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Soil Organic Matter Importance, Assessment, Methodological Problems

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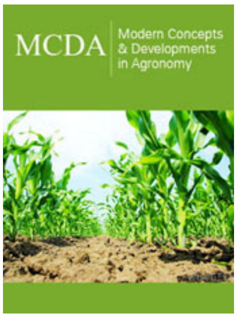

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Abstract

Soil Organic Matter (SOM), also known as humus, is the prerequisite for soil formation and one of the basics for human and animal nutrition. As a result of climate change, a reduction in the CO2 - concentration in the atmosphere is expected due to "Carbon Sequestration". Determination and evaluation of SOM still involves many problems. There are no scientifically based guide values for the (site-specific) humus content of the soil. Total levels say nothing about the supply status of the soil with organic matter. An assessment of the supply status is therefore carried out using the so-called humus balance method according to VDLUFA. It is necessary to differentiate between permanent humus and nutrient humus. Permanent humus cannot be determined analytically, but its delimitation can be proven experimentally in long-term field experiments. The nutrient humus is subject to constant conversion by soil organisms. Its average content is 0.3% organic carbon (C_{org}). This and Nitrogen (N) in the soil have a high spatial and temporal variability. In one field, the differences in C_{org} - content are often more than 0.5 percentage points; however, with 0.2 percentage points C_{org} already makes the difference between "well cared for" and "impoverished". On the other hand, there is an upper limit for the humus content, exceeding which would otherwise cause environmental pollution. With an accumulation rate of no more than 10% and a carbon content of 40% in the dry matter of the plant, carbon sequestration is already arithmetically excluded. Due to the lower yields and thus lower harvest and root residues, the humus supply of the soil in organic farming can only be secured with very high animal stocking densities.

Introduction

Humus (organic carbon and nitrogen in the soil) is the prerequisite for soil formation, the maintenance of its fertility and thus the basis for human and animal nutrition. In connection with climate change, humus became the focus of interest at the end of the last century and CO_2 has become a lucrative trade item. Ideas about saving the climate through "Carbon Sequestration" have been and are being discussed a lot and completely unrealistic expectations have been raised [1,2]. The public is increasingly confronted with reports that convey a distorted picture of modern agriculture and are likely to publicly discredit the industry. Since 2012, scientists have been dealing with widespread misinformation about agriculture and corresponding corrections on the internet platform www.agrarfakten.de. The complex structure of effects of land management is dealt with on the basis of many years of results and experience according to the current state of knowledge on many problems relevant to practice. In 2022, these works were also published in book form [3]. In this context, the results on the humus question and supply, in particular on the basis of long-term experiments, were also worked out, to which reference is made below [4].

Key Statements on the Humus Supply of Agricultural Soils

1. The terms "humus" and "Soil Organic Matter" (SOM) are mostly used synonymously today.

Humus = Soil Organic Matter (SOM)

=organic carbon (C_{org}) in the soil * 1.724

= the living and dead organic matter integrated in the soil.

In practice, it is determined by converting the organic carbon content in the soil (C_{org}) using the above factor, which is ultimately not entirely correct. Therefore, C_{org} is mainly used in the argumentation and for comparisons. Humus is an essential carrier of soil fertility and is closely correlated with chemical, biological and physical soil properties. Optimum site and use-specific humus levels in agricultural land are a cornerstone of sustainable agriculture.

2. In contrast to almost all other relevant soil properties, there are (to date) no scientifically based standard or even orientation values for humus. This inevitably leads to irritation and misinterpretation. There is an almost functional relationship between the carbon content in the soil (C_{org}) and soil physical properties [5]. The humus content in the soil has always been divided into "permanent humus" (inert, stable) and "nutrient humus" (mineralisable, convertible). After many years of cultivation, a site- and cultivation-related humus content sets in and part of it is permanent humus. There is a very close correlation between clay content and permanent humus. Permanent humus is practically impossible to influence. Only the nutrient humus can be varied through management measures [6].

There is no laboratory method to determine the permanent humus content. However, a perennial bare fallow land allows an assessment/calculation of the permanent humus content.

Permanent humus is defined here as "the humus content that is not fallen below under field conditions if any fertilization and cultivation of "humus-consuming" plant species (better bare fallow) are omitted. This cannot then be determined analytically either, but it can be verified experimentally and, in connection with the evaluation of numerous long-term field experiments, which enables an assessment of the given and/or necessary amount of nutrient humus. Figure 1 shows a comparison of the C_{org} - content of bare fallow land with that of unfertilized crop rotation using some examples of long-term field experiments. The difference is minimal and only reaches a C_{org} - content of 0.1 percentage point at one location.

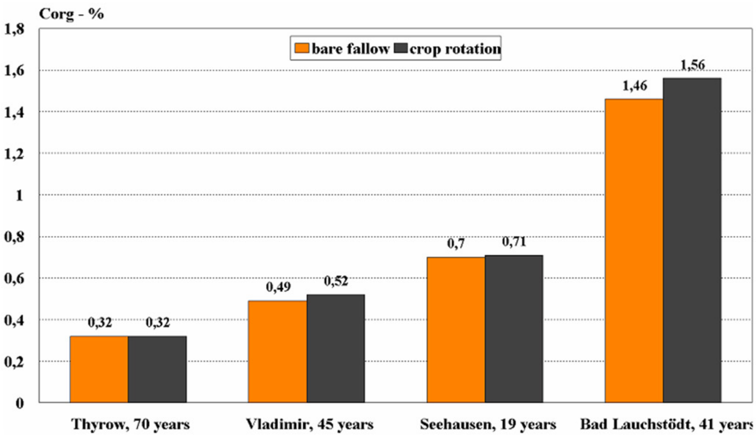

Figure 1: C_{org} - content in the ploughing layer in comparison with unfertilized crop rotation after many years experimental duration [6].

3. The nutrient humus is subject to constant conversion by soil organisms. Its content is on average 0.3% C_{org}, rarely exceeds 0.5% C_{org} and is e.g., T. well below 0.2% C_{org} (Figure 2). Total levels say nothing about the supply status of the soil with organic matter. For example, the sandy soil at the experimental station in Thyrow near Berlin is already well supplied with 0.7% C_{org}, but a C_{org} content of 1% is neither sensible nor possible. In contrast, a C_{org} - content of 1.5% on the Black Earth in Bad Lauchstädt is a sign of complete poverty.

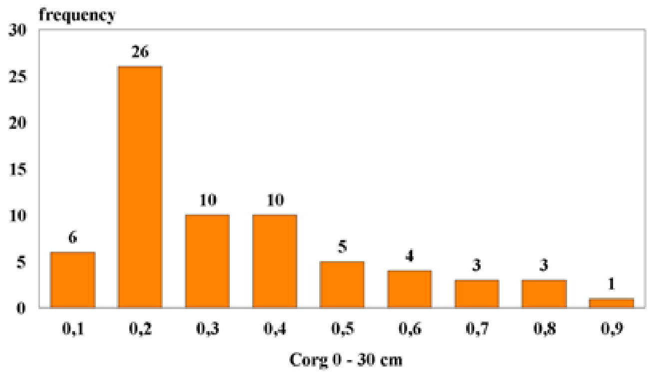

Figure 2: Difference in C_{org} - content between "unfertilized" and "optimal organic and mineral fertilization" in the ploughing layer of 68 long-term field experiments. On average 33 experimental years [6].

4. C_{org} and N in soil have high spatial and temporal variability. In a loft (field), the differences in C_{org} - content are often more than 0.5 percentage points; however, 0.2 percentage points C_{org} often make the difference between “well cared for” and “impoverished”. During a year and also between the years, the results of the soil investigations often show differences of >0.2% C_{org} and are thus far more than ten times the annual change in the humus C_{org} - content, which at normal application rates of organic primary substance is only 0.01% C_{org}, i.e., 400 - 500kg C_{org}/ha (Figure 3). This results in methodological problems in determining humus levels. Figure 3 shows an example. The fluctuations between the years amount to 0.2% C_{org} even on the very homogeneous black soil under experimental conditions and are thus far above the changes that are actually possible. No hasty conclusions should therefore be drawn from short-term series of measurements [7].

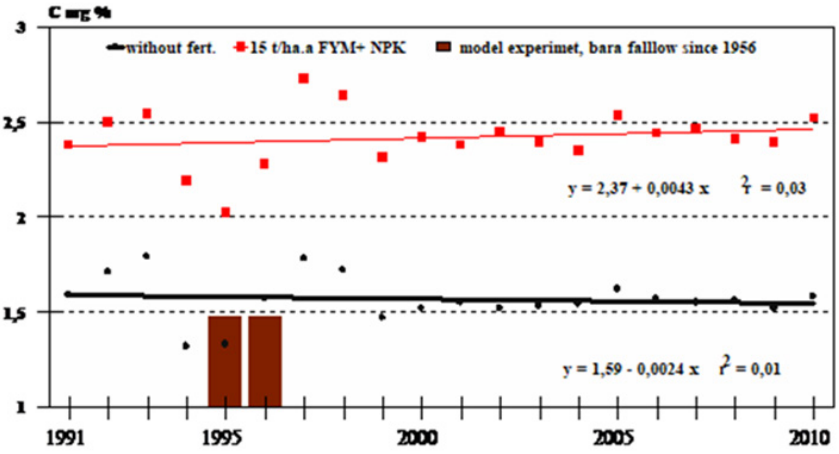

Figure 3: Dynamics of C_{org}-content, depending on fertilization in the Static Fertilization Experiment Bad Lauchstädt [7].

5. The humus balance method [8] is currently the only operational control instrument to achieve the optimum humus content specific to the location and use. A balance surplus of between 0 and +150kg humus C_{org}/ha is the aim, in order to ensure the site-specific soil humus content. The currently used humus balance method of the VDLUFA needs to be updated and specified, primarily for maize of different cultivation forms. This requires complex laboratory and field experiments.

6. With the positive yield development in recent decades, increased amounts of harvest and root residues remained in the soil. The humus balances in farms vary between extreme values of -1000kg and +1000kg humus C_{org}/ha with an average of approx. +200kg humus C_{org}/ha. The humus supply of the soil was thus improved. There is an upper limit for the humus content, exceeding which causes environmental pollution. Strongly positive humus balances lead to undesirable nitrogen losses and are also unsuitable for climate relief (no “CO_2 sink”!). Persistently negative humus balances, on the other hand, endanger soil fertility and productivity.

7. Using the soil as a carbon sink, as is being sought in connection with climate change, can be practically ruled out. Almost all humus sources, such as harvest and root residues, straw, organic fertilizers from animal production, fermentation residues, green manure, compost, (pollutant-free) waste are already being used. Additional C accumulation in the soil requires a correspondingly higher plant production. More than 90% of the primary organic substance added to the soil, based on the starting substance of plant biomass, is mineralized again and the carbon contained therein is returned to the atmosphere. This means that, purely mathematically, the discussion about saving the climate is superfluous by carbon sequestration. With an increase in the C_{org} - content by 10% and assuming around 40% C in the plant dry matter, 100 to 120t/ha of plant dry matter are necessary to increase the C_{org} - content of the soil by just 0.1 percentage point (4-5t/ha) [9].

8. In organic farming, the N-nutrition of the plants comes mainly from the cultivation of legumes and generally through the mineralization of organically bound nitrogen. Due to the lower yields and thus lower harvest and root residues, the humus supply of the soil in organic farming cannot be adequately secured by increased catch crop cultivation and green manure. The cultivation of legumes and “humus-producing” plant species is also only possible to a limited extent. The humus supply can only be secured with very high stocking densities.

9. The generally improved application technology for stable manure and compost and above all the near-ground manure distribution or the introduction of manure into the ground led to a significantly improved utilization of organic fertilizers and reduced greenhouse gas emissions. The previous energetic utilization of manure and liquid manure reduces the content of the easily degradable C_{org} which is recommended.

10. In principle, the global demand for food, industrial and energy raw materials can only be met with needs-based mineral fertilizers and sufficient humus supply.

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