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Soil Compaction on Farmland through Large Farm Machinery

Due to structural changes in agriculture and further developments in agricultural technology the total weight of many machines has increased extremely during past years, which can damage the subsoil. Therefore, some pedologists demand wheel load restrictions. Has the heavy machinery really compacted the soil more? Or has good agricultural management kept abreast with technical development, so that natural soil productivity is maintained? The goal of practical field tests in "Schleswig-Holstein" was to determine whether modern agriculture had caused additional heavy soil compaction.

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The "Institut für Landwirtschaftliche Verfahrenstechnik" at the University of Kiel (Germany) has been monitoring 17 fields for the last two years in Schleswig-Holstein. The aim of these trails is to describe the consequences caused by different methods of farming in the context of soil pressure. All the collected data will be compared to the status data that has been examined by [1] at 34 field trails in the prominent areas "Marsch", "Geest" and "Östliches Hügelland" in 1986/87. [1] had chosen the locations and their farms randomly, so the variation was covering all sizes of arable farms, all kind of farm outputs, and all conditions of mechanisation and crop rotation. In 2003 and 2004 some of these locations have been examined again, with conventional and newer methods. In all trials the mainland, the tramlines and the headlands, which obviously had strongly been affected by the agricultural machinery, were appraised. The reference to all the samples was the uncultivated "wasteland" at the field boundary of each tested field.

The evaluated parameters are physical soil consistence like the dry bulk density, the total pore volume and the pore volume distribution. Furthermore, the functional soil characteristics like the air permeability and the ability to a penetration by roots of summer barley have been measured in a core cylinder.

Results

Some of the results are shown in *Figure 1*, which represents the outcome from 10 singular field trials in the "Östliches Hügelland". The prominent soil type of this region is a sandy loam (sL). The depth of 10 and 20 cm describes the situation in the tilled soil horizon and the depth of 40 and 60 cm represents the actual compaction in the subsoil. Due to the fact, that a restoration of a structural damage in the subsoil is nearly impossible with common technology, a compaction in this layer has to be considered as very bad.

Certainly the total pore volume in the "uncultivated soil" and in the "mainland" was very high in the depth of 10 and 20 cm, this decreases fast to deeper layers. The "headlands" have a little lower total pore volume than the "mainland", but the "tramlines" show a very low total pore volume. The reason for this observable fact in the upper soil is the agricultural traffic in the tramlines under unsuitable conditions. From 40 cm downwards the total pore volume in the tramlines is similar to the "mainland". The subsoil has a nearly homogenous structure: The total pore volume is in between 38 to 39 % and there are no major differences between the two depths and the four sampled field regions. From this data it is obvious that the subsoil was only affected by the heavy agricultural traffic in the headlands and in the tramlines. The little differences in the data shouldn't be overestimated. Because of the natural heterogeneity, all the results in the depth of 60 cm have not been of a significant difference.

Like the total pore volume the macro pore volume in the soil is of high interest, too. Above all, the portion of pores that are big-

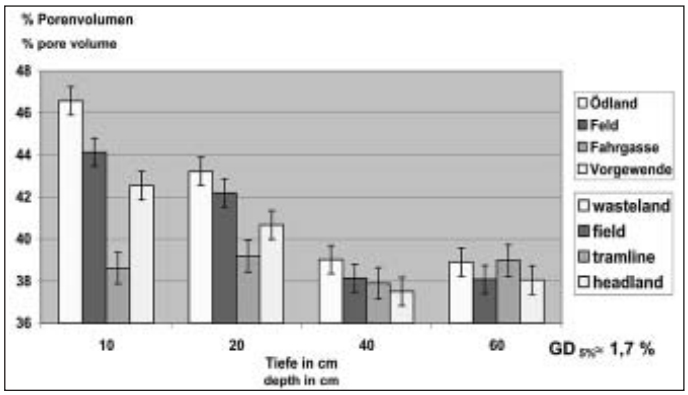

Fig. 1: Total pore volume 2003/04 in a sandy loam

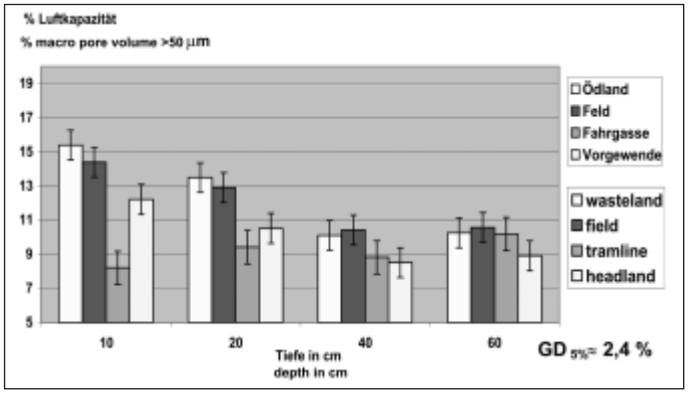

Fig. 2: Macro pore volume 2003/04 in a sandy loam

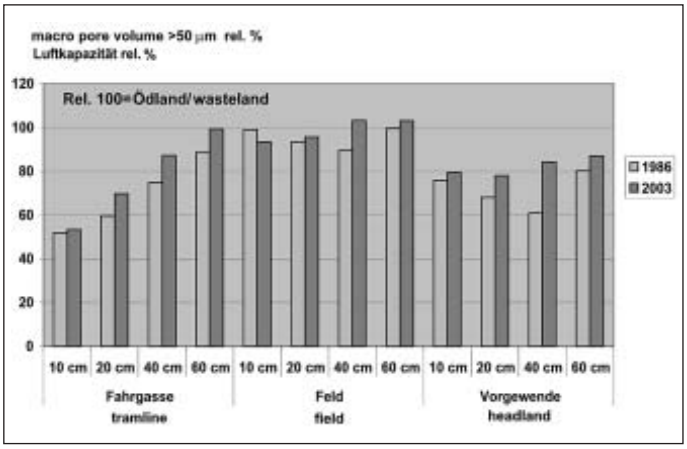

Fig. 4: Comparing macro pores of 1986/87 to 2003/04 in a sandy loam

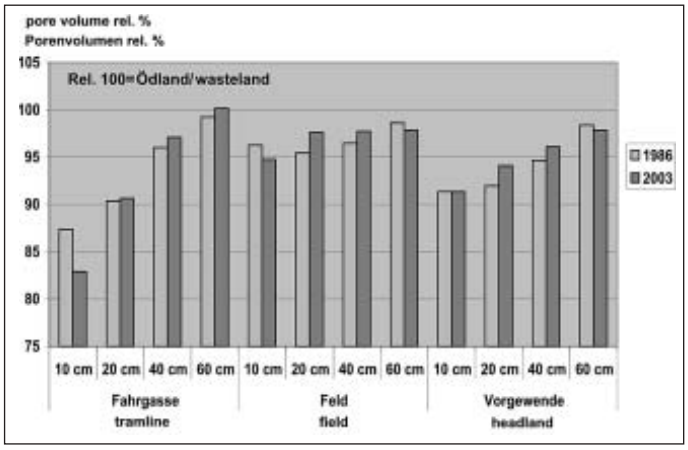

Fig. 3: Comparing total pore volume of 1986/87 to 2003/04 in a sandy loam

ger than 50 µm is essential for the plants. These pores enable the supply of air and water to the plant roots and do increase the ability to penetrate the soil matrix by roots. As expected, the ratio of the wide pores decreases in deeper layers (*Fig. 2*), too. It is remarkable that the areas of the "uncultivated soil" and the "mainland" look very alike from 10 cm downwards to 60 cm. If focusing the ratio of wide pores, 40 cm beneath the tramlines, these pores are diminished; in 60 cm the ratio does adopt the typical characteristics of the other groups again. In all the trials the strongly requested minimum of 5 % (e.g. [2]) was never exceeded. The actual value in the subsoil air capacity was between 9 and 10 %, which has no negative effect on the plants or in the context of soil compaction.

Comparison of 1986/87 to 2003/04

To compare 1986/87 and 2003/04, the data was taken from the appendage in [1]. Due to a change of the figures in the uncultivated soil, a direct comparison of the old and the new data sets was been impossible. Because of this fact, the relationship between each site-specific sample and the uncultivated soil was measured. So it was possible to distinguish the changes indirectly, which happened during the years. Because of the wide scattering in the whole examination, a comparison of the results was very difficult, and a significant outcome was impossible. Therefore the whole tendency of the analyses will be worked out with *Figure 3 and 4*.

As it is obvious (Fig. 3 and 4) the differences between the years 1986 and 2003 did not rise. In fact the opposite happened, most of the figures are higher than in 1986. A high increase is observable in the layer of 40 cm, the samples "headlands", "mainland" and "tramlines" had a higher percentage of the wide pores compared to the old data set. This is very remarkable because it happened to the soil layer, which is located next to the cultivated soil horizon and therefore it is very sensitive to high pressure and wrong cultivation operations. Maybe the changes of the mechanical conditions in the past had mainly a positive effect on the subsoil. Cultivation without ploughing is preventing the direct agricultural traffic on top of the subsoil, with today's wider machinery and a higher transport volume the "rollover" quantity shrank. Due to the high of the large farm machinery and a high share of wheat and colza in the crop rotation of Schleswig-Holstein, there is only little risk to work regularly in unsuitable conditions. Rare situations that lead to a short-dated damage in the soil matrix can be solved in the long term by the self-generating ability of the soil. From this thesis it could not be proven that there was a negative effect to the soil parameters of sandy loam by large farm machinery in Schleswig-Holstein.

Resume

In general there is negative soil compaction at the headlands and partially at the tramlines in Schleswig-Holstein. Notwithstanding there is development in agricultural technology and methods, some soils scientists spot threats to the soil even from low single wheel loads. This irritates the farmers, the scientific society and politics. The soil scientists mention the large machinery will damage the soil irreparably. The basis for this proposition was only taken from algorithmic simulations about the theoretical endurance of soil to pressure. The real interconnection between wheel and soil was never realistically depicted and the quintessence was never practically verified. It needs practical investigations in the fields to assess immediate and long-term effects on soil strain. The results of this practical investigation show that there is no disastrous situation in the fields of Schleswig-Holstein and there is no threat to the sustainability of the land. Farmers do have a very big natural and ecological interest to take care of the land as their main factor of production, even for the coming generations. Objectives of regulatory policy and individual aims do fit together very well. In general all farmers are extremely motivated to practice the modern "Expert Knowledge" (gute fachliche Praxis) as good as possible, so an specifically verbalised enactment of the "Bodenschutzgesetz" seams to be unnecessary.

Literature

Books are identified by •

[1] • *Sonderhoff, W.*: Messungen zum Status der Bodenverdichtung und Bedeutung von Mechanisierungsverfahren. Dissertation, Universität Kiel, 1988, Forschungsbericht Agrartechnik des Arbeitskreises Forschung und Lehre der Max Eyth Gesellschaft

[2] *Lebert, M. und H. Böken*: Vermeidung von Bodenverdichtungen auf landwirtschaftlich genutzten Flächen. Bodenschutz (2004), H.2