The horizontal penetograph an instrument for measuring soil compaction in a big scale

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Introduction

Soil structure characteristic influences plantgrowth and yield. Ecological relevant and soil fertility determining features depend on the extend of soil compactness. This influence the soil water budget (fig. 1) and soil nutrient situation. Transformation processes and storage capacity are also influenced by soil compaction. Of interest is the reaction of the plant which influences the yield. There is a strong correlation between root growth and the degree of soil compaction. The ability of roots to reach deeper zones depend on soil compactness and the penetration ability of the root, which is genetically fixed (fig 2).

On land the variations in the degree of soil compaction is a result of differing surface loads and number of drive over in the same lane. Soil humidity conditions are of great importance for the reaction of the soil to surface loads.

The vertical penetograph

The vertical penetograph is a widely used instrument to measure physical soil conditions. By forcing a cone pointed metal detector vertically into the ground, the resistance force for each depth is detected. To examine a field, a large number of insertions is needed. Depending on how inhomogeneous soil-compaction is distributed. To describe an acre at least 100 insertions are required. This demands a lot of time to be done. To enable a routine measurement of common agricultural fields a mechanised method is to be realised.

The horizontal penetograph

The idea is to change the direction of measurement, from vertical to horizontal measuring. A tractor pulled penetograph, that is adjustable to varying depth fits to this demand.

Construction of the horizontal penetograph

The sensor equipped implement is mounted rear to the tractor. Three penetration force measuring devices are connected (fig 3). They are positioned in a way to measure in different lanes and at different depth at the same time. The depth control can be done either by the hydraulic system of the tractor that keeps the carrier stable in a defined depth despite of soil unevenness, or by a pole support wheel. An ultrasonic sensor records the exact depth at which the penetration force devices are pulled through the soil. The speed and distance is recorded by a non-driven external wheel (Peisler-wheel). The exact location of the each measure point is therefore known.
The soil penetration measuring sensor consists of a cone at the peak and a round case that carries the force-manometer. The cone takes up the force of the breaking soil while driven through the earth and leads it directly onto the force-manometer. The diameter of the case is smaller than that of the cone, so that no shaft friction adulterates the measurement. The angle of the cone is 60 degrees because the stability of the material doesn't allow a 30 degrees angel as in the ASAE-norm recommended. The cone wears of too fast because the measuring speed of the horizontal penetograph is in meters per second.

In the literature (3,4) the need of a steady velocity is often demanded for the comparability of results. Freitag´s (2) and own measurements show that the influence decreases logarithmic, with increasing speed. Therefore the speed-difference of the tractor at two compared measurements plays a neglectable role to all other influences e.g. soil heterosity, moisture etc.

Method of measurement

The electronic parts are the force sensor, the ultrasonic depth control, the speed control and the computer. While measuring, all signals are recorded by the computer. A specially for this use developed computer program enables the interpretation of the measurements (fig. 4,5,6,7).

Interpretation of results

Petelkau (5) describes correlations between soil compaction and yield. The measured tractive force needed to pull the sensor device through each horizon was used as data. Regressions show that the standard deviation of the tractive force has a better correlation to the absolute height of yield, than the means square of the tractive force alone (fig. 8).

These results enable to assess an in homogenous field by statistical methods. The portable computer allows an on land evaluation of the measurement. If necessary a measurement can be repeated. The program gives the standard deviation and the frequency distribution of the defined area's results. This is displayed as curve (fig. 4,5) or diagram (fig. 6,7). A change in soil type (fig. 5) can be detected as well as a small area soil compaction (fig. 4).

Summary

Soil compaction can be measured with the vertical penetograph. Area covering measurement of soil compaction is not possible with this method. The required amount of measurements needed to insure a statistically correct evaluation of the field is too high for a standardarized application. The horizontal penetograph is an instrument which enables continuous measuring in different depths at the same time. An area covering characterisation of the status of soil compaction can be derived by the correlation between the horizontal penetration force and the soil compaction. Changing soil types are detectable and small area compaction can be tracked down.

Literature

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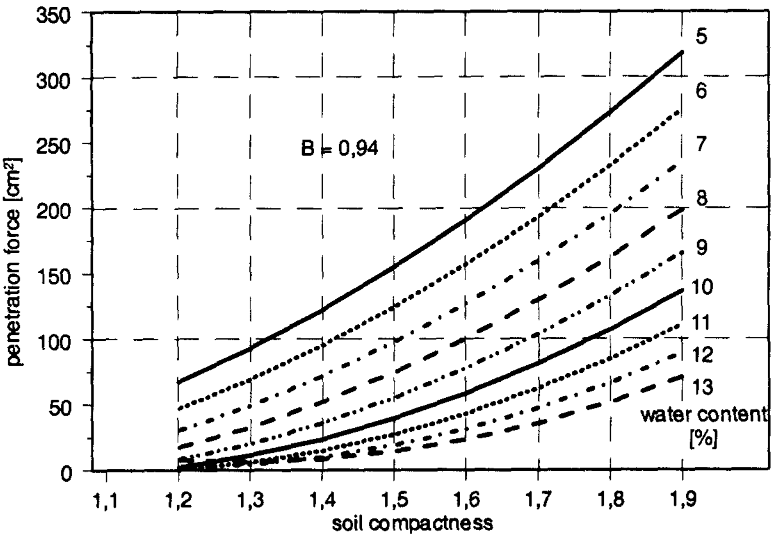

Fig. 1) Penetration force in dependence of soil water content
(ERMICH, LANDMAN 1982)

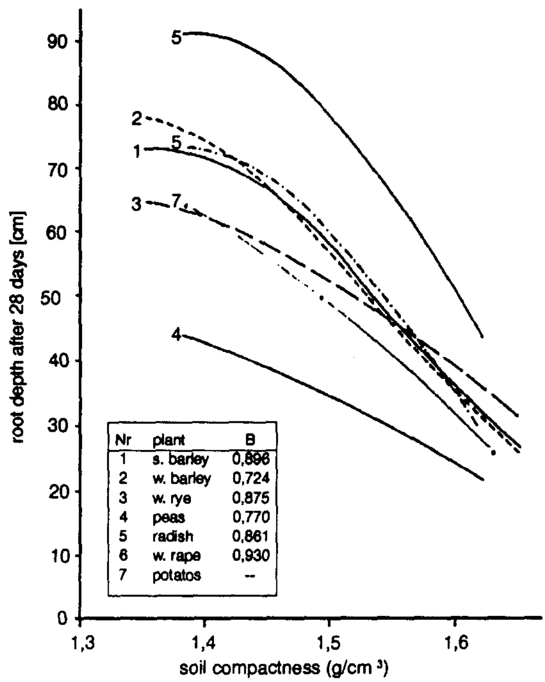

Fig. 2) Root depth after 28 days at different soil compactness states
(PETELKAU et. al. 1988)

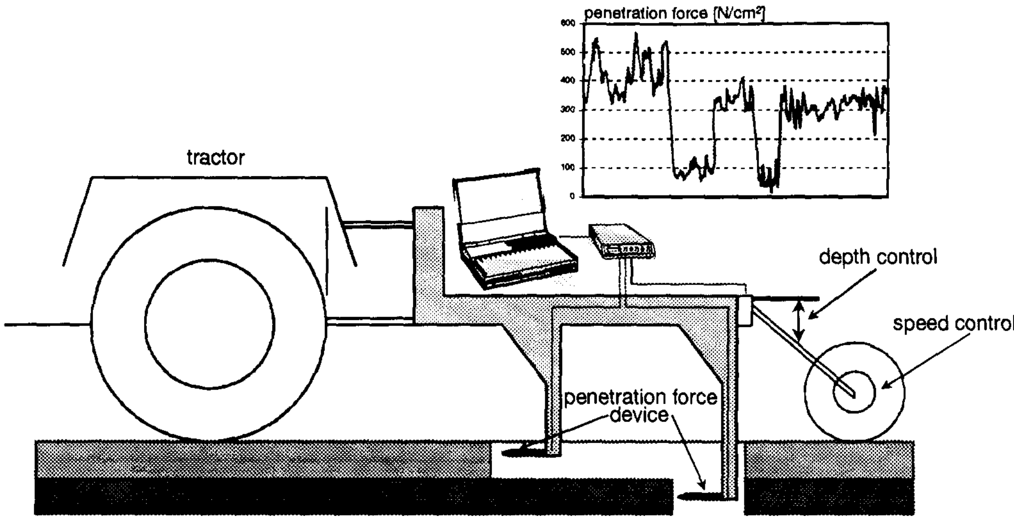

Fig. 3) Horizontal Penetrograph

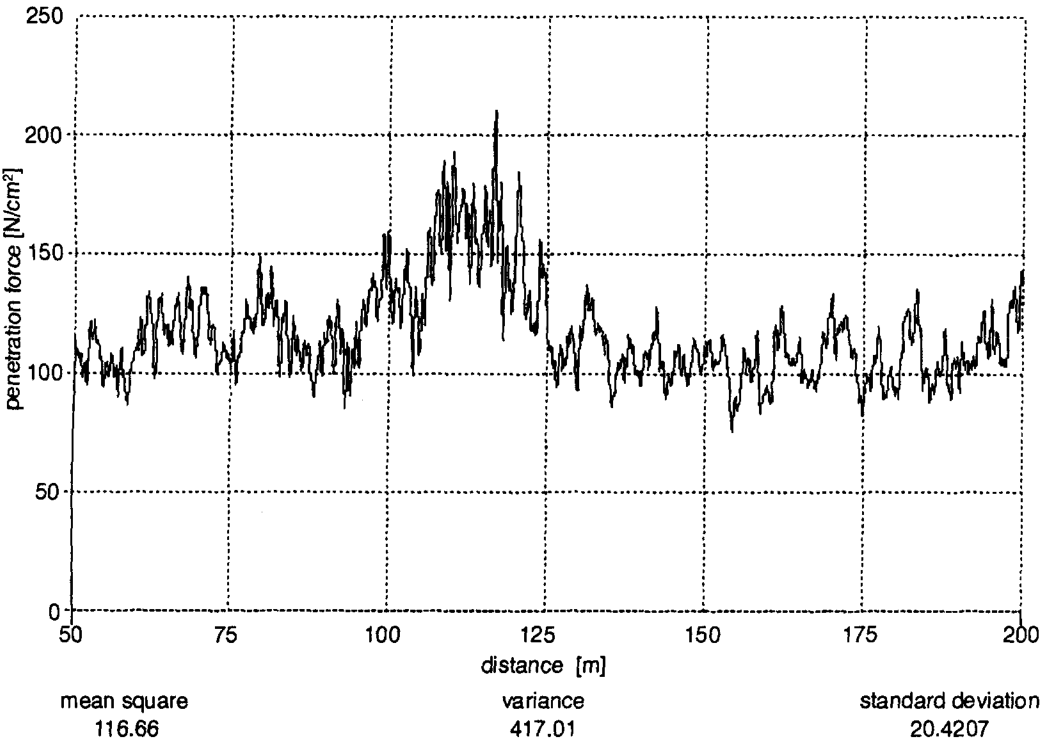

Fig. 4) Horizontal Penetrograph mesurment, showing compaction

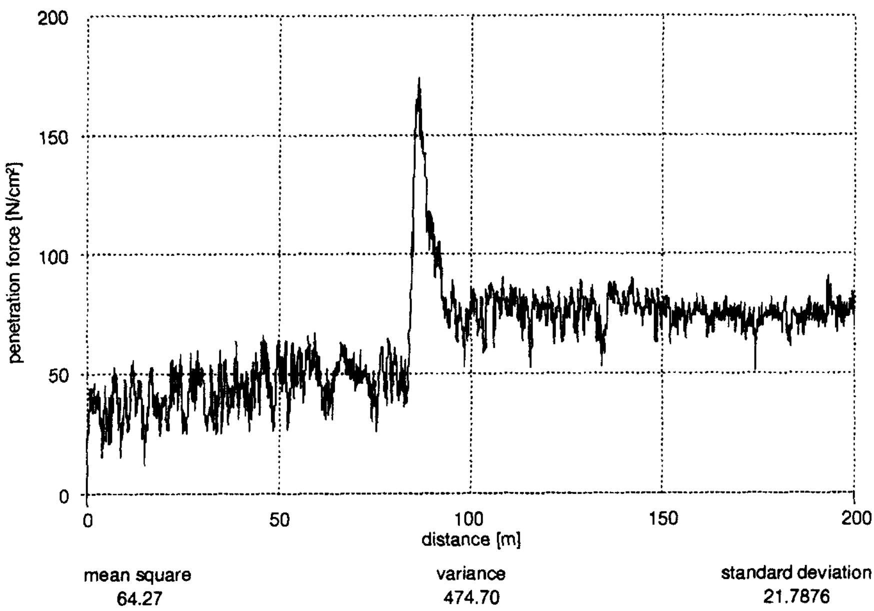

Fig. 5) Horizontal Penetrograph mesurment, showing change in soil type

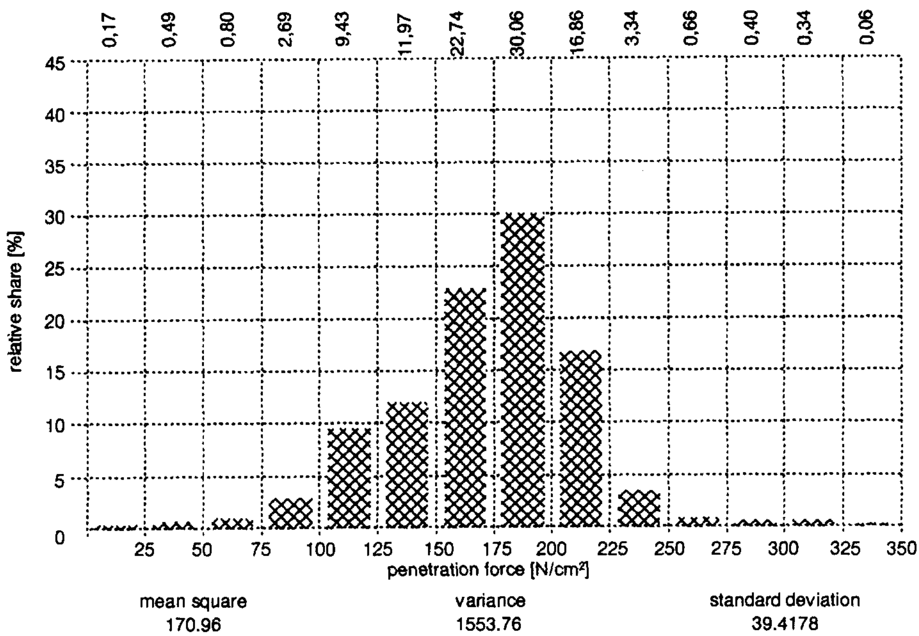

Fig. 6) Frequency of penetration force classes, showing wide distribution

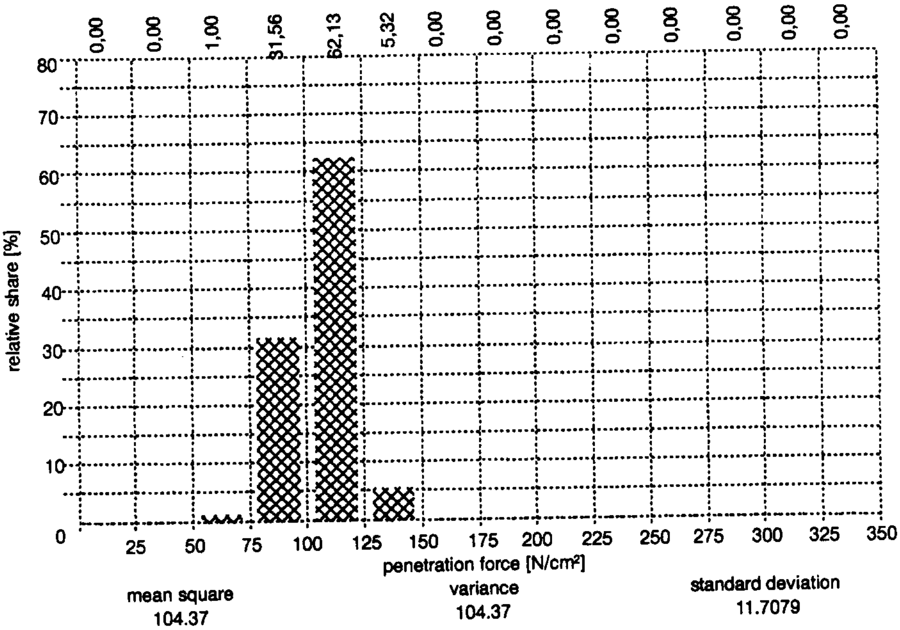

Fig. 7) Frequency of penetration force classes, showing homogenious soil

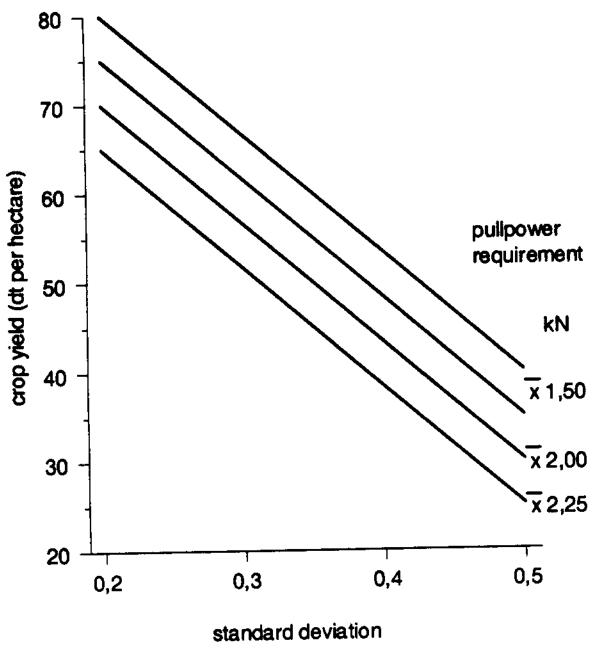

Fig. 8) Correlation of crop yield and standard deviation of pull power (PETELKAU et. al. 1988)

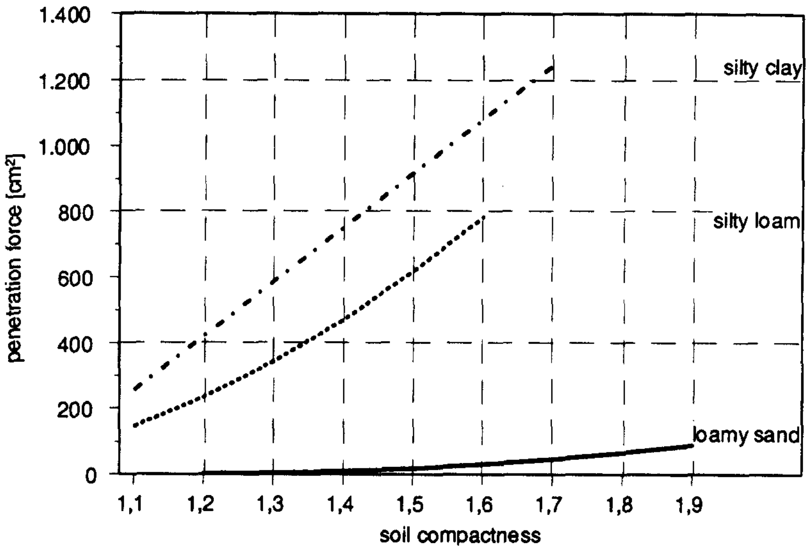

Fig. 9) Dependence of soil type and penetration force (ERMICH, LANDMANN 1982)