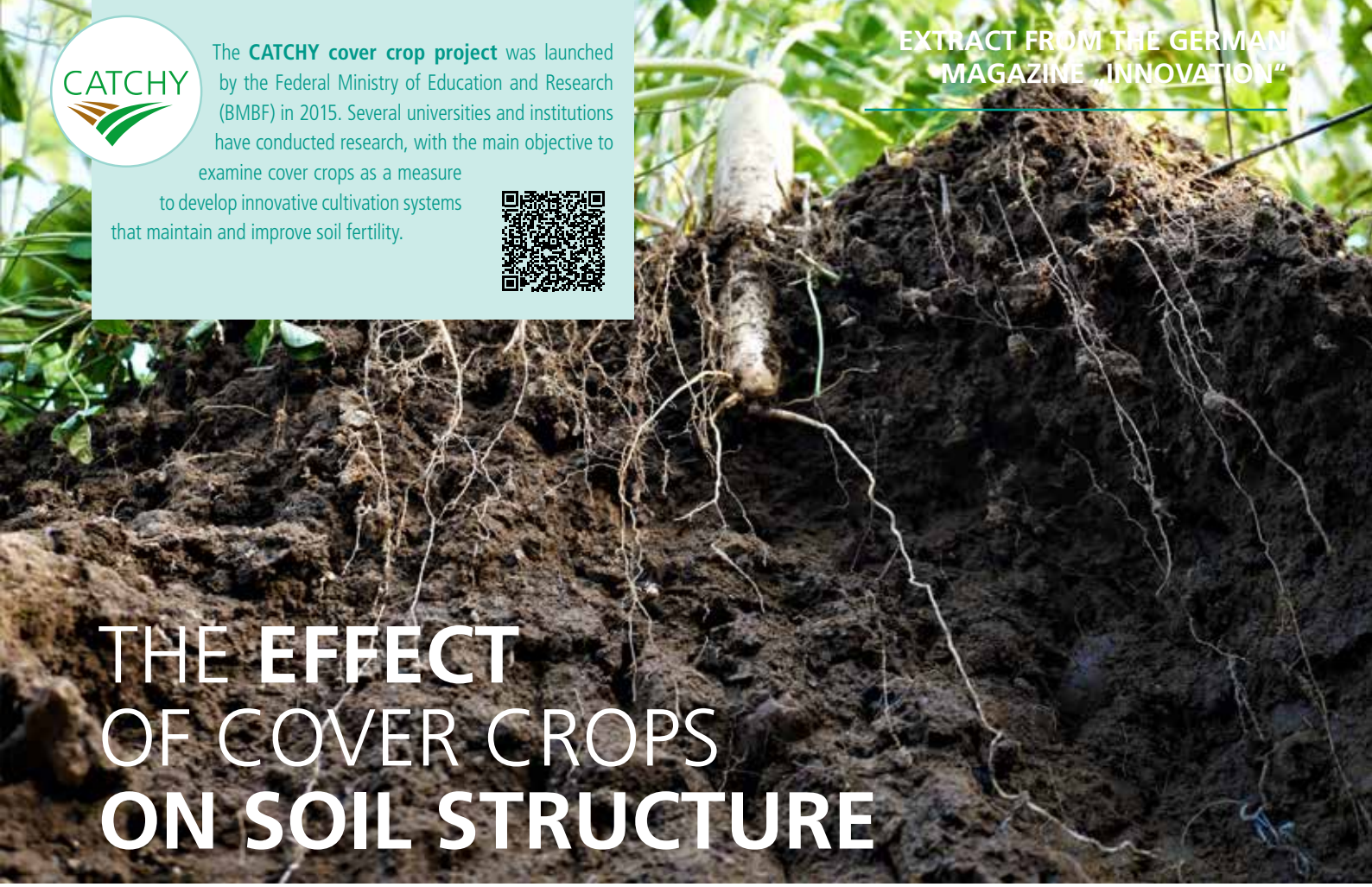
CATCHY

The **CATCHY cover crop project** was launched by the Federal Ministry of Education and Research (BMBF) in 2015. Several universities and institutions have conducted research, with the main objective to examine cover crops as a measure to develop innovative cultivation systems that maintain and improve soil fertility.



THE **EFFECT** OF COVER CROPS **ON SOIL STRUCTURE**

The intensity and frequency of extreme weather conditions is increasing. Drought, heat, wind, heavy rain and wetness – these weather effects have a major impact on the soil and are an enormous challenge for agriculture. Dr Norman Gentsch from the Institute of Soil Science at the Leibniz University of Hanover shows how these challenges can be met with the help of various cover crop mixtures using his results from the CATCHY project.

One of the main causes of soil degradation on agricultural land is erosion caused by wind or water. However, successive integration of cover crops into the crop rotation can improve the soil structure and thus increase the soil's resistance to erosion.

The results of the CATCHY project demonstrate why a diverse cover crop mixture provides the highest stability of soil aggregates compared to fallow and other cover crops.

»The successive integration of cover crops into the crop rotation can be used to improve aggregate stability in cultivated soils.«

Dr Norman Gentsch

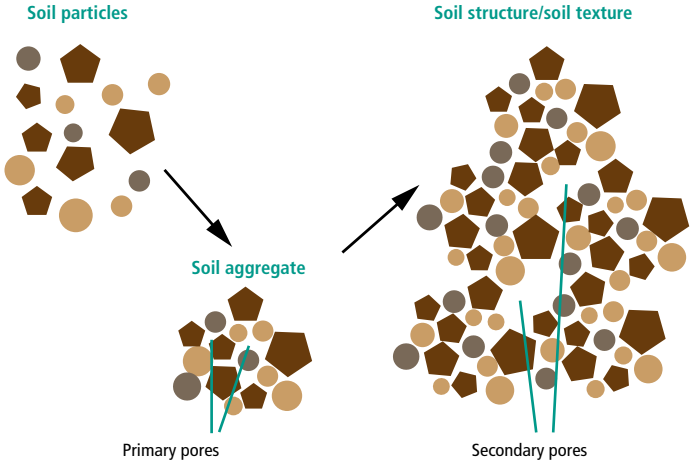
Why do I need a good soil structure?r?

The soil structure is an important indicator of the condition of the soil and its fertility. It describes the structure of the solid soil particles and the pore space between them. It is therefore an important regulator for water and nutrient flows, gas exchange with the atmosphere and for biological activity. A good soil structure reduces waterlogging and makes the subsoil more accessible to the roots.

This means that more nutrients and water are available for plant growth. A stable soil structure also increases resistance to damaging effects such as wind and water erosion or compaction from being driven over. Within the limits set by the soil type (texture) and soil chemical parameters, the soil structure can be improved by cultivating cover crops. Plants have an influence on this through direct and indirect pathways:

- Root morphology – differences between plants in rooting depth, root density and root diameter affect biopores in the soil;
- Root exudates – Root exudates have either a direct effect on aggregate stabilisation or an indirect effect via processing by microorganisms and their excretions;

FIG. 1: THE SOIL STRUCTURE IS COMPOSED OF SEVERAL SOIL AGGREGATES.



- Litter quality – the decomposition of energy-rich litter mobilises polysaccharides as a binding agent for soil particles;
- Soil organisms – Plants influence the activity of soil organisms, which use secretions and excretions to firmly bind soil particles together. Soil fungi in particular are key organisms.

By the selection of crops grown in the field, whether as cover crops or main crop, different effects on the soil structure can be achieved. For example, studies show that the macro-porosity and aggregate stability during the growth of different cover crops depends on their root morphology. In general, the soil contains a mixture of aggregates of different size classes. These different soil aggregates are composed of smaller soil particles held together by organic binding agents.

Several soil aggregates (also known as micro-aggregates) combine to form macro-aggregates and form the final soil structure. This is also illustrated in Fig. 1. Larger aggregates in the soil favour larger pore diameters (primary and secondary pores) and thus improve the flow of water, air and nutrients in the soil, but also the resistance to stress effects (e.g. water erosion). In the laboratory, the stability of the soil aggregates is measured after a defined application of force (e.g. by water). Depending on the more aggregates can withstand this, the more stable the soil structure in the field is against the effects of stress (e.g. harmful compaction or erosion by wind and water).

Root activity promotes soil stability

The aggregate stability of the different cover crop variants was examined in the CATCHY long-term field experiment after the second cover crop.

To exclude the direct influence of the different plant species, the measurements were not carried out during the vegetation period of the cover crop, but in October after sowing winter wheat after maize.

In the trial, all crop rotations with cover crops had between 10 % and 19 % higher mean weight diameter of water-stable aggregates

»Different effects on the soil structure can be achieved by selecting the crops that grow in the field, whether as cover crops or main crops.«

Dr Norman Gentsch

Compaction and wind erosion are symptoms of poor soil structure. Within the limits set by the soil type (texture) and soil chemical parameters, the soil structure can be improved by cultivating cover crops.

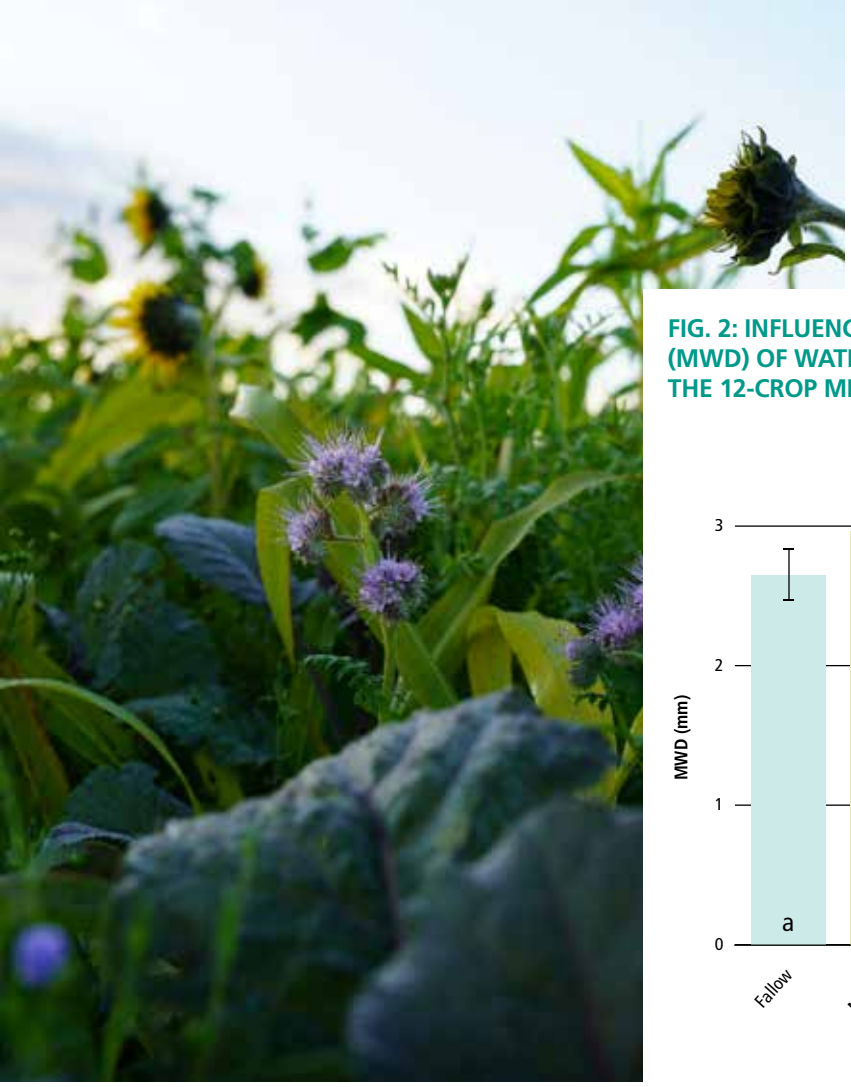
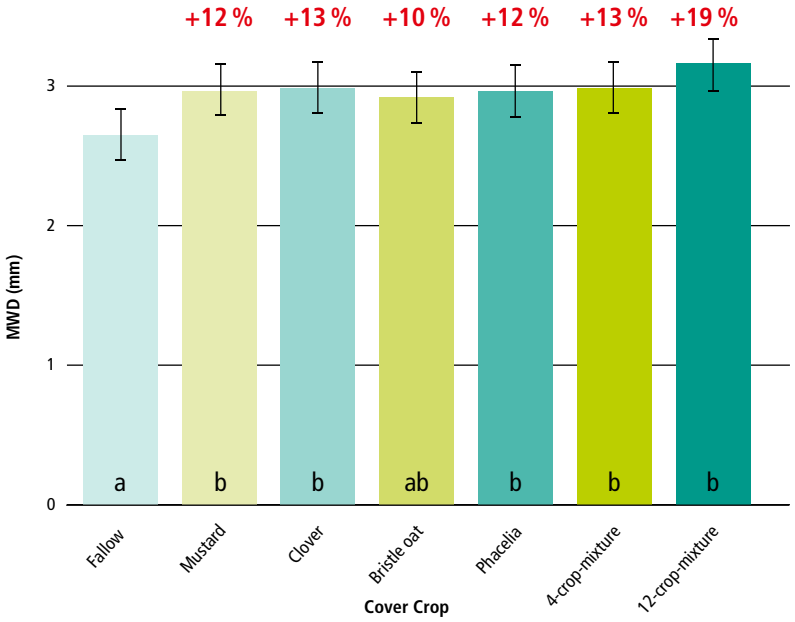


FIG. 2: INFLUENCE OF COVER CROPS ON THE MEAN WEIGHT DIAMETER (MWD) OF WATER-STABLE AGGREGATE IN THE SOIL. AT 19 %, THE 12-CROP MIXTURE SHOWS A HIGHER MWD THAN A FALLOW.



Small letters indicate the affiliation of statistically different treatments. The red values indicate the increase in MWD in per cent compared to fallow. Source: Gentsch et al. 2024, adapted.

(MWD) compared to fallow. The highest MWD was measured under the 12-crop-mixture (TerraLife®-MaizePro DT 50), followed by the 4-crop-mixture and Egyptian clover. Ongoing studies show that cover crop mixtures channel more photosynthesis products into the root zone than pure seeds. Despite its lower root mass, clover as pure seed promotes strong microbial networks, which could explain its positive effect on aggregate stability.

Every soil cultivation (e.g. seedbed preparation) leads to changes in the aggregate structures and thus to changes in the pore volume in the soil. Loosening increases the volume of coarse pores, which on the one hand is good for germination and aeration. On the other hand, however, tilling reduces the medium-sized pores that are important for water storage and destroys macro-aggregates and pore systems. This can have a negative effect on susceptibility to erosion and soil water reserves available to plants. Cover crops can at least partially compensate for negative effects caused by cultivation measures. All cover crops examined showed improvements in aggregate stability, with biodiverse cover crop mixtures showing the highest potential. The long-term establishment of cover crops as an integral part of the crop rotation improves the formation of larger and more stable soil aggregates. This stabilises the soil structure and leads to increased load-bearing capacity as well as protection against erosion and silting, especially during periods of high precipitation.

Conclusion

Multi-layered cover crop mixtures improve the formation of water-stable soil aggregates (Ø + 19 %), both in comparison to fallow as well as to cover crops in pure seed. The resulting optimised soil structure is the basis for healthy soil and the agriculture that takes place on it. The basis for the strengthened soil structure is the input of diverse organic matter into the soil by the cover crop mixture. This enriches nutrients in the soil, activates soil life, forms soil organic matter and, in addition to an optimised structure, provides fertile soils in the long term. In this way, not only is the soil protected from damage and erosion, but a depletion of the nutrient pools and soil microbiology is also prevented. This is an essential process for successful agriculture, especially in times of extreme weather and increasingly limited use of fertilisers and plant protection products.

Dr Norman Gentsch
Institute of Soil Science
Leibniz University of Hanover
gentsch@ifbk.uni-hannover.de