of LTFEs in Germany with regard to important 60 agronomic factors such as climate and soil fertility.

The aim of this paper was twofold: first, to analyse and classify the experimental design of the LTFEs in Germany with regard to land use, research themes and farming systems. Second, the aim was to conduct an analysis of the geospatial distribution of the experimental sites with regard to key factors of agricultural production: climate and soil fertility. The database consisted



of a dataset with meta-information on 205 LTFEs in Germany. The dataset has been compiled in the frame of the project
65 ‘BonaRes’, funded by the German Federal Ministry for Education and Research (BMBF) and is uploaded for free utilization
in the BonaRes data repository (Grosse and Hierold, 2019). It contains information about name of the LTFE, exact location,
holding institution, land use categorie, participation in existing networks, research theme, start (and maybe end) of the trial,
and research parameters. Besides the focus of this project on the acquisition of metadata there is a focus on research data from
70 LTFEs. The aims are to make LTFEs more visible, to enhance networking among LTFEs and to simplify common analyses of
LTFEs. In compiling the dataset, special attention was focused on LTFEs with a minimum duration of 20 years. This age can
be seen as a threshold for the identification of long-term trends. Attention was given to LTFEs in the context of soil research,
i.e., the objects of research should at least include soil properties and yield as an important soil function. The setup of each
75 trial should allow for statistical analyses, i.e., have factors, treatments, replications and as much as possible a static design.
The geospatial analysis was performed by comparing the regional distribution of LTFEs to that of climatic water balance
classes (CWB) and the Müncheberger Soil Quality Rating (MSQR) as two complex site classifications. The representativeness
of LTFEs according to these site sizes was assessed. LTFEs are classified according to their land use and their research themes
to simplify the identification of similar experiments. The identification of suitable LTFEs in similar (or different) landscapes
shall be enhanced. Therefore, a table with the IDs of all experiments, their thematic classification, their CWB class and their
80 MSQR class is provided in the attachment. More details for each LTFE can be identified in the published dataset (Grosse and
Hierold, 2019) through the ID of the LTFE. Thus, cooperation with LTFE holders can be initiated more easily.

2 Material and Methods

A combination of three methods was applied: a literature review to identify LTFEs in Germany, a fact sheet-based addition of
information to the identified LTFEs, and a geospatial analysis employing the CWB and the MSQR (Figure 1).

An extensive literature review was conducted to identify LTFEs. The search items were ‘long-term field experiment’, ‘long-
85 term experiment’, ‘long-term field trial’, and ‘long-term trial’, as well as the German items ‘Dauerfeldversuch’,
‘Dauerdüngungsversuch’, ‘Dauerversuch’, ‘Langzeitfeldversuch’ and ‘Langzeitversuch’. Sources were scientific papers as
well as other articles, books, trial guides and websites. The focus was on the exact position of the LTFE and the following
90 metadata: name of the LTFE, website (if available), institution, land use category, participation in existing networks, research
parameters, and trial setup including factors, treatments and randomization. For the coordination and simplification of the trial
description, the BonaRes Fact Sheet was established, which asks for all relevant trial information (Grosse et al., 2019). It was
sent to the trial holders, and the fact sheet was completed for 40 trials. Trial holders also delivered important information as
personal communication.

The LTFEs were classified according to their research themes to simplify the identification of similar experiments. The
95 following research themes were selected: fertilization, tillage, crop rotation or other research themes. LTFEs were considered



to belong to one group if one factor was fertilization, tillage, crop rotation, or another theme. Two or more factorial experiments were sorted in all relevant classes, i.e., multiple nominations were possible. LTFEs on arable land are existent in all three classes, and LTFEs on grassland exist only as fertilization trials.

94 LTFE are precisely known in their position, and an additional 87 LTFEs are located on the approximate trial area. In the 100 latter case, either the exact position is not known or the former LTFEs are now overbuilt with streets, parking spaces or buildings.

For the geospatial analysis, 191 LTFEs were grouped into the three classes of fertilization experiments, tillage experiments and crop rotation experiments and were characterised according to the following site information: (a) CWB and (b) MSQR. 14 LTFE were excluded from the analysis because they were dealing with research themes other than fertilization, tillage or 105 crop rotation or did not include field crops or grassland experiments.

The CWB was chosen as a suitable parameter to represent the climatic conditions for agricultural land use and because of its huge relevance for vegetation growth. Its impact may be even larger than that of temperature (Crimmins et al., 2011), and it may determine the growing season (Sattar et al., 2019). We used data from the German Meteorological Service (DWD) for the period 1981-2010 for the main growing season, defined from 1 May to 31 October (Ad-hoc-AG Boden, 2005). The data 110 are available for the whole territory of Germany with a pixel resolution of 1 km. The CWB is defined in Formula (1) as the difference in precipitation (P) and potential evapotranspiration (PET). It is a quantitative measure of the water supply in a given time period and for a specific region. The PET depends on location factors such as crop cover, topographical effects, soil conditions and soil water storage. It can therefore only be determined selectively. However, for a better comparison for spatial calculations, the so-called grass reference evapotranspiration is considered, which indicates the evapotranspiration of a 115 standardized grass cover in standardized soil with optimal water supply (Pereira et al., 2015).

$$\text{CWB} = P - \text{PET} \quad (1)$$

The classification of the climatic water balance in seven classes follows the Survey Guideline KA5 (Ad-hoc-AG Boden, 2005) (≤ 150 ; -150 to < -50 ; -50 to < 50 ; 50 to < 150 ; 150 to < 300 ; 300 to < 500 ; ≥ 500 mm), which are classified there from extremely low to extremely high (Ad-hoc-AG Boden, 2005).

120 To derive data for agricultural areas, either arable land or grassland intersections with the CORINE Land Cover (Corine, 2018) dataset were made.

For (b), a soil quality map (BGR, 2014) is used, which applies the Müncheberger Soil Quality Rating (MSQR). It has a pixel resolution of 250 m. The BGR had applied this complex assessment procedure (Mueller et al., 2010; Ad-hoc-AG Boden, 2010), which was developed as a visual procedure for estimating yield potential in the field, by modelling data from the soil overview 125 map (BGR, 2007), but only for arable land. It takes soil structure and soil degradation threats into account and integrates eight basic soil indicators with 13 hazard indicators into a rating of soil quality. The rating is shown on an ordinal scale of 0 to 102, with higher values indicating higher yield potential (Daedlow, 2018). The eight soil indicators are substrate, A-horizon depth, topsoil structure, subsoil structure, rooting depth, profile available water, wetness and ponding, slope, and relief. The 13 hazard indicators are contamination, salinization, sodification, acidification, low total nutrient status, shallow soil depth above hard



130 rock, drought, flooding and extreme waterlogging, steep slope, rock and surface, high percentage of coarse texture fragments, unsuitable soil thermal regime, and miscellaneous hazards (e.g., exposure to wind and water erosion). Most of the indicators are sensitive to agricultural management, which makes the MSQR most useful for studying the effects of agricultural management on soil. The MSQR has been proven useful in other studies of geo-spatial representation (Askari et al., 2013; Hanauer et al., 2017; Smolentseva et al., 2014). Since no MSQR is available for grassland areas, the LTFEs on grassland were
135 excluded in this analysis.

Out of the 157 fertilization, tillage or crop rotation LTFEs on arable land, 26 could not be assigned to a class of MSQR because the fields are surrounded by buildings and are therefore not part of arable land. If an LTFE did not obtain an assignment at a GIS intersection, the value was determined by manual plausibility examination of the nearest 5 to 7 grid cells. One LTFE could not be assigned to a class of MSQR because it compares three different soils in boxes.

140 Calculations always refer to utilized agricultural areas or parts thereof, arable land or grassland.

The information was analysed with Microsoft Excel. The geospatial analysis was performed using the ESRI software ArcMap 10.6.1 (ESRI, 2018).

The research on LTFEs is not completed but is ongoing. The information about LTFEs is continuously updated and expanded. New LTFEs are integrated, and the information about each LTFE is extended. The state of research is November 2019.

145 3 Results and Discussion

3.1 Overview of LTFEs in Germany

In total, 205 LTFEs across Germany with a minimum duration of 20 years were identified, of which 140 trials are ongoing and 65 are terminated (status: November 2019). Further LTFEs reaching the 20-year threshold within the next five years (until 150 2024) were also included (n=6; Figure 2a). Most of the trials have a duration between 20 and 49 years (n=124; Figure 2a). 50 trials have a duration between 50 and 99 years. Three trials run for more than 100 years ('Ewiger Roggen', Halle, 1878 - today; 'Statischer Düngungsversuch V120', Bad Lauchstaedt, 1902 – today; 'Dauerdüngungsversuch Dikopshof', Wesseling, 1904 - 2009). The age of 22 terminated trials is unknown since only the starting date of the trials is known but not the exact ending year. As these trials were mentioned in different important sources as being ongoing (Amberger and Gutser, 1976; Debreczeni and Körschens, 2003; Körschens, 1990, 1994, 1997, 2000), it is known that their duration was at least 20 years.

155 The land use in 168 LTFEs is arable field crops, in 34 trials grassland, in two trials vegetables and in one trial pomiculture (Figure 2b). There are more long-term grassland experiments in Germany; we have not included them in our research because they are dedicated to research themes other than questions of sustainable soil use and bioeconomy.

The majority of LTFEs were established after 1947, when research was resumed after the Second World War (Figure 3).

160 The research themes of the LTFEs can be assigned to the following categories: fertilization, tillage, crop rotation, 'other' themes and combinations of these (Table 1). Due to two or more factorial trials, multiple nominations of experiments for the different research themes were made (n=251). Most LTFEs are established for research on fertilization (Figure 3 and Table 1)



(n=158). This result is coincident with the results from a study in the international context (Berti et al., 2016). In Germany, the entity of fertilization LTFEs can be subdivided into field crop experiments (n=124) and grassland experiments (n=34). Historically, questions regarding the effects of fertilization on plant growth were the focus of research, while in more recent 165 times, the effects on the soil and the environment are investigated. In the focus of the experiments are either different kinds of fertilizers or different amounts of fertilizers or comparisons with/without a specific fertilizer or combinations of these. Most frequently, organic fertilization versus mineral N fertilization is examined. In fewer experiments, the effect of straw fertilization is the subject of research. Additionally, the effects of mineral K fertilization, mineral P fertilization, liming, green manure, mineral Mg fertilization, compost, or sludge are examined (Table 1). More rarely, different points in time of the 170 fertilizing measure are compared.

In 1996/1997, a series of grassland fertilization experiments was established by several German state authorities. This explains the high number of LTFEs established in these years (Figure 3).

38 LTFE address tillage variations (Table 1). Most of these tillage experiments compare different tillage intensities. Most often, reduced tillage depth or conservation tillage are the subjects of research. Also, inversion versus non-inversion tillage is 175 compared. Further research themes are sowing methods, different forms of primary tillage, the effects of stubble tillage, and tillage frequency (Table 1). The oldest tillage experiment started in 1923 (Statischer Dauerversuch Bodennutzung, Berlin-Dahlem), but 25 tillage experiments started in 1990 or later (Figure 3). Therefore, most of the tillage experiments are ‘younger’ experiments, a result also congruent with the findings of (Berti et al., 2016).

Thirty-two LTFEs have the research theme ‘crop rotation’. Mostly, the effect of crop rotation on soil properties and yield is 180 investigated. Therefore, rotational cropping versus monoculture is compared. Additionally, plant health is the focus, e.g., compatibility of different cereal species or different percentages of cereals in crop rotation (Table 1). Most of the crop rotation experiments were established after 1950. 19 experiments of the 32 crop rotation experiments are still ongoing. The oldest crop rotation experiment, the ‘Eternal Rye’, was established in 1878 by the Martin Luther University of Halle.

23 trials address research themes other than fertilization, tillage or crop rotation. The ‘other’ research themes are highly diverse. 185 ‘Environmentally friendly plant protection’, mainly reduced pesticide intensity, is the most frequent research theme among the ‘other’ research themes (n=5). ‘Irrigation’ is the second most frequent (n=4). ‘Effects of different forms of fallow’ is within the focus of three LTFEs. ‘Frequency and start of utilization of grassland’, ‘Land use systems comparison’, ‘Monitoring of Organic Farming’ and ‘Use of biodynamic preparations’ are each within the focus of two LTFEs. Three other research themes are present in only one LTFE (Table 1):

190 A total of 184 trials are set up with conventional agriculture, 14 with organic agriculture and five with so-called integrated agriculture. Two trials compare conventional agriculture with organic agriculture (Figure 4a).

The holding institution for 96 trials is a university or technical college, and for 61 trials, it is a state authority. 27 trials are in the responsibility of non-university scientific institutions such as research institutes. 21 trials are or were held by industry (Figure 4b).



195 All information is published in an online overview map (<https://ltfe-map.bonares.de>). It is available in German and English. The map content can be displayed according to different categories, e.g., the research themes of the LTFEs. In addition, the overview information details about every single LTFE are provided in a pop-up window. Therefore, it offers valuable information for potential users for orientation and initiation of cooperation.

3.2 Geospatial Analyses

200 In the following analyses, the number of LTFEs is compared to the proportion of classes of CWB and MSQR, separately, according to their research topics (fertilization, tillage, crop rotation). Fertilization experiments are subdivided into field crops (including two vegetable experiments) or grassland experiments. In tillage and crop rotation experiments, no grassland experiments exist. While the CWB is available for the whole territory and can be evaluated separately for arable land and grassland, the MSQR soil quality is available only for arable land.
205 The total numbers of experiments in these analyses are 158 fertilization experiments (124 field crops and 34 grassland experiments), 38 tillage experiments and 32 crop rotation experiments (multiple nominations possible).

3.2.1 Geospatial Analysis of LTFEs in Relation to the Climatic Water Balance (CWB) Distribution

For the analysis, the CWB of the vegetation period (1 May to 31 October) was used according to Survey Guideline KA5 (Ad-hoc-AG Boden, 2005). An overview of the distribution of these CWB classes and of LTFEs in Germany is given in Figure 5.

210 For the analyses, approximately 17.9 million hectares of agricultural land are subdivided according to their land use as arable land (approximately 13.5 million hectares) or grassland (approximately 4.4 million hectares) (Umweltbundesamt, 2019). According to Table 2 and Figure 5, arable land is distributed among classes 1-7 of the CWB (Table 2; Figure 5): the largest shares of 33% each are classified as CWB classes 2 (from -150 mm to <-50 mm) or 3 (from -50 mm to <50 mm), respectively. The area of CWB class 2 is mainly located in the lowlands of Germany: in the western and northern Rhine-Main Valley, in a 215 majority of the north-eastern lowland and the Loess Boerde. The area of CWB class 3 is mainly distributed in the north-eastern part of Germany and in parts of the Southern German Escarpment Landscape, the northern foothills of the Alps (lower Bavarian upland) and the lower uplands, as there are the Lower Saxon and Hessian lowlands, Vogtland district and Erzgebirge foreland. 23% of the arable land is allotted to CWB class 1 (<-150 mm). This extremely low CWB is located almost exclusively in eastern Germany, especially in the rain shadow of the Harz: the Fläming, the plates and lowlands of mid Brandenburg and the 220 heathland of Brandenburg. Minor shares of 7% and 4% are allotted to CWB classes 4 (from 50 mm to <150 mm) and 5 (from 150 mm to <300 mm), respectively. CWB class 4 is located mainly in the foothill of the Alps and around the secondary mountains and in the western Schleswig-Holstein (moraines of Schleswig-Holstein). CWB 5 is mainly located in Germany's southern foothill of the Alps. CWB class 6 (from 300 mm to <500 mm) is not present in Germany's arable land, and CWB class 7 (>500 mm) is not present in Germany's agricultural land (arable and grassland).



225 Among the grassland, the largest share of 33% is classified as CWB class 3 (Table 3). 23% of grassland are classified as CWB class 5. 18% are classified as CWB class 2, 14% as CWB class 1 and 9% as CWB class 4. CWB class 6 is present in a small share (3%) of Germany's grassland at higher altitudes in the Alpine region.

To analyse sites in every CWB class, each class would have to be represented through LTFEs. Ideally, the shares of LTFEs in each class would correspond to the agricultural area. This is, of course, not the case (Table 2), as LTFEs were not established 230 systematically in the landscape. Each CWB class present in the arable land is represented by LTFEs, but they are not found in the same shares. CWB class 1 is overrepresented by all LTFE types, CWB class 2 is underrepresented by crop rotation LTFEs, class 3 is underrepresented by fertilization LTFEs and crop rotation LTFEs, class 4 is underrepresented by tillage LTFEs and overrepresented by crop rotation LTFEs (although in number, there are only 4 crop rotation LTFEs), and class 5 again is overrepresented by crop rotation LTFEs (although in number, there are only 6 crop rotation LTFEs) (Table 2; Figure 5) Overall, 235 the three CWB classes 1-3 representing 89% of the arable land area also host 89% of the LTFEs with a certain bias towards the driest CWB class 1. Given that no spatial planning was considered during the allocation of LTFEs, this is a remarkably good distribution.

Among grassland LTFEs, not every CWB class is represented by LTFEs (Table 3). Thus, CWB class 6 is present in a small share of grassland (3%) but is not represented by any grassland LTFEs. CWB classes 2 and 5 are underrepresented by grassland 240 LTFEs, while CWB classes 3 and 4 are overrepresented by grassland LTFEs. Overall and compared to the arable land area, the three driest CWB classes 1-3 represent only 65% of the grassland area and host 71% of the grassland LTFEs.

3.2.2 Geospatial Analysis of LTFEs in Relation to the Müncheberger Soil Quality Rating (MSQR) Distribution

An overview of the distribution of the MSQR classes and of LTFEs in Germany is given in Figure 6. Soils classified as 'very high' are located mainly in the central part of Germany. Soils classified as 'high' exist in the central part and in the south of 245 Germany as well as in some smaller areas in the north-western region of Germany, including the coastal lines. Soils classified as 'low' and 'medium' are predominant in the northern part of Germany but also exist in some areas in the middle and south of Germany. Soils classified as 'very low' mainly exist in north-eastern Germany. Soils classified as 'extremely low' exist mainly in small areas of mid-east and mid-west and north-west Germany (Figure 6).

The classification of the agricultural area into the six MSQR classes (Table 4) is as follows: The largest share (28%) of 250 agricultural area is classified as 'medium'. The smallest shares are classified as 'extremely low' (6%) and 'very high' (10%). Medium shares are classified as 'very low' (17%), 'low' (21%) and 'high' (18%). LTFE sites exist in all MSQR classes, and overall, the distribution of the LTFE sites follows a similar pattern as that of the MSQR classes, with the exception of a bias towards the 'high' MSQR class.

3.2.3 Geospatial Analysis of LTFEs in Relation to the combined CWB and MSQR Distribution

255 The share of the arable area in Germany and the share of LTFEs on arable land in every CWB-MSQR intersection are compared (Figure 7). According to this analysis, in the MSQR class 'extremely low', the share of LTFEs matches the share of arable



land area in each CWB class. In the other MSQR classes, CWB 1 is overrepresented by LTFEs compared to the respective land area. Thus, regarding climate, the distribution of LTFEs is biased towards dry areas with very low CWB class 1. The reason for this bias is probably because most of these LTFEs are located in the region surrounding Berlin and the region Bad 260 Lauchstädt/Halle/Seehausen, which are both historical agricultural research areas.

In CWB class 2, the distribution of LTFEs is biased towards high and very high MSQR classes. This result is mainly caused by the sites Bonn, Braunschweig, Gießen and Göttingen.

CWB class 3 is underrepresented by LTFEs in the MSQR classes of very low, low, medium and high.

CWB classes 4 and 5 are rather adequately represented by LTFEs in every MSQR class. However, these CWB classes rarely 265 exist in Germany.

Franko et al. (2011) identified in their analysis of 40 LTFEs for the validation of a C-Model that more experimental results on clay soils would be required. However, for the landscape approach proposed in this paper, more LTFEs in areas with CWB class 3 on soils classified as MSQR ‘very low’, ‘low’, ‘medium’ and ‘high’ and in areas with CWB class 2 on soils classified as MSQR ‘very low’, ‘low’ and ‘medium’ would be required.

270 4 Conclusions

To obtain adequate information about each CWB and MSQR class through LTFEs, more LTFEs would have to be established. However, nearly every class is represented by at least some LTFEs. For the common analysis, there are other, more important constraints: data are not easy to access, and sometimes the older data are not digitized. Here, BonaRes offers great opportunities 275 through the provision of support for data preparation and through the establishment of a common database. This opportunity should be used more by LTFE holders in the future.

Data availability

The LTFE metadata are available in the BonaRes Respository: Grosse, M., and Hierold, W.: Long-term Field Experiments in Germany [Data set], BonaRes, <http://doi.org/10.20387/BonaRes-3tr6-mg8r>, 2019.

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290 **Declaration of Interest Statement**

The authors declare that they have no conflict of interest.

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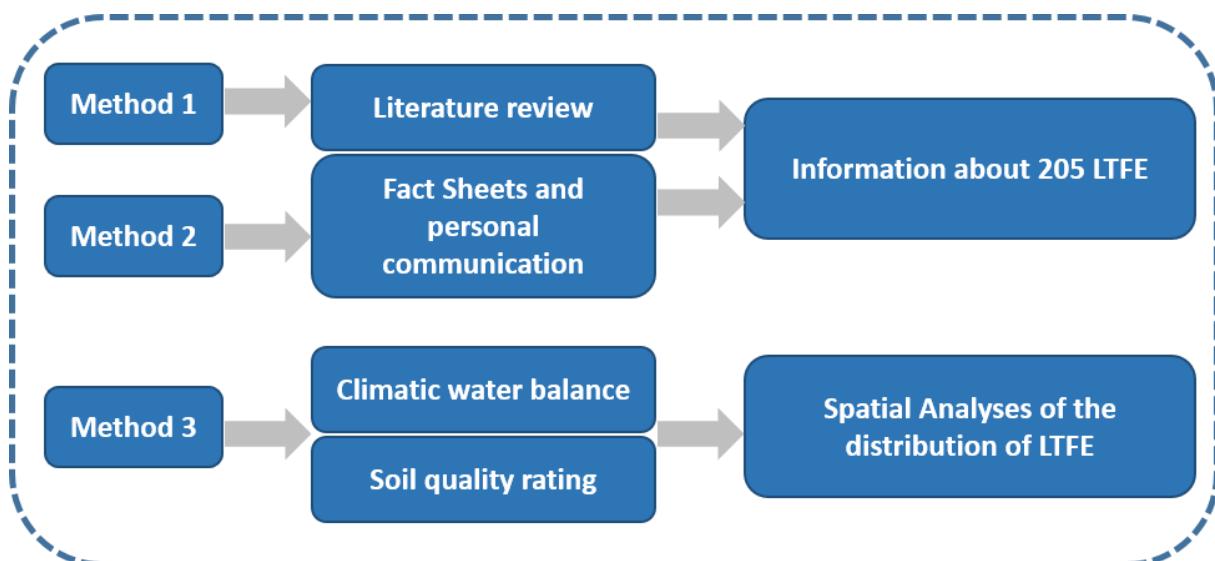
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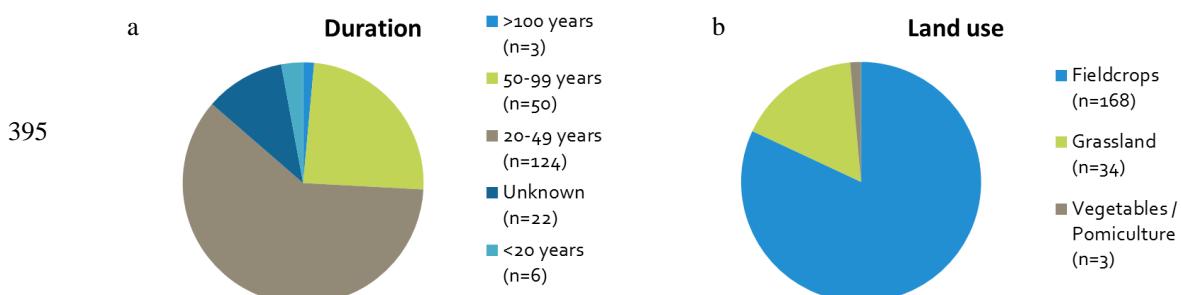
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Figures and Tables

(In the order of their appearance)



390 **Figure 1: Methods used for assessing the representativeness of the LTFE distribution in Germany.**



400 **Figure 2: Results of the literature research (I) (n=205).**

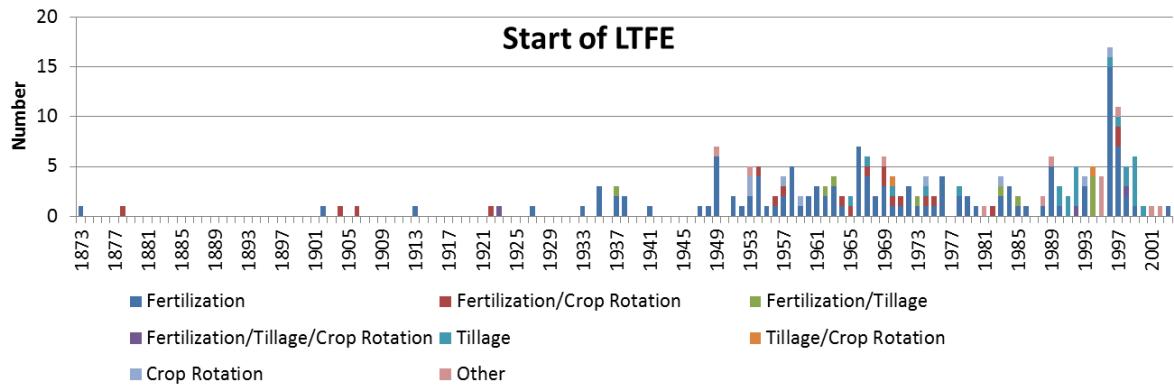


Figure 3: Number of LTFEs set up per year according to the research themes of the experiments (total number of LTFEs=205).

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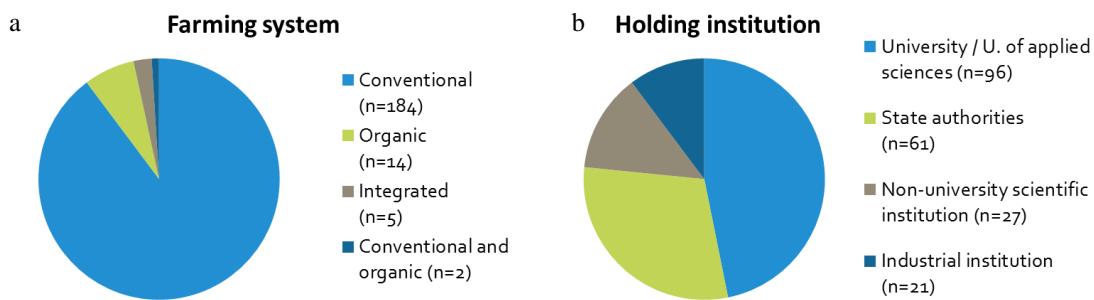
Table 1: Research themes in LTFEs (multiple nominations possible, sorted by frequency).

Theme	Number of trials
Fertilization – field crops experiments	124
Organic fertilization	58
Mineral N-fertilization	55
Straw fertilization	24
Mineral K-fertilization	15
Mineral P-fertilization	14
Liming	10
Green manure (with vs. without)	8
Mineral fertilization (not specified)	6
Mineral Mg-fertilization	4
Compost	3
Sludge	2
Tillage – field crops experiments	38
Reduced depth or conservation tillage	24
Inversion vs. non-inversion tillage	12
Sowing methods	10
Different forms of primary tillage	7
Stubble tillage (with vs. without)	3
Tillage frequency	3
Other	2



Fertilization – grassland experiments	34
Mineral P-fertilization	11
Mineral K-fertilization	10
Mineral N-fertilization	6
Liming	4
Organic fertilization	2
Sludge	2
Mineral fertilization (not specified)	1
Acid vs. alkaline fertilization	1
Crop rotation – field crops experiments	32
Crop rotation (not specified)	23
Rotational cropping vs. monoculture	4
Effect of precrop	2
Crop rotation organic vs. integrated	1
Different percentages of cereals	1
Different percentages of wheat	1
Other – field crops and grassland experiments	23
Plant protection	5
Irrigation	4
Effects of different forms of fallow	3
Frequency and start of utilization of grassland	2
Land use systems comparison	2
Monitoring of Organic Farming	2
Use of biodynamic preparations	2
Chopped woody plants for weed suppression	1
Effect of weather conditions	1
Thistle control	1

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Figure 4: Results of the literature research (II) (n=205).



420 **Table 2: Climatic water balance (CWB) classification of arable land in Germany and the number or share of the different LTFE types in each CWB class.**

CWB class vegetation period	Range [mm]	Agricultural area (arable)		LTFE total (arable land) (n=169)		Fertilization LTFE* (n=124)		Tillage LTFE* (n=38)		Crop rotation LTFE* (n=32)	
		area [ha]	share [%]	number	share [%]	number	share [%]	number	share [%]	number	share [%]
1	< -150	3 135 676	23	66	39	49	40	13	34	13	41
2	-150 - <-50	4 473 111	33	49	29	39	31	12	32	6	19
3	-50 - <50	4 468 852	33	35	21	21	17	11	29	3	9
4	50 - <150	926 798	7	10	6	10	8	1	3	4	13
5	150 - <300	492 110	4	9	5	5	4	1	3	6	19
6	300 - <500	0	0	0	0	0	0	0	0	0	0
7	>500	0	0	0	0	0	0	0	0	0	0

*multiple nominations possible

425 **Table 3: Climatic water balance (CWB) classification of agricultural used area for grassland in Germany and the number or share of the LTFEs on grassland in each CWB class.**

CWB class vegetation period	Range [mm]	Agricultural area (grassland)		Grassland LTFE (n=34)	
		area [ha]	share [%]	number	share [%]
1	< -150	599 247	14	6	18
2	-150 - <-50	792 064	18	3	9
3	-50 - <50	1 420 319	33	15	44
4	50 - <150	398 496	9	7	21
5	150 - <300	1 009 952	23	3	9
6	300 - <500	137 968	3	0	0
7	>500	0	0	0	0

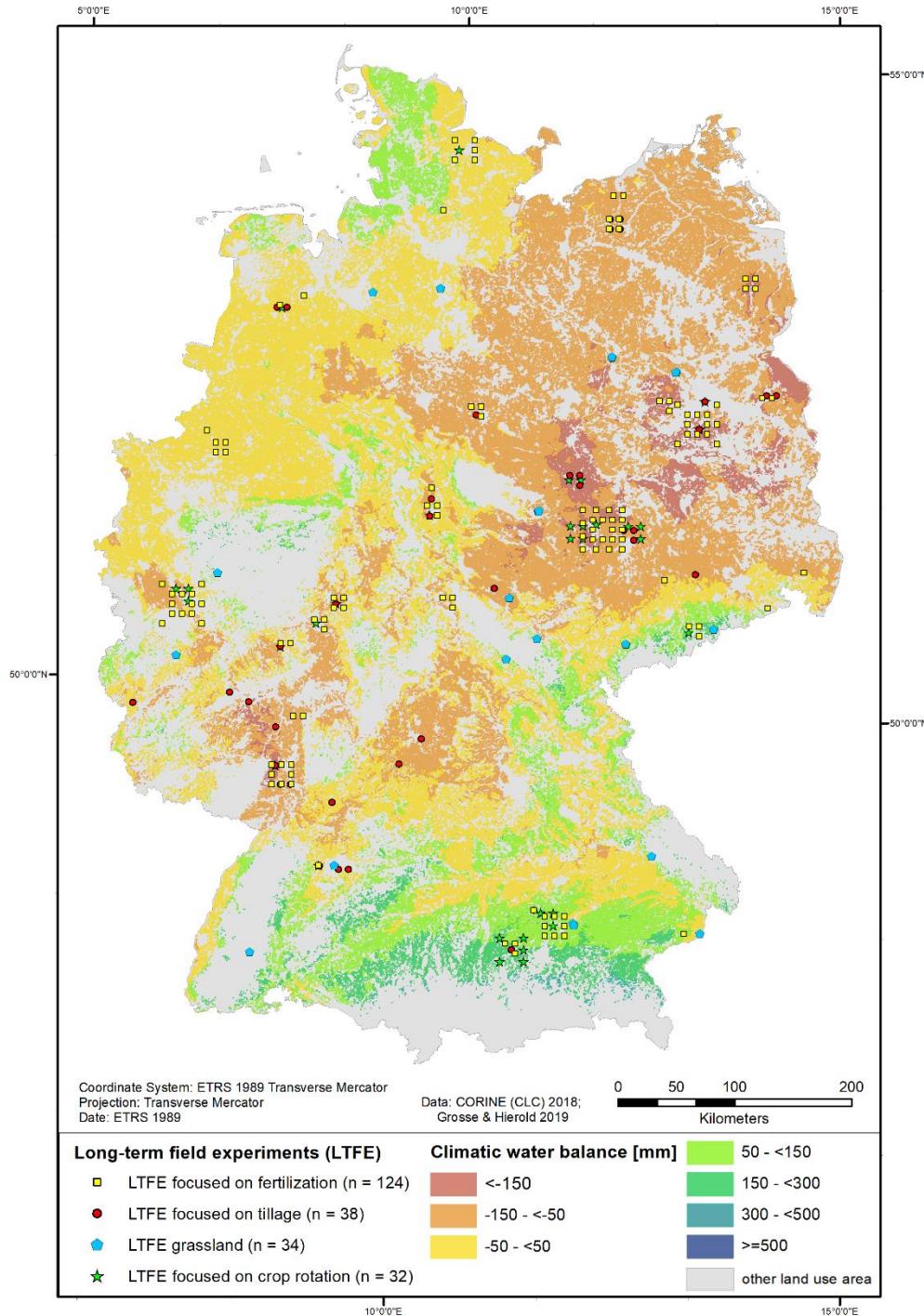


Figure 5: Overview of the distribution of the different climatic water balance classes and the different LTFE types in Germany. The positions of the LTFEs are dispersed to avoid overlapping.

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Table 4: Müncheberger Soil Quality Rating (MSQR) classification of arable land in Germany and the number or share of the different LTFE types in each MSQR class

MSQR	Agricultural area		LTFE total (arable land) (n=169)		Fertilization LTFE* (n=123)		Tillage LTFE* (n=38)		Crop rotation LTFE* (n=32)	
	area [ha]	share [%]	number	share [%]	number	share [%]	number	share [%]	number	share [%]
extremely low	705 687	6	9	5	5	4	4	11	3	9
very low	2 149 584	17	29	17	22	18	5	13	5	16
low	2 656 535	21	18	11	13	11	3	8	1	3
medium	3 532 109	28	32	19	28	23	6	16	4	13
high	2 182 221	18	45	27	28	23	13	34	11	34
very high	1 181 237	10	36	21	27	22	7	18	8	25

*multiple nominations possible

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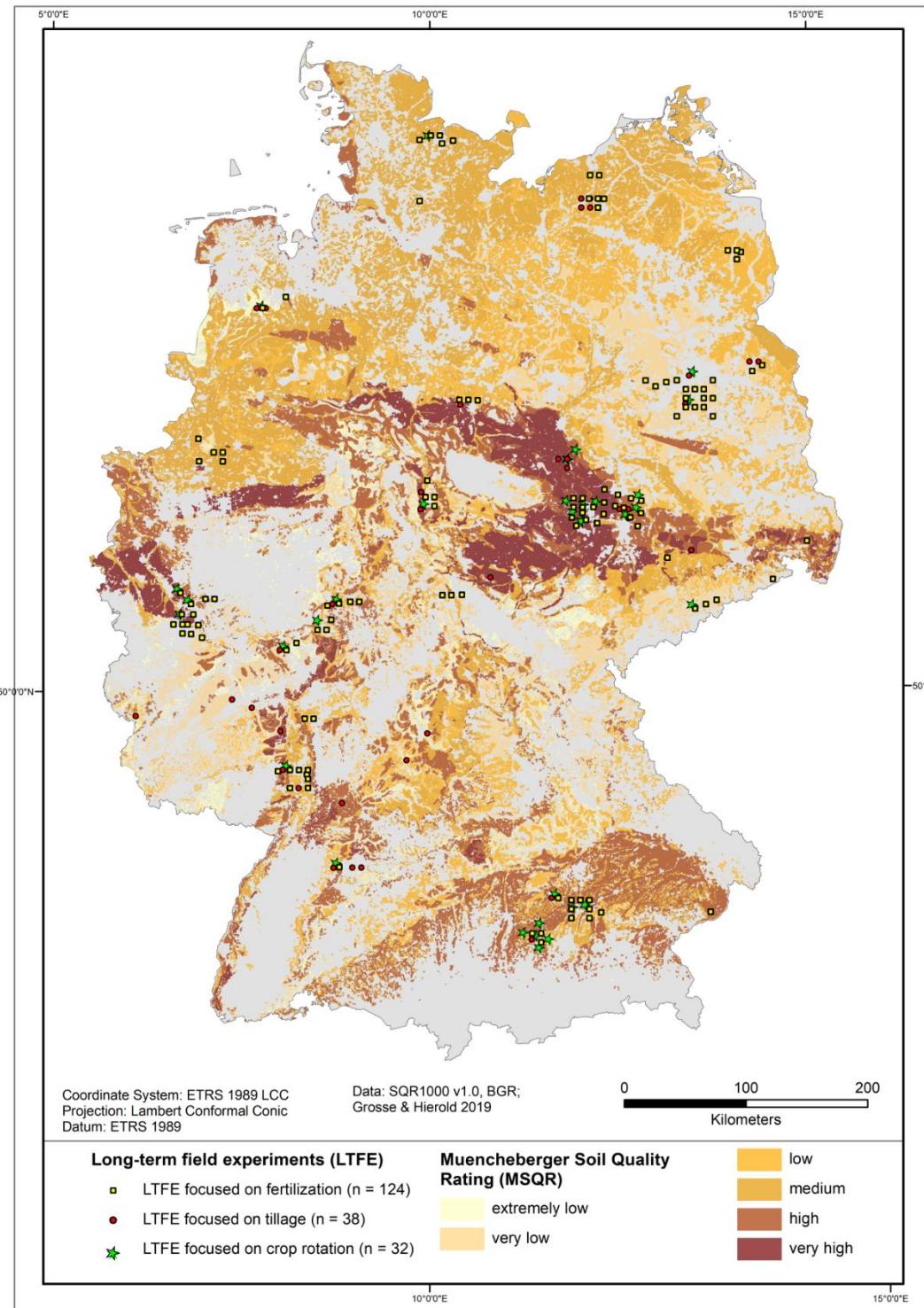


Figure 6: Overview of the distribution of the different Müncheberger Soil Quality Rating classes and the different LTFE types in Germany. The positions of the LTFE are dispersed to avoid overlapping.

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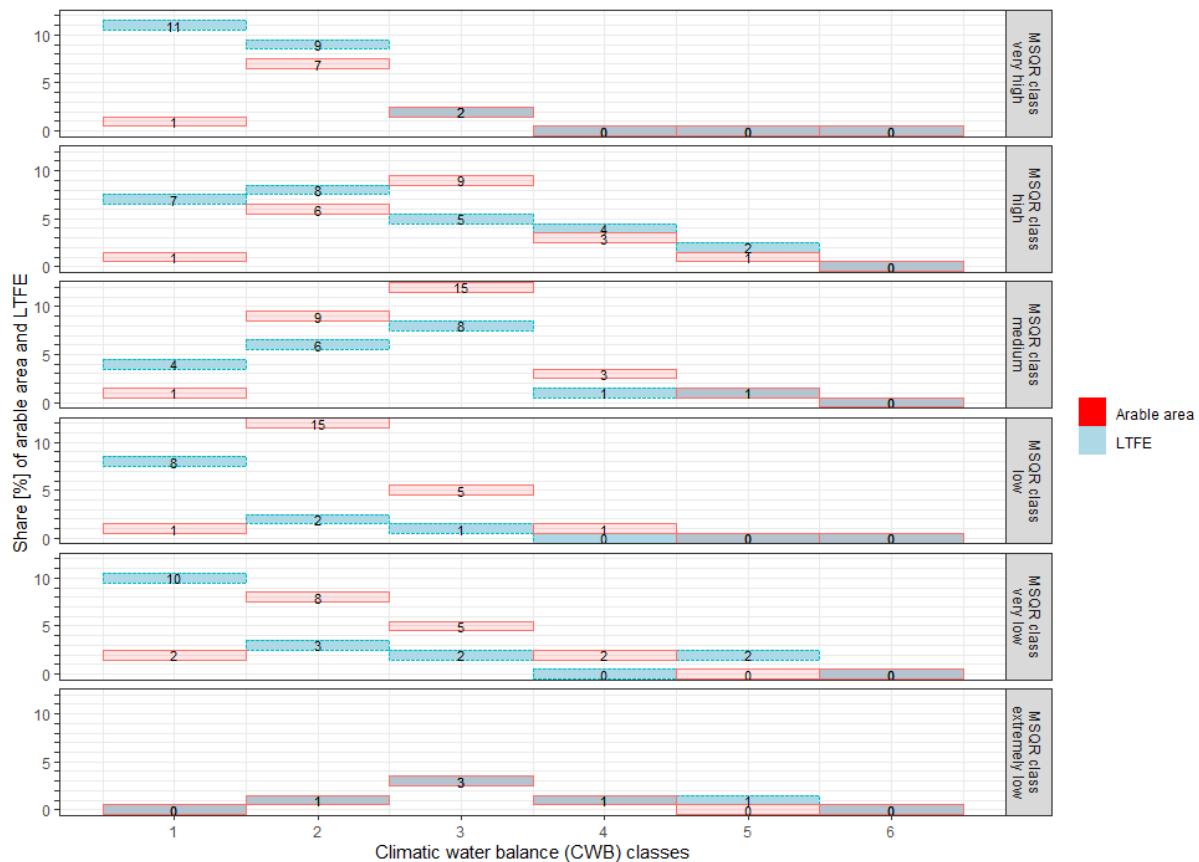


Figure 7: Share of arable area and long-term field experiments in every climatic water balance – Müncheberger Soil Quality Rating combination. The numbers in the boxes indicate the percentages.

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Appendix

Table A 1: IDs of all long-term field experiments, their original name, their holding institution, their CWB class (1 May to 31 October), their MSQ class, and their thematic classification. More details about the LTFEs can be found in the complete dataset (Grosse & Hierold, 2019).

I D	LTFE Name	Institution	C W B Cl as s	MSQ R Class	Thematic Classification
Fieldcrops LTFE					
1	Bodenbearbeitungsversuch Dichtelbach	Landwirtschaftskammer Rheinland-Pfalz	3	very low	Tillage
2	Bodenbearbeitungsversuch Welschbillig	Landwirtschaftskammer Rheinland-Pfalz	3	very low	Tillage
3	Bodenbearbeitungsversuch Wintersheim	Landwirtschaftskammer Rheinland-Pfalz	1	very high	Tillage
4	Statischer Duengungsversuch V120	Helmholtz-Zentrum fuer Umweltforschung (UFZ), Leipzig	1	very high	Fertilization
5	Erweiterter Statischer Duengungsversuch V120a	Helmholtz-Zentrum fuer Umweltforschung (UFZ), Leipzig	1	very high	Fertilization
6	Modellversuch Stalldungsteigerung	Helmholtz-Zentrum fuer Umweltforschung (UFZ), Leipzig	1	very high	Fertilization
7	Bracheversuch V505a	Helmholtz-Zentrum fuer Umweltforschung (UFZ), Leipzig	1	very high	Other
8	Statischer Stickstoffduengungsversuch	Thueringer Landesamt fuer Landwirtschaft und Laendlichen Raum (TLLLR)	2	very low	Fertilization
9	Statischer Kalkduengungsversuch (M16)	Thueringer Landesamt fuer Landwirtschaft und Laendlichen Raum (TLLLR)	2	very low	Fertilization
1	Dauerduengungsversuch L28	Thueringer Landesamt fuer Landwirtschaft und Laendlichen Raum (TLLLR)	2	very low	Fertilization
1		Humboldt-Universitaet zu Berlin	1	very low	Fertilization/Tillage/Crop rotation
1	Statischer Dauerversuch Bodennutzung (BDa_D3)	Humboldt-Universitaet zu Berlin	1	very low	Fertilization/Tillage/Crop rotation
1	Internationaler Organischer-Stickstoff-Dauerduengungsversuch (BDa_IOSDV)	Humboldt-Universitaet zu Berlin	1	very low	Fertilization
1	Agrarmeteorologisches Intensivmessfeld (BDa_E-Feld)	Humboldt-Universitaet zu Berlin	1	very low	Other
1	Bodenbearbeitungsversuch (Versuchsfeld Westerfeld)	Hochschule Anhalt, Bernburg-Strenzfeld	1	very high	Tillage
1	Anbausysteme-Vergleich	Landesanstalt fuer Landwirtschaft und Gartenbau Sachsen-Anhalt (LLG)	1	very high	Crop rotation/Other
7		Landesanstalt fuer Landwirtschaft und Gartenbau Sachsen-Anhalt (LLG)	1	very high	Tillage/Crop rotation/Other
1	Grundbodenbearbeitung und Distelbekämpfung, oekologisch viehlos	Landesanstalt fuer Landwirtschaft und Gartenbau Sachsen-Anhalt (LLG)	1	very high	Tillage/Crop rotation/Other
1	Bodenbearbeitung und Bestelltechnik in der Fruchtfolge	Landesanstalt fuer Landwirtschaft und Gartenbau Sachsen-Anhalt (LLG)	1	very high	Tillage/Other
2	Dauerduengungsversuch Dikopshof	Rheinische Friedrich-Wilhelms-Universitaet Bonn	2	very high	Fertilization/Crop rotation
0					



2	Selektions-Dauerversuch SDV	Rheinische Friedrich-Wilhelms-Universitaet Bonn	3	very high	Crop rotation
1					
2	Strohduengung zu Getreide	Rheinische Friedrich-Wilhelms-Universitaet Bonn	2	very high	Fertilization
2					
2	Phosphatformenversuch	Rheinische Friedrich-Wilhelms-Universitaet Bonn	2	very high	Fertilization
3					
2	Organische Duengung	Rheinische Friedrich-Wilhelms-Universitaet Bonn	2	very high	Fertilization
4					
2	Strohduengung mit Faulschlamm	Rheinische Friedrich-Wilhelms-Universitaet Bonn	2	very high	Fertilization
5					
2	Kaliformenversuch	Rheinische Friedrich-Wilhelms-Universitaet Bonn	2	very high	Fertilization
6					
2	Strohduengung mit verschiedenen N-Formen	Rheinische Friedrich-Wilhelms-Universitaet Bonn	2	very high	Fertilization
7					
2	Phosphatvorratsduengung	Rheinische Friedrich-Wilhelms-Universitaet Bonn	2	very high	Fertilization
8					
2	Kalkversuch mit Spurenelementen	Rheinische Friedrich-Wilhelms-Universitaet Bonn	2	very high	Fertilization
9					
3	Versuch mit Faulschlaemmen	Rheinische Friedrich-Wilhelms-Universitaet Bonn	2	very high	Fertilization
0					
3	Dauerduengungsversuch	Rheinische Friedrich-Wilhelms-Universitaet Bonn	2	high	Fertilization/Crop rotation
1					
3	Langzeit Duengungsversuch (FV4)	Julius Kuehn Institut, Braunschweig	2	very high	Fertilization/Tillage
3					
3	C-Dauerfeldversuch (FV36)	Julius Kuehn Institut, Braunschweig	2	very high	Fertilization
4					
3	Suedfeld-Duengungsversuch	Julius Kuehn Institut, Braunschweig	2	very high	Fertilization
5					
3	Folgenabschaetzung der Wechselwirkung von Fruchtfolge, Duengung und Pflanzenschutz	Julius Kuehn Institut Dahnsdorf	1	high	Other
6					
3	Langzeit-Duengungsversuch	Forschungsring fuer Biologisch-Dynamische Wirtschaftsweise e.V., Darmstadt	2	low	Fertilization
7					
3	Klassischer DFV (4b2, organische und mineralische Duengung)	YARA GmbH & Co. KG, Duelmen	3	medium	Fertilization
8					
3	Dauerduengungsversuch IOSDV	YARA GmbH & Co. KG, Duelmen	3	medium	Fertilization
9					
4	Zuckerruebenfruchtfolgeversuch	Martin-Luther-Universitaet Halle	1	very high	Fertilization/Crop rotation/Other
0					
4	Dauerduengungsversuch (Zuckerruebenmonokultur)	Martin-Luther-Universitaet Halle	1	very high	Fertilization/Crop rotation
1					
4	Dauerduengungsversuch Getreide	Martin-Luther-Universitaet Halle	1	very high	Fertilization/Crop rotation
2					
4	Dauerduengungsversuch Getreide	Martin-Luther-Universitaet Halle	1	very high	Fertilization/Crop rotation
3					
4	N-Formen-Versuch	Technische Universitaet Muenchen	4	high	Fertilization/Crop rotation
4					



4 P-Duengung	Technische Universitaet Muenchen	4 high	Fertilization
5			
4 Stroh/Stalldung-Fruchtfolge	Technische Universitaet Muenchen	4 high	Fertilization
7			
4 N-Duengung/Fruchtfolge	Technische Universitaet Muenchen	4 high	Fertilization
8			
4 N-Steigerung mit Kalkstickstoff	Technische Universitaet Muenchen	4 high	Fertilization
9			
5 Versuch 020 N-Formen-Versuch	Technische Universitaet Muenchen	3 high	Fertilization
0			
5 Bodenbearbeitungsversuch Suedzucker	Institut fuer Zuckerruebenforschung Goettingen	2 very high	Tillage
1			
5 Erschoepfungsversuch (EV)	Justus-Liebig-Universitaet Gießen	2 low	Fertilization
2			
5 Kalkduengungsversuch	Justus-Liebig-Universitaet Gießen	2 high	Fertilization
3			
5 Dauerversuch Biologische	Justus-Liebig-Universitaet Gießen	2 high	Fertilization/Crop rotation
4 Stickstofffixierung (BSG)			
5 Oekologischer Ackerbauversuch	Justus-Liebig-Universitaet Gießen	2 extremely low	Fertilization/Tillage/Crop rotation
5 Gladbacherhof			
5 Bodenbearbeitungsversuch Hohes Feld	Georg-August-Universitaet Goettingen	3 high	Tillage
6			
5 Garte-Sued-Bodenbearbeitung (Reinshof)	Georg-August-Universitaet Goettingen	2 very high	Tillage
7			
5 Garte-Nord-Bodenbearbeitung (Reinshof)	Georg-August-Universitaet Goettingen	2 high	Crop rotation
8			
5 Langzeitversuch zur P- und K-Duengung	Georg-August-Universitaet Goettingen	2 high	Fertilization
9 auf dem Reinshof			
6 Bodenbearbeitungsversuch Suedzucker	Institut fuer Zuckerruebenforschung Goettingen	3 high	Tillage
0			
6 Kastenparzellenversuch Sandboden /	Leibniz-Institut fuer Gemuese- und Zierpflanzenbau, Grossbeeren	1	Fertilization
1 Lehmboden / Tonboden			
6 PK-Mangelversuch	Justus-Liebig-Universitaet Gießen	1 very low	Fertilization
2			
6 Dauerfeldversuch P60	Landesamt fuer Laendliche Entwicklung, Landwirtschaft und Flurneuordnung, Brandenburg	1 low	Fertilization
3			
6 Dauerfeldversuch M4	Landesamt fuer Laendliche Entwicklung, Landwirtschaft und Flurneuordnung, Brandenburg	1 very low	Fertilization
4			
6 Versuchsfeld der Versuchsstation Gross Luesewitz	Julius Kuehn Institut, Gross Luesewitz	2 very low	Other
5			
6 Ewiger Roggen	Martin-Luther-Universitaet Halle	1 medium	Fertilization/Crop rotation
6			
6 Schmalfuss'scher Dauerversuch, Feld A,	Martin-Luther-Universitaet Halle	1 very high	Fertilization
7 Kalkduengung			
6 Schmalfuss'scher Dauerversuch, Feld C,	Martin-Luther-Universitaet Halle	1 very high	Fertilization
8 Kaliumduengung			



6	Schmalfuss'scher Dauerversuch, Feld D,	Martin-Luther-Universitaet Halle	1	very high	Fertilization
9	Phosphorduengung				
7	Organische Duengung (Feld F)	Martin-Luther-Universitaet Halle	1	very high	Fertilization
0					
7	Dauerfeldversuch "Bodenfruchtbarkeit"	Rheinische Friedrich-Wilhelms-Universitaet Bonn	3	very high	Fertilization
1		Universitaet Hohenheim	4	medium	Fertilization/Crop rotation
7	Dauerversuch Duengung-Fruchtfolge	Universitaet Hohenheim	3	low	Tillage
2					
7	Versuch zur Bodenbearbeitung	Christian-Albrechts-Universitaet Kiel	3	high	Fertilization
3					
7	Dauerduengungsversuch	Christian-Albrechts-Universitaet Kiel	3	medium	Fertilization
4					
7	Stickstoffversuch "Decline-Versuch"	Christian-Albrechts-Universitaet Kiel	3	medium	Fertilization/Crop rotation
5					
7	Fruchtfolgeversuch	Christian-Albrechts-Universitaet Kiel	3	medium	Fertilization/Crop rotation
6					
7	N-Duengung zu Wintergerste	Christian-Albrechts-Universitaet Kiel	3	medium	Fertilization
7					
7	Duengerartenvergleich (Versuch I)	Martin-Luther-Universitaet Halle	5	medium	Fertilization/Crop rotation
8					
7	Kombinationswirkung (Versuch II)	Martin-Luther-Universitaet Halle	5	very low	Fertilization
9					
8	Naehrstoffverhaeltnisversuch	Landwirtschaftliche Versuchsstation der BASF AG	1	very low	Fertilization
0					
8	Feldwirtschaftsversuch	Landwirtschaftliche Versuchsstation der BASF AG	1	low	Fertilization
1					
8	Naehrstoffmangelversuch	Landwirtschaftliche Versuchsstation der BASF AG	1	low	Fertilization
2					
8	WW-Fruchtfolgeversuch	Landwirtschaftliche Versuchsstation der BASF AG	1	low	Fertilization/Crop rotation/Other
3					
8	Bodenbearbeitungsversuch	Landwirtschaftliche Versuchsstation der BASF AG	1	high	Fertilization/Tillage
4					
8	Bodenbearbeitungsversuch	Institut fuer Zuckerruebenforschung Goettingen	2	high	Tillage
5					
8	Dauerduengungsversuch L28	Saechsisches Landesamt f. Umwelt, Landwirtschaft u. Geologie (LfULG)	3	high	Fertilization
6					
8	Dauerduengungsversuch (V140)	Leibniz Zentrum f. Agrarlandschaftsforschung (ZALF) e.V.	1	low	Fertilization
7					
8	Bodenbearbeitung (V760)	Leibniz Zentrum f. Agrarlandschaftsforschung (ZALF) e.V.	1	low	Tillage
8					
8	Modellbetrieb Organischer Landbau, Felder 931 - 934	Leibniz Zentrum f. Agrarlandschaftsforschung (ZALF) e.V.	1	low	Other
9					
9	Kalium-Steigerungsversuch	Versuchsring Suedhannover, Landwirtschaftskammer Hannover	2	low	Fertilization
0					
9	Hoeckelheim/Suedniedersachsen	Landwirtschaftskammer Niedersachsen	3	medium	Fertilization
9	P-Duengung auf Sandmischkultur				
1					
9	Bodenbearbeitung/Fruchtfolge	Georg-August-Universitaet Goettingen	3	extremely low	Tillage/Crop rotation
2					



9	Bodenbearbeitung	Georg-August-Universitaet Goettingen	3	extre mely low	Tillage
3					
9	Internationaler Organischer	unbekannt	3	extre mely low	Fertilization
4	Stickstoffduengungs-Versuch (IOSDV)				
9	Dauerversuch 'Auswirkung von	Bayerische Landesanstalt fuer	5	extre mely low	Crop rotation
6	Daueranbau'	Landwirtschaft (LfL)			
9	Verbesserte Dreifelderwirtschaft	Bayerische Landesanstalt fuer	5	high	Crop rotation
7		Landwirtschaft (LfL)			
9	Getreide/Mais Fruchfolge	Bayerische Landesanstalt fuer	5	high	Crop rotation
8		Landwirtschaft (LfL)			
9	Einfluss von Grundbodenbearbeitung	Bayerische Landesanstalt fuer	5	high	Tillage
9		Landwirtschaft (LfL)			
1	Internationaler Organischer	Bayerische Landesanstalt fuer	5	high	Fertilization
0	Stickstoffduengungs-Versuch (IOSDV)	Landwirtschaft (LfL)			
0					
1	Internationaler Organischer	Justus-Liebig-Universitaet Gießen	2	high	Fertilization
0	Stickstoffduengungs-Versuch (IOSDV)				
1					
1	Organische Duengung / Stalldung	Justus-Liebig-Universitaet Gießen	2	high	Fertilization
0	Schafpferchversuch				
2					
1	Gruenduengung / Strohduengungsversuch	Justus-Liebig-Universitaet Gießen	2	high	Fertilization
0					
3					
1	Bilanzversuch Kastenanlage	Justus-Liebig-Universitaet Gießen	2	high	Fertilization
0					
4					
1	Wirkungen differenzierter	Technische Universitaet Muenchen	4	high	Fertilization/Til lage/Crop rotation
0	Bodenbearbeitungssysteme im				
5	Dauerversuch Scheyern	Martin-Luther-Universitaet Halle	1	high	Fertilization/Cr op rotation
1	Fruchfolgeduengungsversuch				
0					
6					
1	Konzentrationsversuch	Martin-Luther-Universitaet Halle	1	high	Crop rotation
0					
7					
1	Duengungs-Kombinationsversuch	Martin-Luther-Universitaet Halle	1	high	Fertilization
0	Seehausen (F1-70)				
8					
1	Bodenbearbeitungsversuch	Martin-Luther-Universitaet Halle	1	high	Tillage
0					
9					
1	Guelledauerversuch	Martin-Luther-Universitaet Halle	1	high	Fertilization
1					
0					



1	Bodenfruchtbarkeitsversuch	Martin-Luther-Universitaet Halle	1	high	Fertilization/Tillage
1					
1	Internationaler Organischer	Landwirtschaftliche Untersuchungs- und	2	high	Fertilization/Tillage
1	Stickstoffduengungs-Versuch (IOSDV)	Forschungsanstalt Speyer			
2					
1	Humusversuch	Landwirtschaftliche Untersuchungs- und	2	medium	Fertilization/Other
1		Forschungsanstalt Speyer			
3					
1	Kali-Magnesium-Kalk-Versuch	Landwirtschaftliche Untersuchungs- und	2	medium	Fertilization
1		Forschungsanstalt Speyer			
4					
1	Klaerschlammversuch	Landwirtschaftliche Untersuchungs- und	2	medium	Other
1		Forschungsanstalt Speyer			
5					
1	Bracheversuch	Landwirtschaftliche Untersuchungs- und	2	medium	Other
1		Forschungsanstalt Speyer			
6					
1	Dauerduengungsversuch L28	Saechsisches Landesamt f. Umwelt, Landwirtschaft u. Geologie (LfULG)	1	medium	Fertilization
1					
7					
1	Duengungs- und Beregnungsversuch	Humboldt-Universitaet zu Berlin	1	high	Fertilization/Other
1	(Thy_D1)				
9					
1	Stroh- und N-Duengung in Fruchfolgen	Humboldt-Universitaet zu Berlin	1	very low	Fertilization/Crop rotation
2	mit unterschiedlichem Getreideanteil				
0	(Thy_D5)				
1	Statischer Naehrstoffmangelversuch	Humboldt-Universitaet zu Berlin	1	very low	Fertilization
2	(Thy_D41)				
1					
1	Naehrstoffmangelversuch Winterroggen	Humboldt-Universitaet zu Berlin	1	very low	Fertilization
2	Monokultur (Thy_D42)				
2					
1	Statischer Bodenfruchtbarkeitsversuch	Humboldt-Universitaet zu Berlin	1	very low	Fertilization
2	(Thy_D6)				
3					
1	Strohduengungsversuch (Thy_D2)	Humboldt-Universitaet zu Berlin	1	very low	Fertilization
2					
5					
1	Modellbetrieb Organischer Landbau,	Leibniz Zentrum f.	1	very low	Other
3	Felder 901 - 904	Agrarlandschaftsforschung (ZALF) e.V.,			
6		Muencheberg			
1	Statischer Dauerfeldversuch ""organisch-	Leibniz-Institut fuer Gemuese- und	1		Fertilization
3	mineralische N-Duengung""	Zierpflanzenbau, Grossbeeren			
7					
1	Versuch zur Bodenbearbeitung	Universitaet Hohenheim	3	low	Tillage
3					
8					



1 Gehoelzhaeckselapplikation	Universitaet Hohenheim	3 very low	Other
3			
9			
1 Versuch 700 (Reduzierte	Universitaet Hohenheim	3 extre	Tillage
4 Bodenbearbeitung)		mely	
0		low	
1 Effiziente Naehrstoffverwertung, K-	Saechsisches Landesamt f. Umwelt,	2 extre	Fertilization
4 Eichversuche	Landwirtschaft u. Geologie (LfULG)	mely	
2		low	
1 Effiziente Naehrstoffverwertung, K-	Saechsisches Landesamt f. Umwelt,	4 extre	Fertilization
4 Eichversuche	Landwirtschaft u. Geologie (LfULG)	mely	
3		low	
1 Referenzflaeche	Rheinische Friedrich-Wilhelms-	3 mediu	Fertilization
4	Universitaet Bonn	m	
4			
1 Statischer Versuch Bodennutzung	Humboldt-Universitaet zu Berlin	1 very	Fertilization/Til
4 (Thy_D3/1)		low	lage
6			
1 Statischer Dauerfeldversuch Organische	Humboldt-Universitaet zu Berlin	1 mediu	Fertilization
4 Duengung und Humusreproduktion		m	
7 (Thy_D3/2)			
1 Statischer N-Duengungsversuch in	Humboldt-Universitaet zu Berlin	1 very	Fertilization
4 Winterroggen-Monokultur (Thy_D7)		low	
8			
1 Alte dreifeldrige Fruchtfolge	Bayerische Landesanstalt fuer	5 very	Fertilization/Cr
4	Landwirtschaft (LfL)	low	op rotation
9			
1 Fruchtfolgen im oekologischen Landbau	Bayerische Landesanstalt fuer	5 very	Fertilization/Cr
5	Landwirtschaft (LfL)	low	op rotation
0			
1 Fruchtfolgen im oekologischen Landbau	Bayerische Landesanstalt fuer	4 high	Fertilization/Cr
5	Landwirtschaft (LfL)	op rotation	
1			
1 Fruchtfolgeversuch (FF)	Justus-Liebig-Universitaet Gießen	2 high	Crop rotation
5			
2			
1 Bodenbearbeitungs-Versuch (BB)	Justus-Liebig-Universitaet Gießen	3 high	Tillage
5			
3			
1 Bodenbearbeitungsversuch Suedzucker	Institut fuer Zuckerruebenforschung	1 high	Tillage
5	Goettingen		
4			
1 Bodenbearbeitungsversuch Suedzucker	Institut fuer Zuckerruebenforschung	2 high	Tillage
5	Goettingen		
5			
1 Bodenbearbeitungsversuch Suedzucker	Institut fuer Zuckerruebenforschung	3 high	Tillage
5	Goettingen		
6			



1 Bodenbearbeitungsversuch Suedzucker	Institut fuer Zuckerruebenforschung	2 medium	Tillage
5	Goettingen	m	
7			
1 Strategievergleich umweltschonender	Julius Kuehn Institut Dahnsdorf	1 low	Other
5 Pflanzenschutz (BS1)			
8			
1 Oekologischer Landbau (oeko1)	Julius Kuehn Institut Dahnsdorf	1 high	Other
5			
9			
1 Strategien zur Minderung der Anwendung	Julius Kuehn Institut Dahnsdorf	1 high	Other
6 chemischer Pflanzenschutzmittel (BS4)			
0			
1 Kalk-Duengungsversuch	FEhS-Institut fuer Baustoff-Forschung e.V.	3 high	Fertilization
6			
1			
1 Phosphorduengungsstrategien	Universitaet Rostock	2 high	Fertilization
6			
2			
1 Koernermais Daueranbau	Hoehere Landbauschule Rotthalmuenster	3 extremely	Fertilization
6		low	
5			
1 Winterweizen Daueranbau	Hoehere Landbauschule Rotthalmuenster	3 medium	Other
6			
6			
1 E-Feld (bis 1957)	Georg-August-Universitaet Goettingen	3 medium	Fertilization
6			
7			
1 Dauerfeldversuch (DE-1b-F-1, Am	YARA GmbH & Co. KG, Duelmen	3 medium	Fertilization
9 Kotten)			
3			
1 Dauerfeldversuch (DE-1b-F-2, Am Hof)	YARA GmbH & Co. KG, Duelmen	3 no data	Fertilization
9			
4			
1 Dauerfeldversuch (DE-1b-F-3, IPU Schlag	YARA GmbH & Co. KG, Duelmen	3 medium	Fertilization
9 9)			
5			
1 Feldmodellversuch ""Krumenaufbau""	Leibniz Zentrum f. Agrarlandschaftsforschung (ZALF) e.V., Muencheberg	1 medium	Fertilization/Tillage
9			
7			
2 Kalkformenversuch	SKW Stickstoffwerke Piesteritz	3 medium	Fertilization
0			
3			
2 Dauerduengungsversuch (M70)	Landesamt fuer Laendliche Entwicklung, Landwirtschaft und Flurneuordnung, Brandenburg	1 low	Fertilization
0			
5			
2 Getreidedauerversuch	Martin-Luther-Universitaet Halle	1 very low	Fertilization/Crop rotation/Other
0			
6			



2	Stroh-Stallmistversuch	Christian-Albrechts-Universitaet Kiel	3	very low	Fertilization
0					
7					
2	Phosphor-Steigerungsversuch	Christian-Albrechts-Universitaet Kiel	2	very low	Fertilization
0					
8					
2	Fruchtfolgeversuch	Landesforschungsanstalt fuer Landwirtschaft und Fischerei Mecklenburg-Vorpommern	2	medium	Fertilization/Tillage
0	Bodenbearbeitung/organische Duengung	Landesforschungsanstalt fuer Landwirtschaft und Fischerei Mecklenburg-Vorpommern	2	medium	Fertilization/Tillage
9	Winterraps (FF 1.1)	Landesforschungsanstalt fuer Landwirtschaft und Fischerei Mecklenburg-Vorpommern	2	medium	Fertilization/Tillage
2	Fruchtfolgeversuch	Landesforschungsanstalt fuer Landwirtschaft und Fischerei Mecklenburg-Vorpommern	2	medium	Fertilization/Tillage
1	Bodenbearbeitung/organische Duengung	Landesforschungsanstalt fuer Landwirtschaft und Fischerei Mecklenburg-Vorpommern	2	medium	Fertilization/Tillage
0	Sommerweizen (FF 1.2)	Landesforschungsanstalt fuer Landwirtschaft und Fischerei Mecklenburg-Vorpommern	2	medium	Fertilization/Tillage
2	Fruchtfolgeversuch	Landesforschungsanstalt fuer Landwirtschaft und Fischerei Mecklenburg-Vorpommern	2	medium	Fertilization/Tillage
1	Bodenbearbeitung/organische Duengung	Landesforschungsanstalt fuer Landwirtschaft und Fischerei Mecklenburg-Vorpommern	2	medium	Fertilization/Tillage
1	Winterweizen (FF 2.1)	Landesforschungsanstalt fuer Landwirtschaft und Fischerei Mecklenburg-Vorpommern	2	medium	Fertilization/Tillage
2	Fruchtfolgeversuch	Landesforschungsanstalt fuer Landwirtschaft und Fischerei Mecklenburg-Vorpommern	2	medium	Fertilization/Tillage
1	Bodenbearbeitung/organische Duengung	Landesforschungsanstalt fuer Landwirtschaft und Fischerei Mecklenburg-Vorpommern	2	medium	Fertilization/Tillage
2	Silomais (FF 2.2)	Martin-Luther-Universitaet Halle	1	medium	Fertilization
2	Schmalfuss'scher Dauerversuch, Feld B	Martin-Luther-Universitaet Halle	1	medium	Fertilization
1	(physiologischen Reaktion von				
3	Duengemitteln)				
2	Schmalfuss'scher Dauerversuch, Feld E,	Martin-Luther-Universitaet Halle	1	medium	Fertilization
1	Stickstoffduengung				
4					
2	E-Feld (ab 1957)	Georg-August-Universitaet Goettingen	3	very high	Fertilization
1					
7					
2	Modellversuch zur Bodenbildung	Martin-Luther-Universitaet Halle	1	very high	Fertilization
1					
8					
2	Weihenstephaner Kali-Formenversuch	unbekannt	4	no data	Fertilization
1					
9					
2	Kleinparzellenversuch Hu1 bzw. Hu1To9	Universitaet Rostock	2	no data	Fertilization
2					
0					
2	Organische Duengestoffe - Wirkung	Leibniz Zentrum f. Agrarlandschaftsforschung (ZALF) e.V., Muencheberg	1	low	Fertilization
2	(V140/06)				
1					
2	Organische Duengestoffe - Wirkung	Leibniz Zentrum f. Agrarlandschaftsforschung (ZALF) e.V., Muencheberg	1	low	Fertilization
2	(V140/07)				
2	Organische Duengestoffe - Wirkung	Leibniz Zentrum f. Agrarlandschaftsforschung (ZALF) e.V., Muencheberg	1	low	Fertilization
2	(V140/08)				
3	Organische Duengestoffe - Wirkung	Leibniz Zentrum f. Agrarlandschaftsforschung (ZALF) e.V., Muencheberg	1	low	Fertilization
2	(V140/09)				
4					



2	Bodenbearbeitungsversuch am Galgenberg	Technische Hochschule Bingen	1	very low	Tillage/Other
2					
5					
Grassland LTFE					
1	Stickstoffduengung auf Gruenland	Landesanstalt fuer Landwirtschaft und Gartenbau Sachsen-Anhalt (LLG)	1	Fertilization	
0					
1	Stickstoffduengung auf Gruenland	Landesanstalt fuer Landwirtschaft und Gartenbau Sachsen-Anhalt (LLG)	3	Fertilization	
2					
3	Schachbrettversuch /	Rheinische Friedrich-Wilhelms-Universitaet Bonn	4	Fertilization	
2	Dauerduengungsversuch auf Gruenland	Technische Universitaet Muenchen	4	Fertilization	
4	K-, P-, N-Steigerung zu Gruenland				
6					
9	Gruenlanddauerversuch (V102)	Leibniz Zentrum f. Agrarlandschaftsforschung (ZALF) e.V.	1	Fertilization	
5					
1	P-Duengungsversuch	FEhS-Institut fuer Baustoff-Forschung e.V.	5	Fertilization	
1					
8					
1	Gruenlandversuch Weiherwiese	Bayerische Landesanstalt fuer Landwirtschaft (LfL)	3	Fertilization	
3					
5					
1	Kalk-Duengungsversuch	FEhS-Institut fuer Baustoff-Forschung e.V.	4	Fertilization	
4					
1					
1	Gruenlandversuch Veitshof	Technische Universitaet Muenchen	3	Fertilization	
6					
3					
1	Statischer Dauerduengungsversuch	Hoehere Landbauschule Rotthalmuenster	3	Fertilization	
6					
4					
1	Phosphorduengung auf Gruenland	Saechsisches Landesamt f. Umwelt, Landwirtschaft u. Geologie (LfULG)	3	Fertilization	
6					
8					
1	Kaliumduengung auf Gruenland	Saechsisches Landesamt f. Umwelt, Landwirtschaft u. Geologie (LfULG)	3	Fertilization	
6					
9					
1	Phosphorduengung auf Gruenland	Saechsisches Landesamt f. Umwelt, Landwirtschaft u. Geologie (LfULG)	4	Fertilization	
7					
0					
1	Kaliumduengung auf Gruenland	Saechsisches Landesamt f. Umwelt, Landwirtschaft u. Geologie (LfULG)	4	Fertilization	
7					
1					
1	Phosphorduengung auf Gruenland	Landesanstalt fuer Landwirtschaft und Gartenbau Sachsen-Anhalt	3	Fertilization	
7					
2					
1	Kaliumduengung auf Gruenland	Landesanstalt fuer Landwirtschaft und Gartenbau Sachsen-Anhalt	3	Fertilization	
7					
3					
1	Phosphorduengung auf Gruenland	Landesanstalt fuer Landwirtschaft und Gartenbau Sachsen-Anhalt	1	Fertilization	
7					
4					



1	Kaliumduengung auf Gruenland	Landesanstalt fuer Landwirtschaft und Gartenbau Sachsen-Anhalt	1	Fertilization
7				
5				
1	Phosphorduengung auf Gruenland	Thueringer Landesamt fuer Landwirtschaft und Laendlichen Raum (TLLLR)	5	Fertilization
7				
6				
1	Kaliumduengung auf Gruenland	Thueringer Landesamt fuer Landwirtschaft und Laendlichen Raum (TLLLR)	5	Fertilization
7				
7				
1	Ueberpruefung der Kalkempfehlung fuer Gruenland	Saechsisches Landesamt f. Umwelt, Landwirtschaft u. Geologie (LfULG)	3	Fertilization
7				
8				
1	Umweltbewusste Gruenlandbewirtschaftung	Saechsisches Landesamt f. Umwelt, Landwirtschaft u. Geologie (LfULG)	3	Fertilization/Ot her
9				
1	Grundduengung im Gruenland	Saechsisches Landesamt f. Umwelt, Landwirtschaft u. Geologie (LfULG)	3	Fertilization
8				
0				
1	Phosphorduengung auf Gruenland	Thueringer Landesamt fuer Landwirtschaft und Laendlichen Raum (TLLLR)	3	Fertilization
8				
1				
1	Kaliumduengung auf Gruenland	Thueringer Landesamt fuer Landwirtschaft und Laendlichen Raum (TLLLR)	3	Fertilization
8				
2				
1	Phosphorduengung auf Gruenland	Landesamt fuer Laendliche Entwicklung, Landwirtschaft und Flurneuordnung, Brandenburg	1	Fertilization
8				
3				
1	Kaliumduengung auf Gruenland	Landesamt fuer Laendliche Entwicklung, Landwirtschaft und Flurneuordnung, Brandenburg	1	Fertilization
8				
4				
1	Phosphorduengung auf Gruenland	Thueringer Landesamt fuer Landwirtschaft und Laendlichen Raum (TLLLR)	2	Fertilization
8				
5				
1	Kaliumduengung auf Gruenland	Thueringer Landesamt fuer Landwirtschaft und Laendlichen Raum (TLLLR)	2	Fertilization
8				
6				
1	Niederblockland	Niedersaechsisches Landesamt fuer Bodenforschung (NLfB)	2	Fertilization
8				
7				
1	Kalkbedarf der Hochmoorkulturen	Niedersaechsisches Landesamt fuer Bodenforschung (NLfB)	3	Fertilization
8				
8				
1	Koenigsmoor/Nordheide	Niedersaechsisches Landesamt fuer Bodenforschung (NLfB)	3	Fertilization
8				
9				
1	Versuch 250 (Naehrstoffmangelversuch)	Universitaet Hohenheim (Institut fuer Kulturpflanzenwissenschaften (340b))	4	Fertilization
9				
8				



1 Versuch 251 (Wechselduengungsversuch) Universitaet Hohenheim (Fachgebiet 4 Fertilization
9 Nachwachsende Rohstoffe und
9 Bioenergiepflanzen)