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# Good farming practice in the application of high-performance harvesting machinery

## Technical assessment of ground reaction to high wheel loads

*Within farm management the „soil-plant-climate" complex including rotation, cultivation, fertilisation, plant protection and harvest are accepted steps towards achieving high quality yields. Here the farmer uses a wide selection of highly-specialised and expensive technology which on cost grounds must be optimally exploited. But in order to remain competitive and environmentally protective at the same time damaging side effects must be avoided [1].*

*Good farming practice should be applied to avoid conflicts in this area. Here's an example involving soil compaction damage.*

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Demands for more productivity lead to larger machinery and vehicles with associated performance increases and field operations combining several functions at a pass which can reduce the number of journeys over the field.

The size and performance increases mean, however, that weight also rises – up to a total of 50 t which means a load per wheel of over 10 t. This applies to large bunker-capacity harvesting machines. In the best scenarios, these operate on minimally cultivated and dry fields.

### Measuring methods with an example

With regard to the complexity of influential parameters in the interaction of tyres and soil there is no single method that answers all questions. Instead, there exists different possibilities of objectively addressing individual points as well as linking each with subjective impressions.

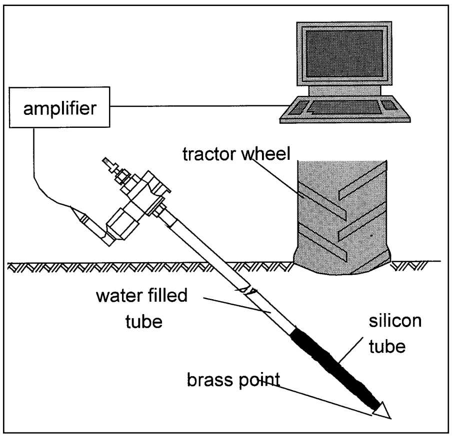
*Subjective judgement*

Good farming practice rests on experience and observation with which the ground can be judged regarding moisture content and condition. This is supplemented through the visible effect of the vehicle, for instance through wheelslip and track depth.

The reduced ground pressure deriving from the larger contact area of broad tyres and their resistant to tracking through soil displacement mean they perform better in this context. With this, parameters are identified that can be quantified and can lead to an objective judgement. It is the farmer himself, however that decides on the tolerable limit to the parameters. The final decision will differ according to the compaction condition and the moisture of the soil.

*Ground pressure*

The ground pressure resulting from the wheel load, tyre contact surface and tyre air pressure affects soil in-depth. Pressure, therefore, is measured through suitable sensors in untreated ground in topsoil as well as lower topsoil. The measuring system with pipe sensors has proved efficient in that it allows a large number of repeat and comparative measurements under practical conditions (*fig. 1*). The pipe sensor readings react to pressures throughout the entire surrounding area. From these, the sensor gives an average value for the pressure from various directions. As opposed to fixed sensors, the pipe sensor suits itself to the ground in question



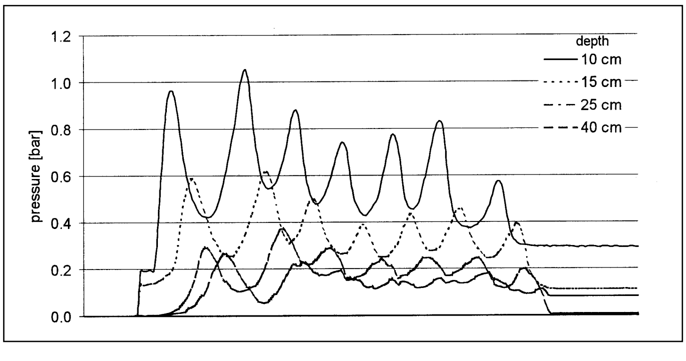




*Fig. 1: Ground pressure and pressure development measuring system under the crawler track pulleys*

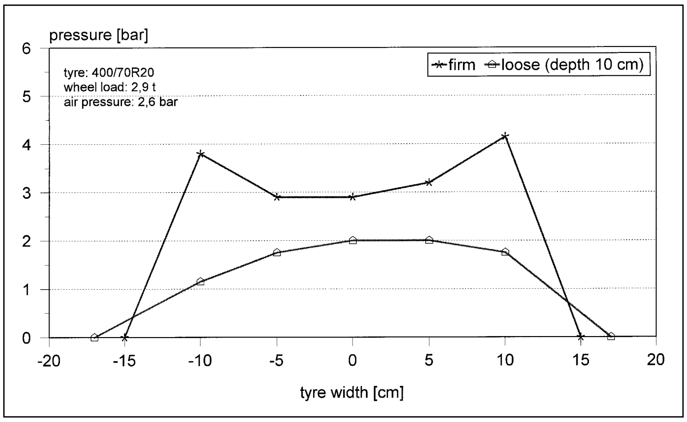



*Fig. 2: Contact area pressure over the tyre breadth*

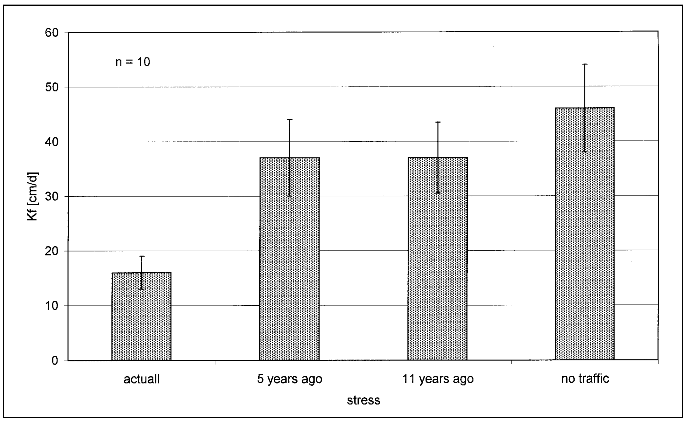



*Fig. 3: Effect of tracks on saturated water conductivity (depth 30 cm)*

and allows itself to be moved with the main flow direction of the ground. A fixed sensor doesn't follow the ground flow and therefore registers higher pressures [1].

The values correlated well with the air pressure and the parameters of the ground. Thus, this practical farming method gave a direct statement regarding the energy applied into the ground. The extent of this had an influence on whether the ground parameters altered.

The electronic measurement recordings allowed the collating of the additive effective of wheels following one another. Given as an example here is the pressure development under crawler tracks. Load bearers here are mainly the support and driving pulley rollers and not the entire track surface. Additionally, this method is very suitable for measuring the pressure distribution in the contact areas on compliant driving surfaces. Contrary to surfaced roads, ground yields when driven on and the high-pressure zones in each case are respectively different (*fig. 2*).

*Penetrometer*

The penetrometer identifies the firmness of the ground. The resultant measurements correlate very closely with the compaction and the water content of the soil [2, 3, 4]. In this way, the method is very suitable for direct comparison between tracks and ground which has not been driven on.

This measuring takes place with a practical instrument with the sensor pressed vertically in the ground, or with the horizontal penetrometer which is attached to the tractor and is suitable for large-scale operation.

*Pore volume and layer compaction*

Both these parameters identify ground compaction as well as physical factors in association with functions of the soil and its air and water household. From this point of view, the pores are grouped according to size. Especially the large rough pores (>50 µm) are important for the functionality and the compaction behaviour of the soil.

Sample taking took place on the field with stab cylinders of 100 cm$^3$ in multiple repetition and in near proximity to one another because the heterogeneity of the soil leads to a scattering of the results (1 to 2% points PV).

The pore volume is associated closely with measured ground pressure. On loose soil at sowing time, even a small pressure (>1 bar; FK 75%) leads to a significant reduction of pore volume. At harvest the ground is in a better load-carrying condition. Here, significantly higher pressures (>2 bar; FK 80%) are required for the ground to be compacted sustainably.

*Infiltration and conductivity for air and water*

The compaction of the soil alters the size of pores and their geometry and with this the ability to absorb, and conduct further, air and water. The respective conductivity (PL and Kf) is investigated in the laboratory and intensifies the measurement values on pore size distribution with regard to the function of the soil (*fig. 3*).

The infiltrometer has particular importance for conditions in the field. With this, it can be determined how quickly the soil can absorb a defined amount of water, analogue to natural precipitation. With this, only the surface effect is recorded, i.e. the effect of tillage or driving track.

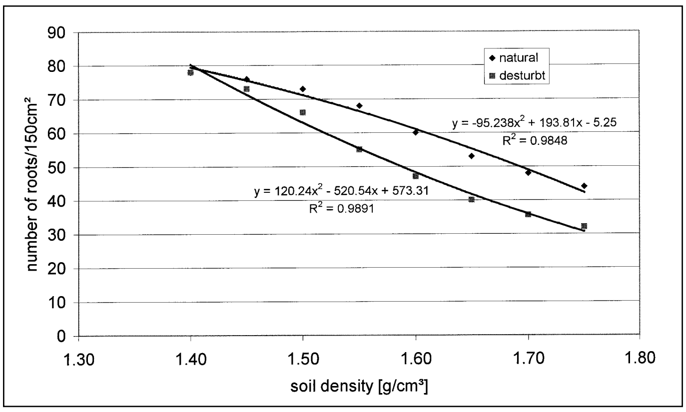
*Root growth test*

With this range of physically-determined methods it also appears as important to include a natural plant-associated method as indicator for soil condition. This takes place under uniform conditions in the laboratory but involving undisturbed samples from the field. These samples are taken from the sampling points in the field by the stab cylinder and therefore represent the track and non-driven field areas in the pre-planned depths. On the uniform cylinders of soil, caryopsis planted (20 on a total of 150 cm$^2$). The roots penetrate the soil according to its compaction, i.e. the resistance that has to be overcome (*fig. 4*). Soil and air moisture content are kept constant. Thus a physiological measurement for the respective compaction is given by the number of roots that appear on the underside of the soil cylinder after 10 days [5]. Samples which are manipulated in the laboratory to represent the conditions of consolidated ground react much more sensitively compared with natural soil samples.

## Conclusion

Several types of methods are available with which to register the effect of high wheel loads on soil. From the technological point of view, those that involve tests which allow results to be assessed on the field are of particular importance. From the agricultural point of view, the most interesting methods are those reflecting the function of the ground, i.e. the development of the crop.

*Fig. 4: Root growth possibilities with increasing soil compaction in undamaged and damaged conditions*



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