Fact sheet
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Organic farming in comparison

Results from 45 years of the DOK trial

Founded by farmers – carried out by researchers
Farmers and researchers in organic farming took the initiative in 1978 to compare organic and conventional farming and set up the DOK trial for this purpose.
It is located in the Leimental region southwest of Basel, on fertile loess soils in the southeast corner of the Upper Rhine Plain. It is now the world's longest-running trial comparing agricultural cultivation systems. With its large database and sample archive, it continues to provide an ideal platform for a wide range of research projects. Dozens of projects have been carried out here over the last 45 years, and thousands of soil and plant samples have been analysed and evaluated. Among other things, this has resulted in 130 publications in scientific journals and specialist journals, as well as numerous doctoral theses and student dissertations. This fact sheet presents and interprets the most important findings from the long-term trial in an easily understandable way.

How is the trial structured?

The cropping systems

The DOK trial compares biodynamic **(D)**, bio-organic **(O)** and conventional **(K)** farming systems. These systems simulate farms with arable farming and livestock farming with 1.4 fertilised livestock units **(LU)** per hectare[1]. The organic systems follow the Demeter and Bio Suisse guidelines. The farmyard manure comes from farms that operate according to the respective systems. The Demeter guidelines require the use of special field and compost preparations and the scheduling of field work in consideration of the cosmic constellation.
Today, the conventional method corresponds to integrated production with an even nutrient balance. This is achieved with the additional use of mineral fertilisers (at a high level if required) and plant protection according to ecological damage thresholds. Since the beginning of the second crop rotation period (1985), there has also been a purely mineral-fertilized conventional system that represents a livestock-free farm **(M)**.

The crop rotation

The seven-year crop rotation with two and a half years of soil rest without ploughing under clover grass is typical for livestock farms in Switzerland. The annual crops are root crops (beetroot, maize, potatoes, cabbage), cereals (wheat, barley) and soybeans as a grain legume. The intercrops grown are used either as green manure or as fodder.

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The crop rotation runs with a time lag on three parallel plots. In each year, therefore, there are three different crops in the crop rotation in the trial plots. The crop rotation is the same in all cropping systems and, therefore, represents a compromise between the systems. It was adjusted slightly after each crop rotation period (FFP) and the position of the crops also changed slightly until 2013. In the beginning, barley and white cabbage were grown - later, beetroot instead of the labour-intensive white cabbage. Potatoes, winter wheat and clover grass were grown in each FFP. At the beginning of the third FFP (1992), a third year of grass clover was added instead of barley, as the cereal-based crop rotation led to root rot diseases in all systems. Since 1999, maize and soy have been cultivated, and the grass clover has again been in place for two years. The reasons for the changes were the desired optimal use of nitrogen in the crop rotation and the system-independent occurrence of pests, especially wireworms in potatoes[1].

Fertilisation

Two different fertilisation intensities are used in the trial. The full fertilisation level corresponds to the average animal stocking density of a mixed farm in Switzerland with 1.4 Livestock Units (LU) per hectare. In the half fertilisation level, only half the amount of farmyard manure was used in all three systems (corresponding to 0.7 LU) and half the amount of mineral fertiliser in system **K**. The nutrient levels of nitrogen, phosphorus and potash in the two organic systems were 40 % lower than in the conventional system with farmyard manure **K**, whereby the mineral nitrogen in the organic systems was 60 % below that of the conventional system **M**. In the organic systems, the organic matter added with the farmyard manure was reduced by the system-specific treatment of the farmyard manure because, in **O**, rotted manure is used, which is turned once, while in **D**, manure compost is produced, which also receives biodynamic compost preparations. The fertilisation strategy of the conventional methods **K** and **M** is based on the principles for the fertilisation of agricultural crops in Switzerland[2], which only takes part of the farmyard manure nitrogen into account.

Plant protection

In 1978, pesticides were available that are no longer approved today because they are too harmful to the environment, users or consumers. The application rates were sometimes very high. In the conventional systems **K** and **M**, an average of 4 kg of active ingredient per hectare per year was applied at that time – significantly more in potatoes and none at all in grass clover years. Fungicides and herbicides accounted for the largest share. Today, the quantities applied in the conventional systems are significantly lower. The reasons for this are product innovation and the widespread switch to demand-oriented treatments. In the organic system **O**, the use of copper is permitted to control late blight *(Phytophthora infestans)* in potatoes. Colorado potato beetles are controlled with an organic pesticide in the organic systems. Otherwise, organic farming uses preventive methods. On average, 92 % fewer pesticides were applied in the organic methods than in the conventional methods for all crop sequences and crops.

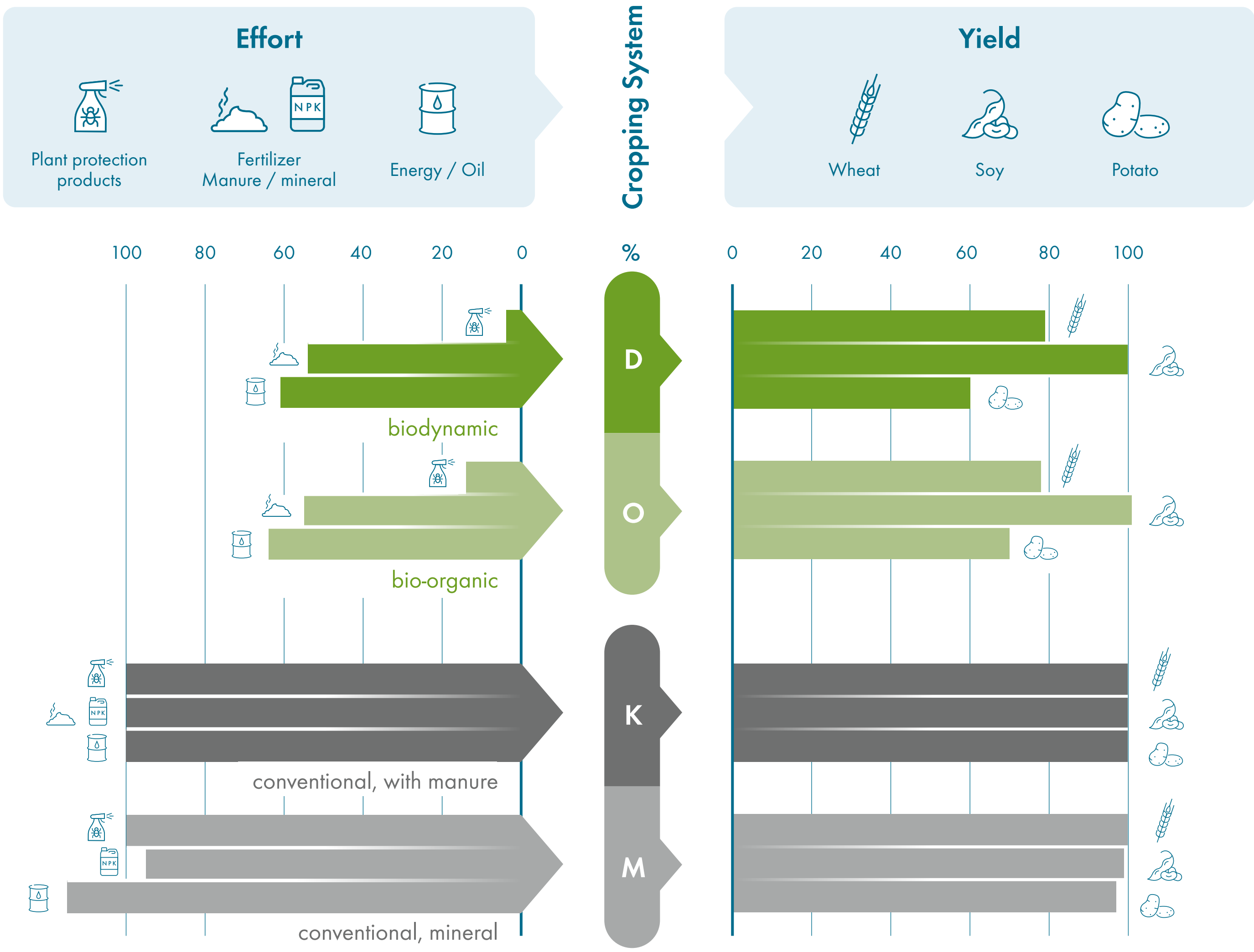
Table 1: Characteristics of the DOK cultivation systems

	Cropping system	**D** biodynamic	**O** bio-organic	**K** conventional, with manure	**M** conventional, mineral
Fertilisation	Farmyard manure	Manure compost and slurry	Rotted manure and slurry	Piled manure and slurry	–
	Mineral fertiliser	Rock dust	Rock dust, potash, magnesia	Urea, ammonium nitrate, calcium ammonium nitrate, triple superphosphate, potassium chloride	
Plant protection	Weed control	Mechanically by harrowing and hoeing		Mechanical and herbicides	
	Plant diseases	Indirect measures	Indirect measures, copper supplements for potatoes	Fungicides	
	Pests	Biocontrol *(Bacillus thuringiensis)*, plant extracts		Insecticides, biocontrol, slug pellets and preventive measures	
	Special features	Biodynamic preparations	–	Growth regulators	

Organic yields remain stable in the long term

The yields recorded since the beginning were stable in the organic systems despite the restriction to farmyard manure. While the yield reduction in the organic systems compared to the conventional systems was 20 % over the first three crop rotation periods, it was reduced to 15 % over six crop rotation periods. However, the yield differences vary greatly depending on the crop. For grass clover, the yield in the organic systems was, on average, only 9 % lower, but for potatoes, the yield reduction was much higher at 32 %. The yield of organic wheat was 22 % lower, while that of silage maize was only 12 % lower. Soybean yields were equally high[3]. The good organic yields of clover grass and soy are due to their ability to fix nitrogen from the air. Legumes have this special ability thanks to their symbiosis with nodule bacteria, which plays an important role in organic farming. In wheat, system **D** achieved slightly higher yields in the last two crop rotation periods compared to system **O**, possibly due to the variety from biodynamic cereal breeding. However, **O** showed a 15 % increase in potato yields compared to **D** due to the more efficient control of late blight. Organic systems are, therefore, very efficient: they produce 85 % of conventional yields with around 50 % less nutrient and energy requirements, as well as 92 % less pesticides. The significant reduction in inputs has a positive impact on biodiversity, the climate and soil fertility. In addition, food, feed and water are less contaminated with fertilisers and pesticides.

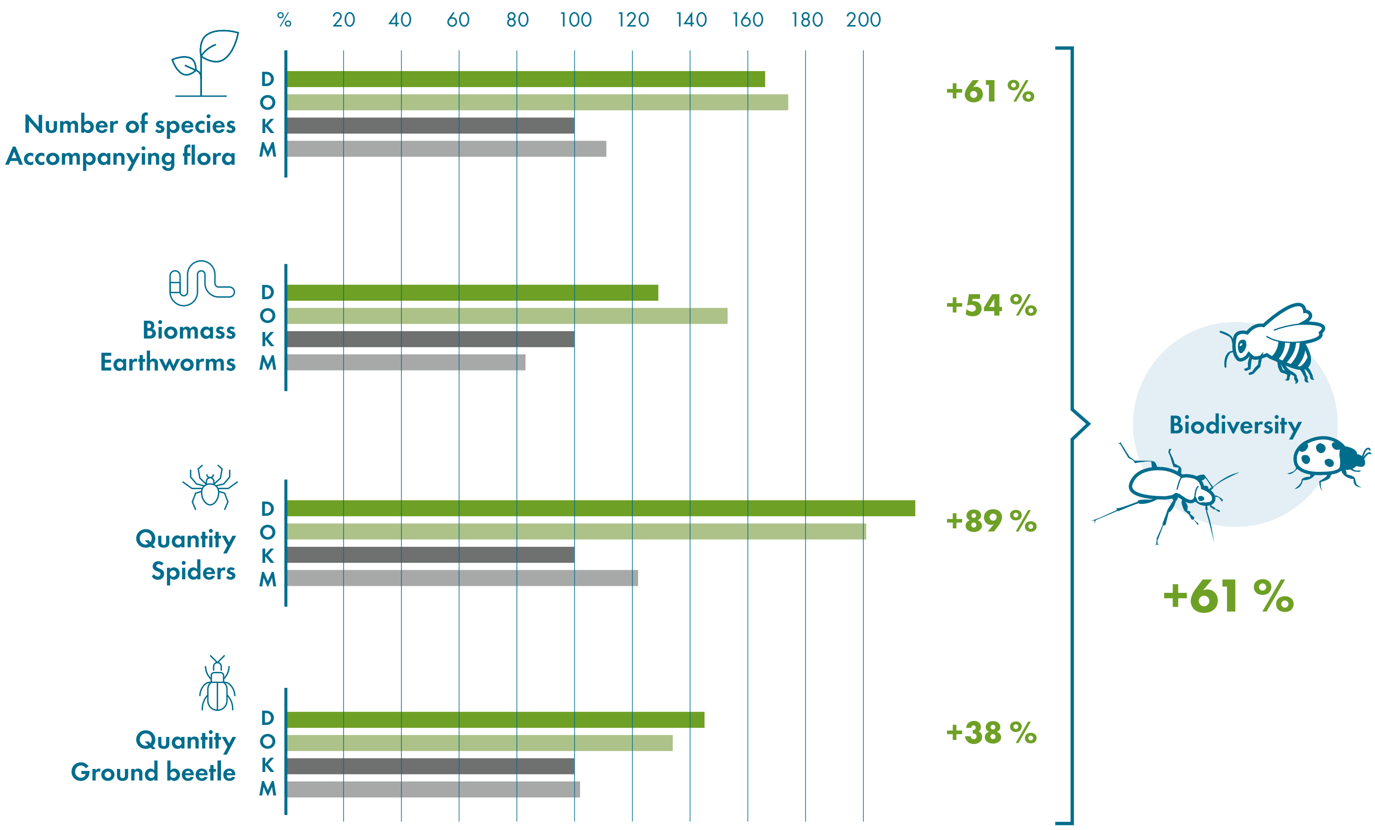
Figure 1: Effort and yield of the DOK systems over the entire duration of the trial



More biodiversity through organic farming

Biodiversity loss is one of the major global problems on which agriculture has a strong influence. For the biodiversity assessment in the DOK trial, species were chosen whose mobility radius does not far exceed the size of the trial areas. Due to the absence of herbicides, plant diversity and seed stocks were significantly higher in the organic systems **D** and **O** than in the conventional system **K**[4]. Ground beetles, short-winged insects and spiders were also approximately twice as common in the organic plots as in **K**[5]. In the first crop rotation periods, the earthworm populations in system **K** were also severely impaired[6]. The organic fertilisation promoted the number and species diversity of nematodes, which feed on bacteria and plants. On the other hand, nematodes that mainly feed on fungi were found in increased numbers in the purely mineral-fertilized system[5] **M**. The soil microorganisms multiply particularly strongly on the root surface but also in the digestive tract of the larger soil organisms when crop residues are decomposed. The dynamics of their community structure are, therefore, closely linked to that of plants and soil animals. The community of bacteria was more strongly influenced by fertilisation intensity, while that of fungi was more strongly influenced by system differences[7]. Mycorrhizal fungi can form a symbiosis with cultivated plants and were detected more frequently in the organic systems. Under drought stress, the mycorrhizal symbiosis on the wheat root in system **D** was particularly pronounced. The more diverse bacterial community in soils of system **O** remained active for longer in dry phases, which had a positive effect on nitrogen mineralization and, thus, on plant growth[8].

Figure 2: Indicators for biodiversity



- **D** biodynamic
- **O** bio-organic
- **K** conventional, with manure
- **M** conventional, mineral

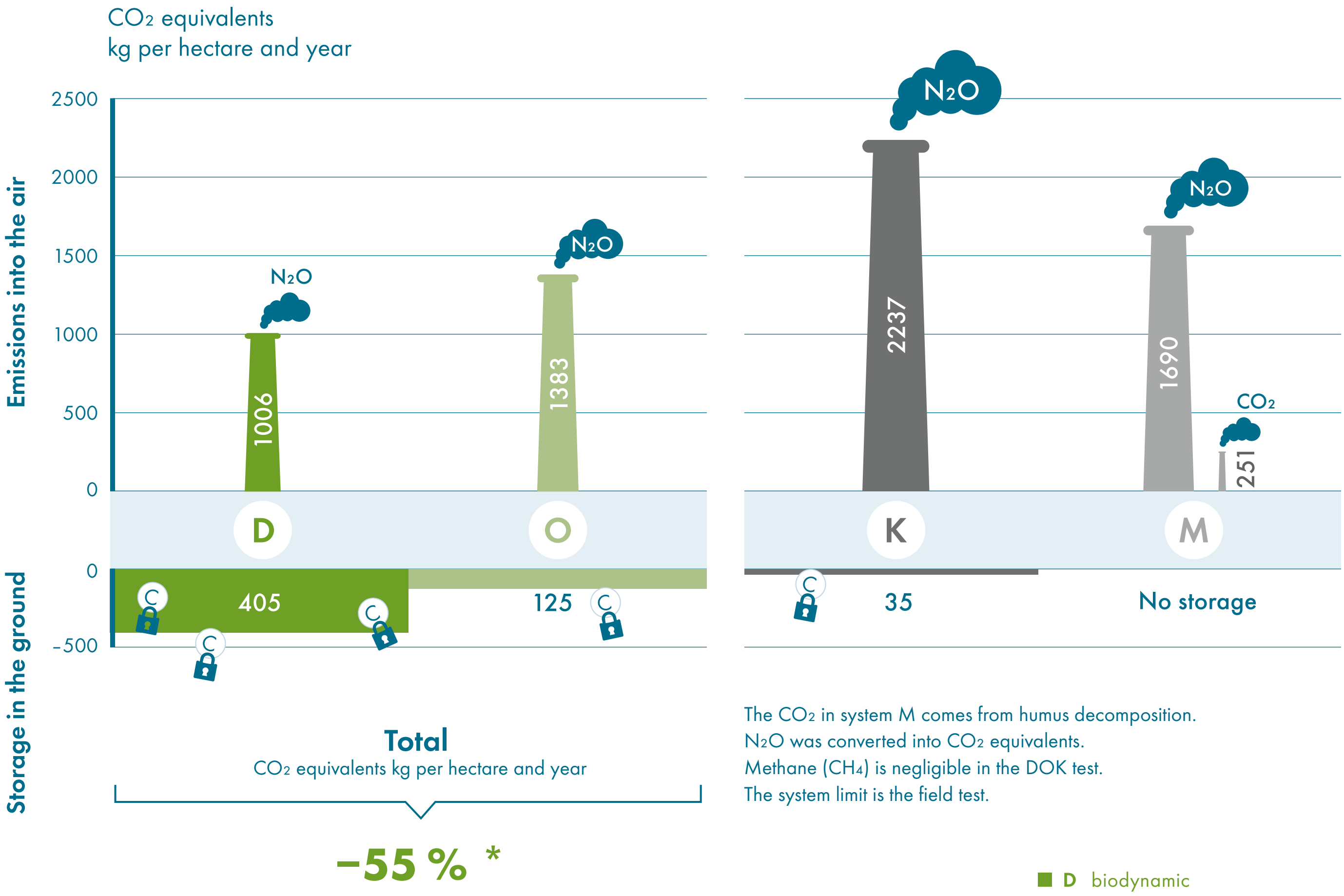
Percentages refer to both organic farming systems combined compared to both conventional systems.

Organic farming is good for the climate

Present-day climate change is caused by so-called "greenhouse gases" (GHG). The three most important GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). In agriculture, measures for both climate protection and climate adaptation are being discussed. System **D** is the only one of the DOK systems that substantially stores organic carbon (C) in the form of humus in the soil, probably due to manure composting[9]. In addition, the lowest nitrous oxide emissions (N_2O) were measured here, while the high nitrogen fertilisation in the conventional systems led to increased GHG emission rates[10]. Overall, the GHG emissions of the areas with full fertilisation were 63 % lower in system **D** and 44 % lower in system **O** than in the conventional system with farmyard manure **K**.

Scientific models, which estimate carbon inputs into soils and form the basis for international climate reports, have so far assumed that below-ground C inputs are proportional to above-ground biomass: that is to say the higher the yield of a crop, the more C is introduced into the soil. This would mean that more C is introduced into the soil in conventional cultivation systems than in organic systems. Results from the DOK trial were able to refute this assumption for winter wheat and maize. They show that below-ground inputs are largely independent of above-ground biomass production and that organic systems even tend to have slightly higher below-ground C inputs despite lower yields[11].

Figure 3: Greenhouse gas emissions from the soil in the form of nitrous oxide (N_2O) and CO_2



*both organic farming systems combined compared to both conventional systems.

The CO_2 in system M comes from humus decomposition.
N_2O was converted into CO_2 equivalents.
Methane (CH_4) is negligible in the DOK test.
The system limit is the field test.

- **D** biodynamic
- **O** bio-organic
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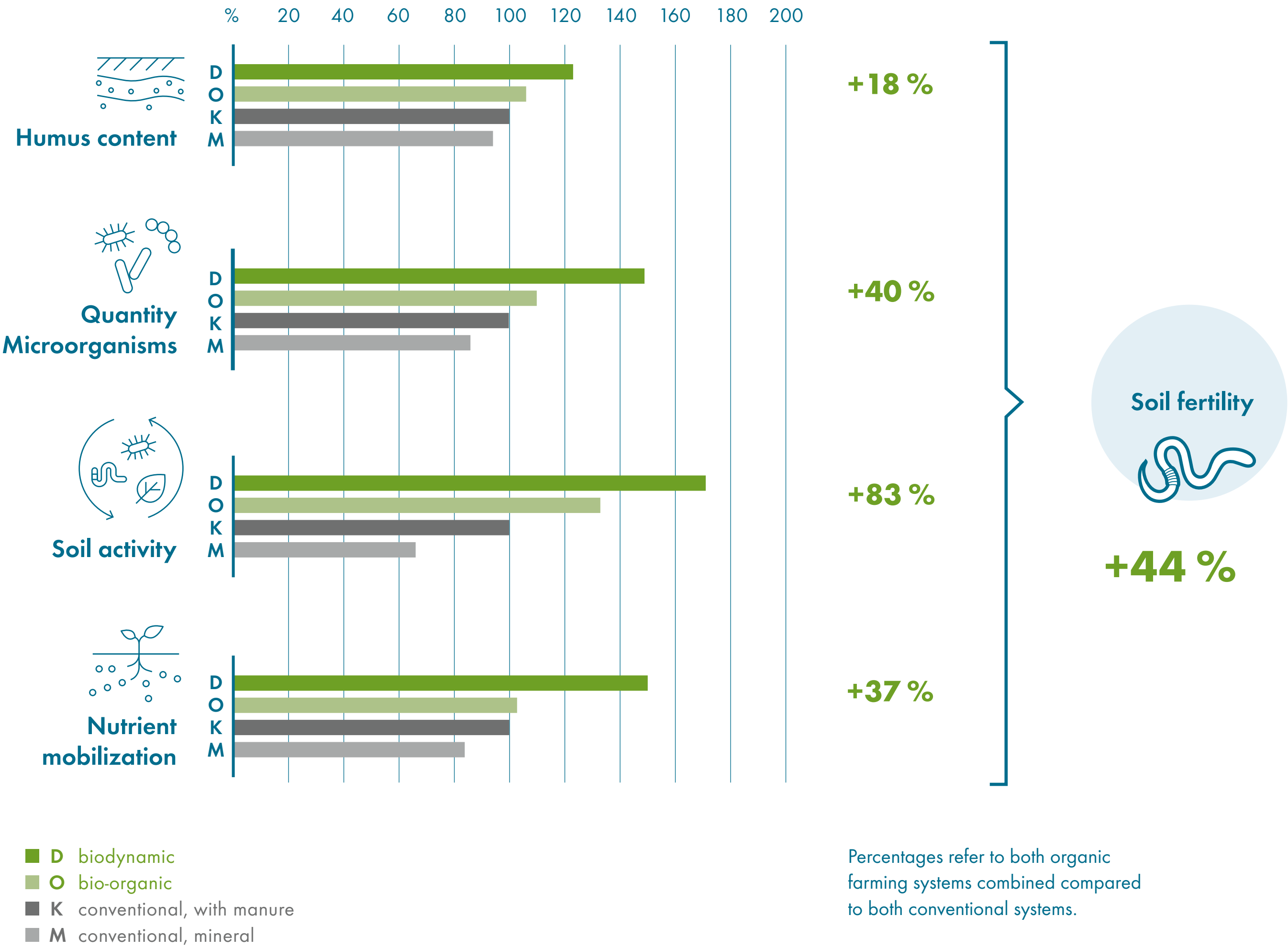
Organic farming promotes soil fertility

The organic **O** and biodynamic **D** cultivation systems both show a less muddy soil surface in uncovered soils. This is because the soils have a more stable structure. After 21 years of conventional cultivation in systems **K** and **M**, the pH values had fallen below the target value, which indicates the recommendation for liming. In these soils, maintaining a pH value above six is important for soil structure, biological activity and plant nutrition. This ensures better water infiltration and higher erosion protection. Five tons of lime were applied per hectare. Liming was not necessary for the organic systems.

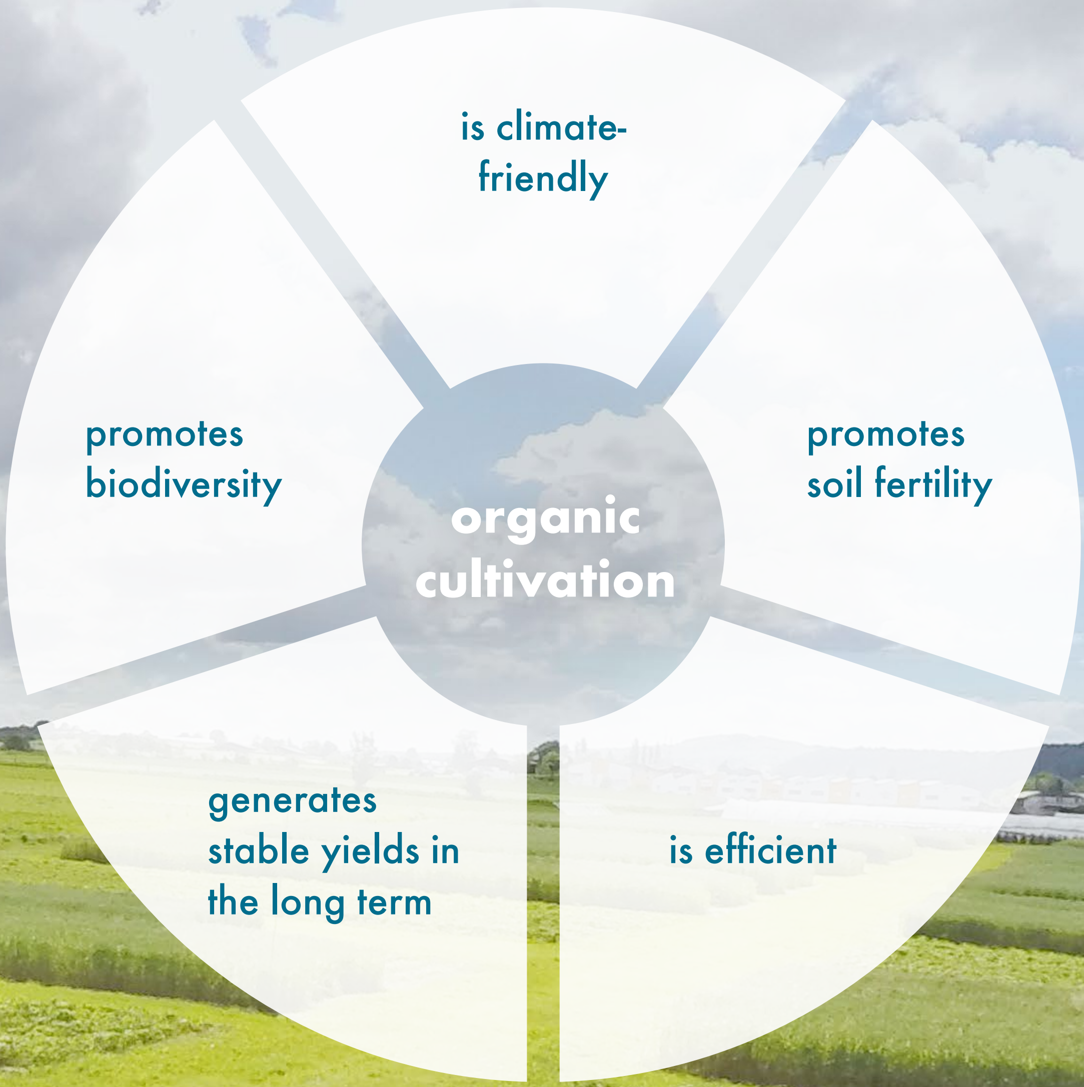
In the processes with full fertilisation and farmyard manure, the humus content and stock remained constant or increased. Without organic fertiliser or with reduced fertilisation, the soils have lost humus[9]. With manure compost application, method **D** achieved significantly higher humus contents than all other methods.

The microbial biomass (number of microorganisms) and its activity and efficiency was significantly higher in the biodynamic system **D** than in the conventional ones. The potential to mobilise organic phosphorus (phosphatase activity) was 50 % higher in the biodynamic system than in the conventional system with manure. All indicators for soil fertility showed better values in the organic systems, especially in the biodynamic system. Soil fertility in **D** with reduced fertilisation reached or exceeded that of **K** with full fertilisation[9].

Figure 4: Indicators for soil fertility



Percentages refer to both organic farming systems combined compared to both conventional systems.



Conclusion

Organic farming offers sustainable solutions to some of the most pressing problems of our time

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Further information

Podcast FiBL Focus
in german

Der DOK-Versuch – Anbausysteme im Vergleich
fibl.org > Infothek > Podcast > FiBL Focus > Episode No. 64

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