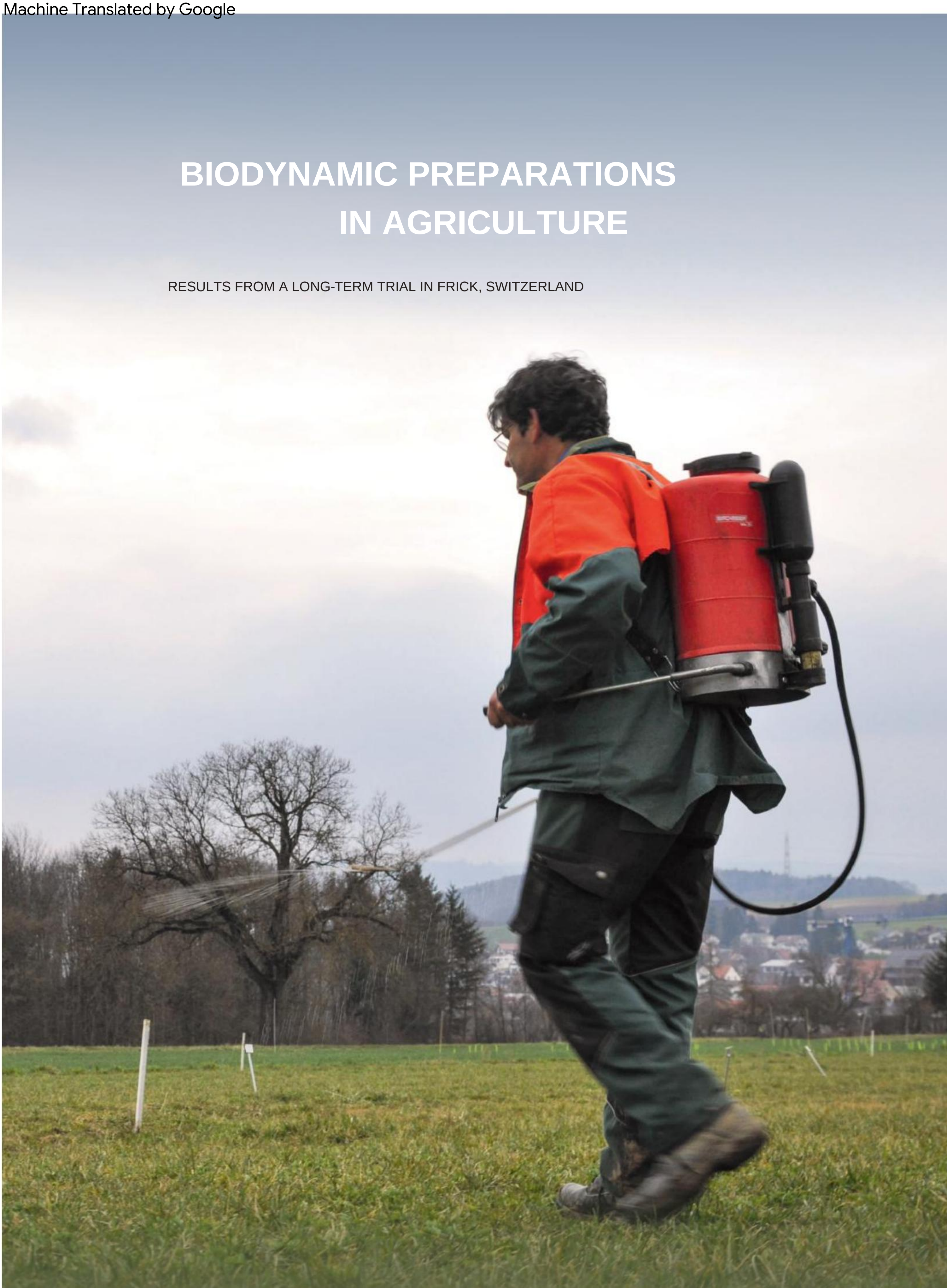
BIODYNAMIC PREPARATIONS IN AGRICULTURE

RESULTS FROM A LONG-TERM TRIAL IN FRICK, SWITZERLAND



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For three decades, FiBL researchers investigated the dynamic-organic-conventional cultivation systems as part of the DOK experiment in Therwil (Switzerland). It became clear that the biodynamic system not only differed significantly from the conventional systems in terms of soil fertility, but also somewhat from the bioorganic system (Mäder et al., 2002).
So the question was: What works here? Is it the biodynamic preparations, the different types of fertilization or the use of copper in the organic system to regulate fungal diseases in potatoes? A comparison of entire cultivation systems cannot break this down. Farmers therefore suggested that FiBL investigate this more closely at the end of the 1990s. At that time, soil protection also came into focus and the use of plows in organic farming was critically assessed with the emergence of conservation soil cultivation techniques. This resulted in a new, factorial long-term experiment in which only one factor was changed at a time in order to be able to estimate its effect individually.
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Inspired by the DOK experiment: the three-factorial experiment in Frick

The experiment was carried out in Frick in autumn 2002 with the three factors biodynamic preparations, fertilization and soil cultivation (Berner et al., 2008). Each factor has two characteristics (Table 1), which were all combined with each other. This resulted in eight procedures. The combination "plow – full manure – without biodynamic preparations" represents a typical bioorganic system, and "plow – manure compost/manure – with preparations" represents a biodynamic cultivation system. The aim of the experiment was to investigate management measures that are believed to increase soil fertility.
Copper was not integrated because another FiBL test showed that the usual application quantities do not have any negative effects on soil microorganisms, at least in the medium term.

The test in Frick was designed with 12 x 12 m plots so that practical machines can be used. In addition to the soil cultivation machines (Table 1), these include a side spreader for the annual spreading of manure compost and a drag hose for spreading manure. For comparison

For the biodynamic preparations, the same fresh manure and manure are distributed over two compost heaps and manure silos and then one heap or silo each is treated with the compost preparations. The manure is spread a few weeks later, while the manure is composted over six months. Until 2014, the preparation work was based on Maria Thun's lunar calendar. Since 2015, the experiment has been working according to Pierre Masson's biodynamic services calendar. The preparations were initially obtained from Rainer Sax, then from his successor at Bütschen (Basel-Land) and in 2014 from the Goetheanum, until FiBL test technician Frédéric Perrochet joined the domestic Swiss preparation group led by Andreas Würsch in 2015. The water for stirring the horn manure and horn pebble preparations was also taken from a rainwater catchment. Horn manure and compost preparations are purchased annually in order to keep storage on site short. A pit sunk into the ground was set up for this purpose. It contains several wooden boxes in which each preparation (except horn pebbles) is stored individually, surrounded by peat. The horn manure is applied at least once in spring and once in autumn; as with compost preparations, this is mainly done when the moon is waning on a rooting day.

Another one or two applications are made shortly after tillage. The Hornkiesel is given regularly in the well-established culture until two weeks before harvest. Aim for 3 to 5 sprays when the moon is rising and ideally with the cosmic element that corresponds to the plant.

Both are distributed in a backpack sprayer after stirring in the field at sunrise (horn pebbles) and in the evening (horn manure). The compost and manure are inoculated with P502 to 507 (compost preparations) when preparing and turning. The conversion of the FiBL farm from Bio Knospe (bioorganic cultivation system)

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TAB. 1: TEST FACTORS IN THE FRICKER LONG-TERM TRIAL

factor	reference	Improved variant
Biodynamic preparations	Without	With (P500 – P507)
Fertilization (both methods at a level of 1 GVE/ha; full manure **approx. 100 kg Ntot/ha)**		Manure compost and a reduced amount of manure
Tillage	Plow (20 cm)	Reduced tillage (cultivator "WecoDyn", plow "Stubble Planer" up to max. 10 cm; occasional non-turning loosening to max. 20 cm)

TAB. 2: DRUG EFFECT

Harvest year	2003	2009	2019
Wheat variety	Titlis	Titlis	Wiwa
Examination year	2005	2013	2020
laboratory	Goetheanum Uwe Geier	research ring, Roya Bornhütter, Uwe Geier	Kassel, Gaby Mergardt
Number of samples	6	8th	8th
sample collection preparation	mixed sample Block 1–4, 3 analysis replicates	mixed sample Block 1–4, 4 analysis replicates	Blocks 1–4 separately per field repetition
Hit rate	100%	50%	50%
differences between Proceedings	small amount	low, analysis replicates uniform	lower than that Differences between field repetitions
criteria	Uniformity, Heavy, moving gung	uniformity, movement, shape intensity, Needle pulls, plate covering	Uniformity, movement, force, Needle pulls, crystallization center, radiation, Plate Covering

Preparation effect only partially recognizable: Comparison of the image-creating analyzes on wheat grains from the Fricker long-term experiment with the aim of assigning the preparations.

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- Frick experiment on the FiBL website: **www.fibl.org/de/locations/switzerland/departments/soil sciences/bw-projects/reduced-tillage**
- On the GLTEN platform: **www.glten.org/experiments/146**

tem) on Demeter (biodynamic cultivation system) in 2013 proved to be a challenge. Before the change, manure and liquid manure were obtained from the FiBL farm and then had to be fetched from an organic farm in Fricktal. The manure and liquid manure composition has therefore changed over time, but always reflected a dairy cattle system similar to that of the FiBL farm.

The crop rotation in the experiment is adapted to the heavy clay soil (approx. 40 to 50% clay) and is common in the Fricktal. It is aimed at a mixed farm with 1 fertilizer unit per hectare (DGVE/ha). The crop rotation in the first two crop rotation periods included: silage maize – winter wheat – sunflowers – spelled – 2-year-old clover grass. Since the meadow quarry proved to be very challenging in the reduced tillage system without a plow and the blackgrass increased significantly, the crop rotation was shortened from 2014 and changed to: winter wheat - silage maize - spelt - 2-year-old clover grass.

In the experiment, agronomic data such as yield and nutrient content in the crop are collected annually. Weed surveys are carried out in arable crops. Soil fertility indicators are determined every three years. For this purpose, the humus content (Corg), nutrient levels and pH, as well as the microbial biomass and microbial activity are measured. A time series of data and archive samples is available. In addition, researchers from FiBL and various European countries have used the experiment as a platform for special studies over the years.

Soil fertility

The scientific synthesis published in 2020 describes that the biodynamic preparations had the least influence on soil fertility of the three factors (Krauss et al., 2020). The switch from plowing to reduced tillage was the most successful measure for increasing soil fertility in the top soil layer in the Fricker long-term experiment, with an increase in humus of 25%, a 32% higher microbial biomass and the promotion of fungal communities and soil organisms in general (0 to 10 cm) (Figure 1). The humus content was also maintained in the 10 to 20 cm layer and the microorganisms were also promoted. The greater peace of the ground and therefore less disturbance to the habitat probably play an important role here. Even over a depth of 1 m, reduced tillage led to an increase in humus reserves. The additional application of manure compost compared to the full manure system, however, only increased the humus content in the top soil layer (0 to 10 cm) by 6% and has so far had little influence on microbial biomass and activity.

Field heterogeneities obviously overshadowed potential effects of the biodynamic preparations. From the start of the experiment, the indicators pH, phosphorus content and microbial bio-

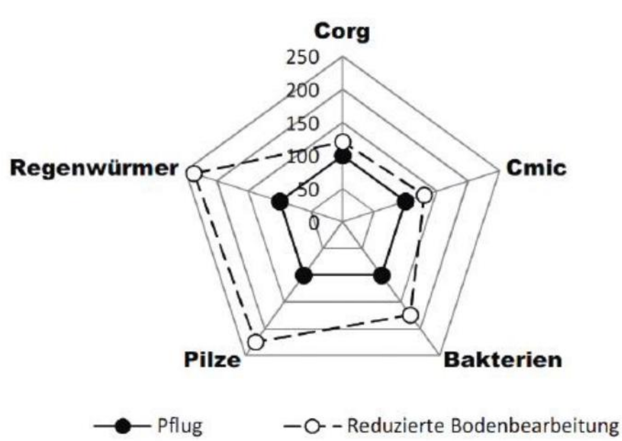
Spreading the manure compost precisely to the plot using the side spreader

mass C and N (Cmic, Nmic) tend to be lower in the 0 to 20 cm soil layer and higher values for the Cmic/Nmic ratio in the plots treated with preparations. Over the course of the experiment, these differentiations were significant in some years (Figure 2). When it came to phosphorus content, mixed samples were initially analyzed without differentiating the preparation factor. However, heterogeneities can also be assumed here. The percentage deviations from the untreated control were within a narrow band for soil fertility indicators, and there was no clear trend towards higher or lower values over time. A slight trend is visible in the humus content (Figure 3): The humus contents under reduced tillage have fallen into the pre-prepared range in recent years.

ed plots are slightly higher. However, the trend and the individual annual values are not significant. It is possible that the humus content responds to the preparations with a delay, as is the case with fertilization. The coming studies will show this.

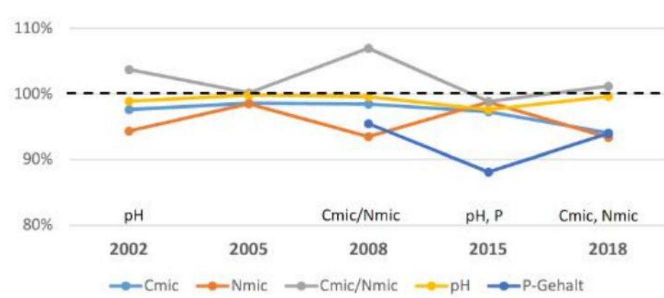
In a bachelor's thesis (Limacher, 2017), the influence of fertilization and preparations on the microbial community was clarified in more detail and the fungal-bacteria ratio in the soil layer from 0 to 10 cm was determined using molecular biological qPCR analyses. In addition, the microbially bound carbon Cmic was calculated by adding soil respiration to the metabolic quotient (qCO_2), which describes the ratio of microbial activity to microbial biomass. This one

FIGURE 1: **SOIL FERTILITY INDICATORS**



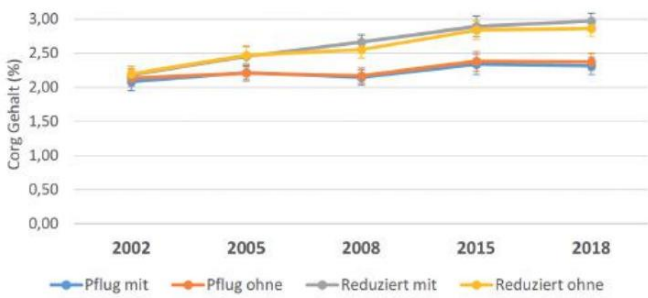
Relative deviations of soil fertility indicators comparing reduced tillage with plowing (= 100%) in 2018 at 0 to 10 cm soil depth. All differences are significant (n=16).

FIGURE 2: **HIGHER PH, LOWER PHOSPHORUS**



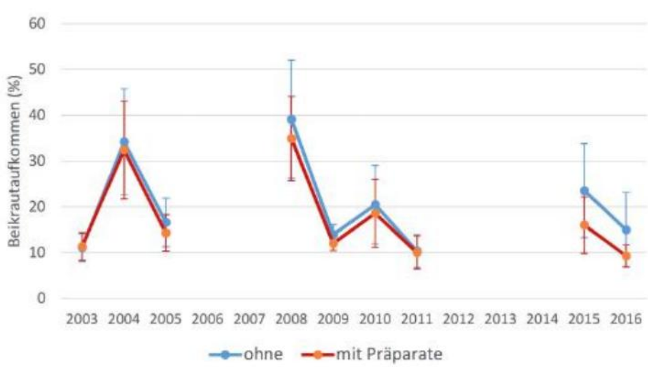
Relative deviations of soil fertility indicators in the comparison of plots treated with biodynamic preparations to untreated plots (= dashed line = 100%: the scale starts at 80% for better readability) in the years 2002 to 2018 at 0 to 10 cm soil depth. Significant differentiating indicators are mentioned per year ($p < 0.05$, n=16).

FIGURE 3: **HUMUS, PROCESSING, PREPARATIONS**



Development of organic carbon content from 2002-2018 at 0-10 cm soil depth. Means (standard errors, n=8) were pooled across fertilizer practices to show the interaction between tillage and preparations.

FIGURE 4: **WEBBING VOLUME**



Weed occurrence in % (each mean and standard error, n=16) in the arable crops of the Fricker long-term experiment. The connecting lines serve the purpose better readability.

allows statements to be made about the energy efficiency of carbon use by microorganisms. In addition, microbial phosphorus and nitrogen were measured. Neither fertilization nor preparations showed significant effects for all measured indicators (data in Limacher, 2017).

In summary, it can be seen that the biodynamic preparations in the Frick experiment had only minor effects on soil fertility in the top soil layer, while the manure compost slowly increased the humus content. From this we conclude that in the biodynamic farming system the use of manure compost is the more differentiating factor in terms of soil fertility. This observation is supported by measurements from the Darmstadt long-term fertilization experiment on fields. There, the humus content increased primarily with the use of larger amounts of rotted manure compared to mineral fertilization (Heinze et al., 2011; Sradnick et al., 2013) and could only be partially increased again through the use of the preparations (Bachinger, 1996; Sradnick et al., 2013). As in Frick, the preparations usually had no influence on the microbial community (Ngosong et al., 2010; Sradnick et al., 2013; Faust et al., 2017), but did show higher microbial activity (dehydrogenase activity) and a greater root density in deeper soil layers (Bachinger, 1996).

Yield and quality

The preparations have had no impact on the yield in Frick over the years (Krauss et al., 2020). A trend towards a lower incidence of weeds in the plots treated with preparations is not significant due to the high distribution, but is increasingly visible over the years (Figure 4). The high weed coverage (> 20%) reflects the conditions in summer crops; the winter cereals wheat and spelled have greater competitive power with < 20% weed coverage.

In the experiment, the quality of wheat grains from 2003, 2009 and 2019 was also determined using image-creating methods (CuCl2 crystallization, climbing images). We blinded a selection of grains from the process combination of plow-manure compost/slurry with or without biodynamic preparations and sent them to experts for analysis and evaluation (Table 2). The table refers to the reports from the respective laboratories from the year of the study. The classification of the preparation variants was only possible in the first year of cultivation. Since the development of criteria over the years has enabled an increasingly standardized description of the CuCl2 crystallization images, the original plan was to re-evaluate the time series by a trained panel. This was not possible due to the pandemic situation in 2020. However, Table 2 shows that ongoing experiences are reflected in the development and refinement of the image-creating methods. This means that the field repetitions are no longer mixed together in order to capture the spatial heterogeneity. The catalog of criteria has also been continues.

The quality analysis of the wheat samples from 2019 was additionally expanded: samples from the bioorganic process (i.e. plow + solid manure + without biodynamic preparations) were added and the quality in the laboratory with standard parameters such as crude protein, sedimentation and falling number or gluten content, as well as the Nutrient contents in straw and grain analyzed. The preparations also showed no differentiation in these laboratory values (data not shown). A 12% lower N content in the straw from the bioorganic process, on the other hand, suggests that the N redistribution from the straw to the grain was better than in the biodynamic process, which was reflected in a slightly increased grain yield in the bioorganic process (8 %, not significant). The sulfur content in straw and grain in the bioorganic system was also significantly reduced (around 30%). This may be due to the lack of manure compost in driving can be returned. However, the differences between the grains from the biodynamic and bioorganic processes were sufficient so that they could be successfully separated using the CuCl2 crystallization analysis. In 2019, laboratory and imaging analyzes showed that fertilization had a greater influence on the quality of wheat grains than biodynamic preparations.

The fact that it was possible to successfully separate the wheat samples in 2019 based on visually recorded differences in the crystal images with regard to fertilization shows that CuCl2 crystallization analysis can be a reliable tool in detecting management differences. From the hit rates from 2009 and 2019 it can therefore be assumed that the effect of the preparations in the Fricker long-term test on wheat samples can no longer be traced in later years. This reflects the general trend in the agronomic indicators of the trial and in soil quality, which also show hardly any statistical differences (Krauss et al., 2020). Whether this is due to the location, the management or the question of whether an exact scientific experiment with plots in a small space can actually reproduce the effect of the biodynamic preparations remains an open question. •

literature

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