

# STEPPING UP SUSTAINABLE FARMING EFFORTS



Climate change brings the spotlight on humus content and its central role for our soils. Not only is humus one of the earth's primary CO<sub>2</sub> stores, it is also instrumental for the ability of soils to store plant-available water for plants to survive in extended drought periods. Grass species and clover-like plants are humus increasing species. This has been shown by long-term experiments by the Kiel University in northern Germany.

Kiel University has been researching into the carbon storage capacities of permanent grassland, field and clover grass since 2004. The trial setup comprises two permanent plots in loamy sand – one plot being farmed organically (Lindhof site) and one conventionally (Hohenschulen site). The carbon reserves in and also the carbon inputs into both sites were observed to derive options for controlling these levels in the long run.

## How to secure and increase humus content

As European winters become warmer, biomass in the soil is expected to rot faster and more thoroughly. This is because, the organisms that are responsible for the rotting process stop their activities only when soil temperatures drop below 0 degrees.

As this happens less often today, we must step up our efforts to simply secure the existing levels of humus in our soils.

Options to achieve this are to reduce the intensity of cultivation on the one hand and add more humus-producing crops and catch crops to the rotation on the other. Such crops include field and clover grass. After all, all humus balancing methods have shown that these grasses supply more humus-building soil carbon than other crops. This is shown in table 1. These calculations were made after the crop had been harvested and removed from the field. Grasses and clovers are great suppliers of humus because they produce plenty of biomass (stubble and roots) which can be incorporated in the soil to nourish the following crop. At the same time, their system of fine roots is constantly expanding and renewing itself and the residues of grass, leys and clover grasses are rotting after the cut, supplying carbon at considerable and yet often underrated levels to the soil. Another way of improving the humus balance and carbon reserves is the application of slurry and manure.

One tonne of humus stores about 580kg of carbon, the release of which would lead to an emission of about 2.1t of CO<sub>2</sub>. According to calculations by Thünen Institute, farmed land stores around 2.4 billion tonnes of humus, which presents the most important carbon reserve in Germany. It becomes obvious that the management of soils has an enormous impact on the conservation and increase of soil carbon reservoirs and consequently on climate change!

**TABLE 1: HUMUS-BUILDING SOIL CARBON LEVELS SUPPLIED BY VARIOUS CROPS**

Crop	Humus balance	
Field grass	<b>Plus 700-800* kg C/ha</b>	Humus building
Silage maize	<b>Minus 800 kg C/ha</b>	Humus draining
Cereals	<b>Minus 400 kg C/ha</b>	

\*= Per harvest year as a main crop; Depending on yield level  
Source: VDLUFA; [https://www.vdlufa.de/download/Humus/Standpunkt\\_Humusbilanzierung.pdf](https://www.vdlufa.de/download/Humus/Standpunkt_Humusbilanzierung.pdf); p.12f



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## Stubble and root production translates into a consistent supply of humus

In the above experiments, the researchers found that the levels of organic carbon reserves in the soil and also the inputs of carbon varied over the course of time. Carbon input levels are measured by measuring the stubble and root material that is formed. Fig. 1 compares the amounts of ash-free stubble and root biomass that were formed annually from various crops in the organically farmed plot at the Lindhof site. The graph compares three forage production systems (a) and three individual crops in forage rotations (b).

A significant increase in humus-building material was observed in 1 (a). This was attributed to the root and stubble material that rots every year in the permanent grassland that was established in 2010.

stubble material that figure 1 attributes to wheat stems in fact from the clover grass. This shows that undersown clover grass can increase the humus levels in cereal crops. The photo below shows such trial plots in which grass was included in grain rotations.

## Clover grass is instrumental

In addition to the crop rotations discussed in figure 1, the trial also looks at two organically grown crop rotations. These findings illustrate again the fundamental role of clover grass.



The trial was set up in a field with uniform soils which had been under an organic regime since 1995. In five plots legumes (clover-grass and grain legumes) made up 40% of the rotation. Each cash crop/legume plot received a fertiliser treatment of an average of 70kg N/ha per year. When the trial started in 2010, the average amount of carbon was 48.6t C<sub>org</sub>/ha in the 0-30cm layer.

Figure 2 shows the changes in organic carbon and the amount of humus by crop and slurry application in the 2011 - 2020 period. It was observed that the carbon reserves were strikingly high in those plots where arable land had been converted into permanent grassland:

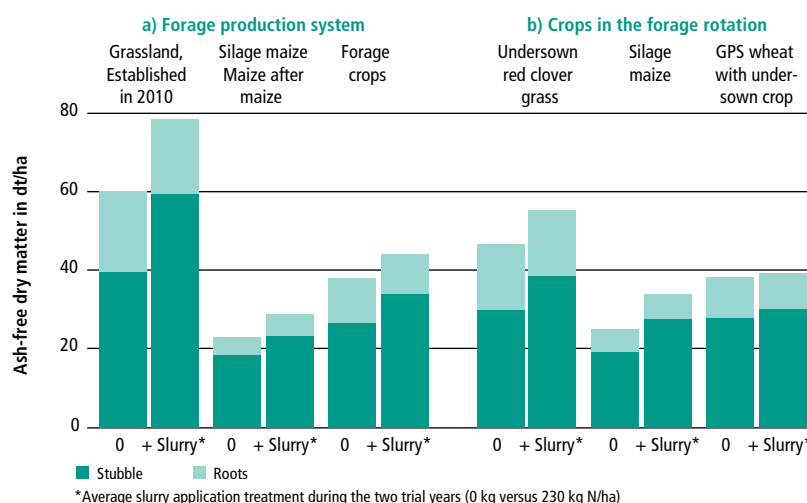
- 4t C<sub>org</sub> per hectare and year without an additional slurry treatment
- 12t C<sub>org</sub> per hectare and year with intensive slurry treatments

» **FROM A CLIMATE PERSPECTIVE, LONG-TERM GRASS PRODUCTION ON ARABLE LAND SHOULD NOT BE TURNED BACK INTO ARABLE PRODUCTION OF OTHER CROPS** «

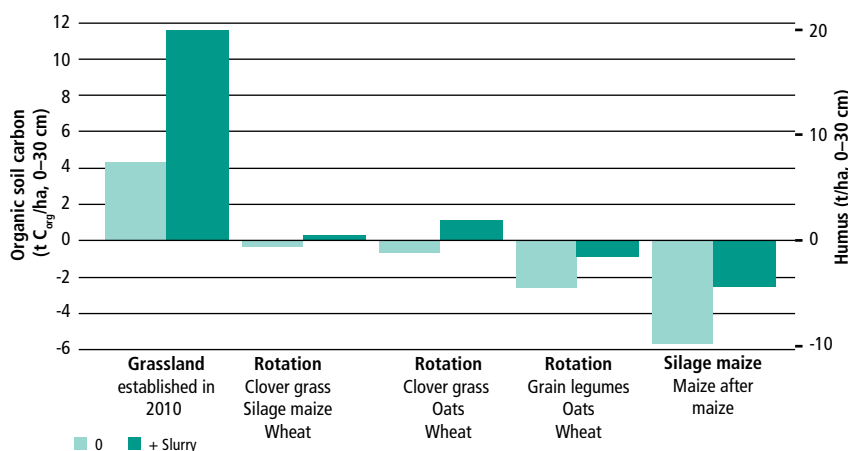
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Graph 1 (b) shows that red clover grass is the biggest supplier of ash-free biomass to a forage crop rotation, followed by winter wheat whole crop silage where the clover grass had been an undersown crop in the previous year. The undersown clover grass was cut as early as in autumn for silage making. This means that some of the root and

**FIG. 1: COMPARING CROPPING SYSTEMS AND THEIR HUMUS-BUILDING POTENTIAL**



**FIG. 2: VARIATIONS IN SOIL CARBON RESERVES BY CROPPING SYSTEM AND SLURRY APPLICATION<sup>1</sup>**



<sup>1</sup>(0 versus 230 kg N/ha) at the Lindhof site in the period 2011 to 2021

### Facts to bear in mind when adding field or clover grass to a rotation

Clover-grass stands are self-sufficient on nitrogen. As a rule, they fix 250kg to 300kg of atmospheric nitrogen per hectare and year and re-introduce it into the cropping cycle. This means N fertiliser applications can be reduced. N fertiliser is harmful to the climate and the production of it is high energy process.

By comparison, arable crops with no under-sown clover grass were found to deplete the humus stores. The same applied to silage maize after silage maize although plenty of slurry was applied here. Clover grass proves to be an important contributor to carbon levels in the last two rotations. Compared to the initial status, it was found however that humus will only be formed if this type of management is combined with intensive slurry application (fig. 2).

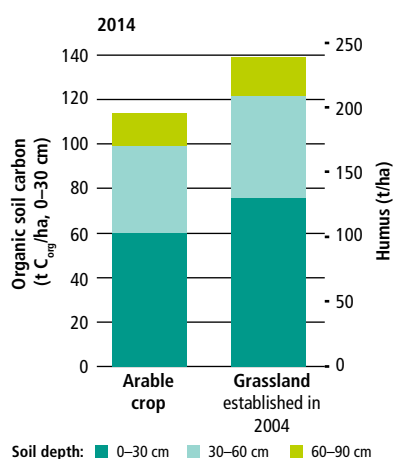
### And what about conventional farming?

In the conventional crop rotation trial, the first step was to establish a permanent grassland without using the plough. This was done in August 2004 in three fields with a



Red clover has positive long-term effects on the building of humus and is a habitat for insects which feel magically attracted by the flowering splendour.

**FIG. 3: THE HUMUS BUILDING POTENTIAL OF GRASSLAND**



long history of oilseed rape, wheat and barley in the rotation. Then the field received an optimal N treatment that allowed a slight N surplus of 40kg/ha parallel to the initial crop rotation.

Figure 3 compares the amount of carbon reserves in the grassland and in the unchanged rotation of arable crops and shows that more than 23 tonnes of organic carbon accumulated during 10 years!

### Conclusion

Based on the long-term findings of Kiel University, we can draw the following conclusions:

- Grass and clover grass are essential contributors to the carbon reserves in the soil and help to secure and increase the current levels. It is extremely difficult for organic farmers to secure the humus content of their arable land without adding clover grass to the rotation.

- In perennial grass stands, humus reserves increase more in the first few years of the cropping system than in later years.
- Also, permanent grassland that had been turned back into arable crop production for the trial showed significantly higher annual humus depletion rates than the fields that were converted from arable production to permanent grassland.

### Dr Ralf Loges

Institute for Plant Production  
and Plant Breeding,  
Grassland and forage  
Production/Organic farming  
Tel. +49 431 880 4654

