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Soil compaction damage

Technical possibilities for avoiding soil compaction in crop production

Soil compaction with negative effects on soil functions that have to be sustained (production, regulating and biosphere functions) – soil compaction damage – is a cropping problem related to location, ground moisture, rotation and mechanisation. In the context of competitiveness and environment-acceptability of modern farming a concept for soil structure preserving fieldwork is suggested based on the four fundamentals the utilisation of technologies, adjustment of work systems, weight-carrying capacity of soil and limiting of mechanisation damage.

The size and weight of tractors, self-pelled machines and transport vehicles have increased enormously in recent decades. Nowadays their technology allows them to be used at the optimum time, cutting labour and cost inputs through wider working widths and reduced tracking on farmland. High wheel loads can damage soil structure more, however, and sometimes at greater depths, especially under wet soil conditions. There is then a risk that soil functions can be damaged [1]. In the FAL, a concept towards sustainable agriculture was developed offering a technical contribution towards avoiding such soil compaction.

Solutional concept

The concept „Soil structure preserving fieldwork“ comprises four basic components (fig. 1).

Results and recommendations

Utilisation of technical possibilities

Attention has been devoted to the (average) running gear/ground contact area pressure for a long time. Where wheel load (t) remains static, increasing contact area results in contact area pressure (bar) and thus ground pressure reduction. Accepted technical solutions towards this include dual or cage wheels, broad or Terra tyres with, more recently, rubber crawler tracks, three-track vehicles and articulated chassis.

With large volume tyres with pressures of < 1 bar, wheel loads of over 5 t can be supported nowadays. Depending on soil condi-

tions, higher, or sometimes even lower tyre pressures, there's the danger of soil damage. But where soil is non-inverted or is dry, conditions are not so sensitive. It is also necessary to know that contact area pressure and ground pressure depend not only on external factors (wheel load) but also very decisively on soil internal parameters (soil type, density, moisture content), making it very difficult to establish general limits or rules to help on-farm decisions.

Important for such aids in avoiding soil damage is information on soil compaction susceptibility through structure and density as well as moisture content [2]. If maximum tyre pressure was the only parameter influencing soil damage this would be much more easily adjusted according to soil conditions by the driver (nowadays, by on-board tyre pressure control). This would be much easier than, e.g., adjusting average contact area pressure. This would also mean there would be encouragement for the tyre industry to develop more soil-structure-protecting tyres wherein their deforming capacities would have to be considered [3].

Technically the answer to soil protection aims could be a soil drivability sensor [4]. Nowadays, track depth offers a transitional solution to drivability, e.g. with a beet harvester (fig. 2). This roughly indicates drivability factors and can be used to judge whether, e.g., to what extent bunker capacity can be used.

Adjusting the working system

Traffic pressure on the soil is reduced through combined operations in a single

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Keywords

Soil compaction, soil protection, technical solutions, best practice management

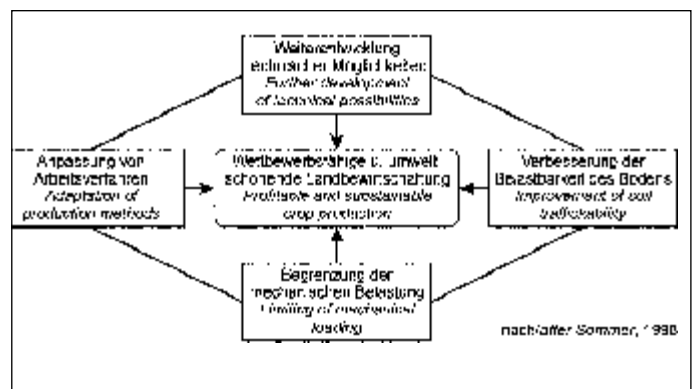


Fig. 1: Concept of soil protecting trafficking

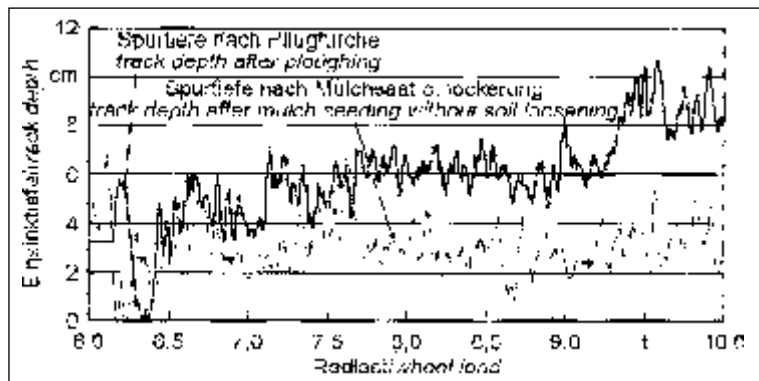


Fig. 2: Track depth of a sugar beet harvester with increasing hopper filling and after different tillage

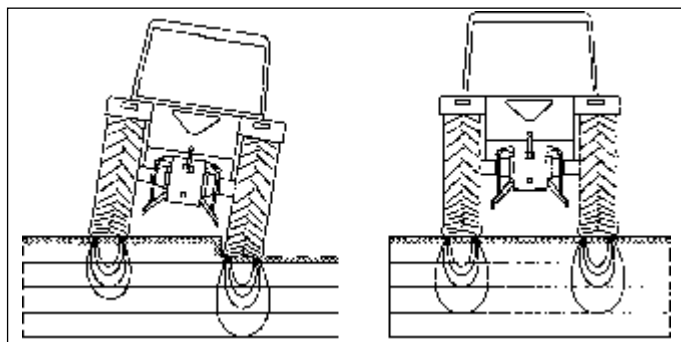


Fig. 3: Pressure bulbs during conventional (left) and onland-ploughing (right)

pass, e.g., basic cultivations and drilling take place in a single operation, tramlines, four-wheel-drive and through using pto-powered implements.

A further possibility not often used in Germany nowadays is on-land ploughing. This prevents ground pressure consolidation penetrating as deep into the ground as with in-furrow ploughing (fig. 3).

Improving soil carrying capacity

Field trials comparing conventional ploughing with non-inversion soil loosening (with paraplow, grubber) show the latter is possible without yield penalties [5]. Reducing the extent of soil disturbance thus avoids the considerable power input for reconsolidation and the required loosening can be achieved when the rotation allows it – perhaps every three years.

This non-classic soil loosening combined with mechanical loosening effect (under dry conditions for the total loosening depth) and biological stabilisation of loosened soil structure through intercrop rooting (which additionally encourages earthworm population and thus the natural vertical pores for water channelling). Combined soil structure preserving fieldwork this offers the right conditions for reducing soil compaction danger. This building block of conservation soil cultivations [6] offers better drivability (fig. 4) now and, in the future, with spatially specific cultivation systems.

Limiting mechanical damage

The real critical points for soil structure preserving field work lies with wheel load, increased driving power and possible wheel-slip. Acting together these mean more soil structure stress. Limits therefore have to be established where soil conditions are sensitive to compaction. For instance, damage can be expected with the appropriate stress factors where soil moisture content is high although this so far is only recognisable by farmers through deeper tracking and retarded plant growth.

Changing from narrow to wide tyres only helps where wheel loads are not simultaneously increased. And where soil conditions are liable to compaction the modern tendency of increasing wheel loads cannot help soil structure – especially that of the layers below the surface – when operations take place in unsuitable conditions, even where wheel load is reduced. Sensor systems can be imagined which consider wheel load, tyre type and pressure and soil moisture in the calculation of drivability [4].

Summary

The fundamentals of the „soil structure preserving field work“ concept depicted should be combined with location and farm-specific conditions for the technological avoidance of soil compaction. Additionally the rotation in cropping is important and too little attention is paid to this aspect.

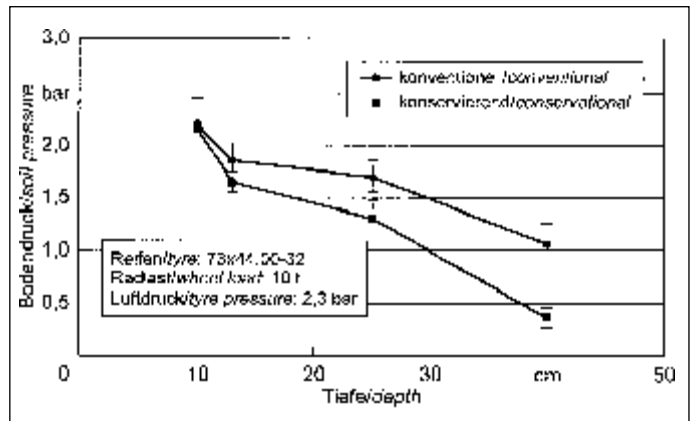


Fig. 4: Soil pressure during sugar beet harvesting after ploughing and conservation tillage, respectively [4]

There can be conflicts between ecological and economic aspects. Help here should come from applying good farming standards involving priorities of soil protection, farm ecology, cropping and field structure and not least the attitude of the farm manager. Here, the recommended concept helps along with further theoretically sound and practically relevant development, preferably in association with soil science.

Literature

- Books are identified by •
- Horn, R., J.J.H. van den Akker and J. Arvidsson: Subsoil compaction. *Advances in Geocology* 32, 2000, 462 p.
 - Chamen, T., L. Alakukku, S. Pires, C. Sommer, G. Spoor, F. Tjink and P. Weißkopf: *Equipment and field practices to avoid subsoil compaction* (in press)
 - Schlotter, V. und H.D. Kutzbach: Innenkontur eines Traktorreifens. *Landtechnik* 56 (2001), H. 1, S. 12-13,
 - Brunotte, J., M. Weißbach, H. Rogasik, E. Isensee und C. Sommer: Zur guten fachlichen Praxis beim Einsatz moderner Zuckerrüben-Erntetechnik. *Zuckerrübe* 49 (2000), H. 1, S. 34-40
 - Sommer, C. und M. Zach: Managing traffic-induced soil compaction by conservation tillage. *Soil & Till. Res.* 24, (1992), pp. 319-336
 - Sommer, C.: Konservierende Bodenbearbeitung – ein Konzept zur Lösung agrarrelevanter Bodenschutzprobleme. *Landbauf. Völknerode* (1998), SH 191, 128 S.