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Tracks and Tires

A Full Scale Laboratory Investigation

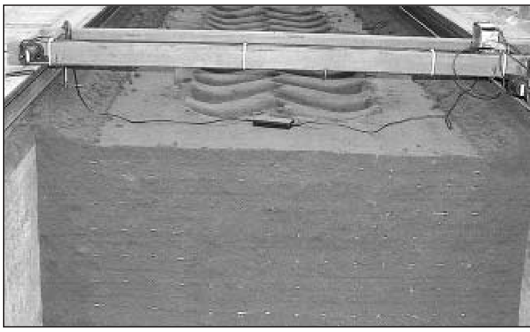

Fig. 2: Talcum powder points of the control after the pass of a tire (800/10.5/10.5) in the soil bin including the frame with the drawstring transducers

In Silsoe, United Kingdom, the effects of tires and tracks with high axle loads (21 to 24 t) on soil compaction were tested under controlled laboratory conditions. Claas Terra Trac tracks proved themselves as significantly more advantageous regarding soil deformation than other tires with the same load. The smaller 600/65-26.5 tires with a 4.5 t load and 1.4 bar inflation pressure caused the same soil deformation as a track with between 10.5 and 12 t. Reduced inflation pressure – with a load comparable to the track – reduced soil deformation significantly, compared to tires with normal inflation pressure, although with more soil deformation than with tracks.

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Keywords

Soil compaction, comparing drive systems, tracks, tires, soil deformation

With increasing axle load, the danger of significant soil compaction rises [3]. Consequently more tracks are being used, however, until now no investigation is available comparing soil compaction below wheels and tracks in controlled laboratory conditions giving repeatable results. Field comparisons of undercarriage systems with contradicting results were summarized by [1] whereby the track type determined the effect on soil compaction. In a laboratory study tires and a rubber belted track were compared with respect to soil compaction at Cranfield University, Silsoe.

Testing frame

Figure 1 shows the testing frame built for the tires and tracks study. The frame can carry and propel either a Claas Terra Trac track system (left hand side Fig. 1; before run) or tires (right hand side, Fig. 1; after run). The test frame is guided on rails along the soil bin and can be loaded up to 16 t with additional weights. Using a hydraulic cylinder, up to 14 t can be transferred onto the drive system via the axle which is guided by a linear bearing.

Measurement of soil deformation

The soil bin is being filled with soil in 5 cm thick layers whereby each layer is rolled to its required density before the next layer is being scraped in. In order to be able to measure the soil movement after the passage talcum powder lines are placed into the soil during the preparation. Therefore a plywood plate with slots in 100 mm distance is placed onto the soil after the soil is being rolled, then talcum powder is put onto the board and brushed into the slots. This is done in three replications and one control position until the soil bin is prepared. After the passage of the single wheel/track tester the soil is cut vertically and the talcum powder lines appear as white dots in the profile as shown in *Figure 2*. Using a pin which is connected to drawstring transducers the position of the talcum powder points is measured and digitalized. Knowing the initial and the final position of the talcum powder points the resulting soil deformation can be plotted as a vector diagram. This method is a further development of an approach used by [4].

The talcum powder points and the frame

Fig. 1: Single Wheel/Track tester with a track (left hand side) before and a tire (right hand side) after a run

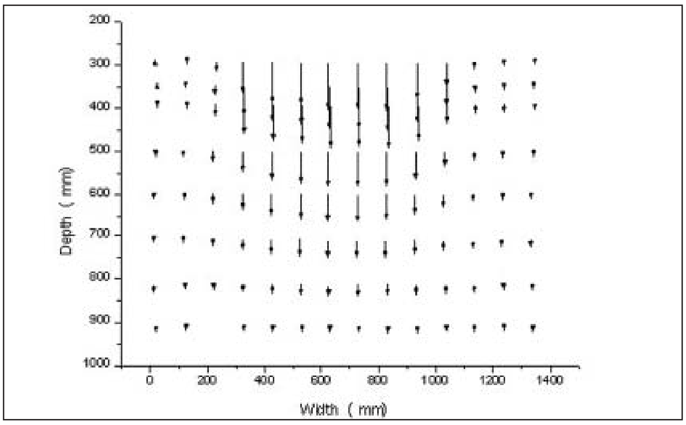

Fig. 3: Vector diagram of soil movement in soil bin after the pass of a tire 800/10.5/2.5

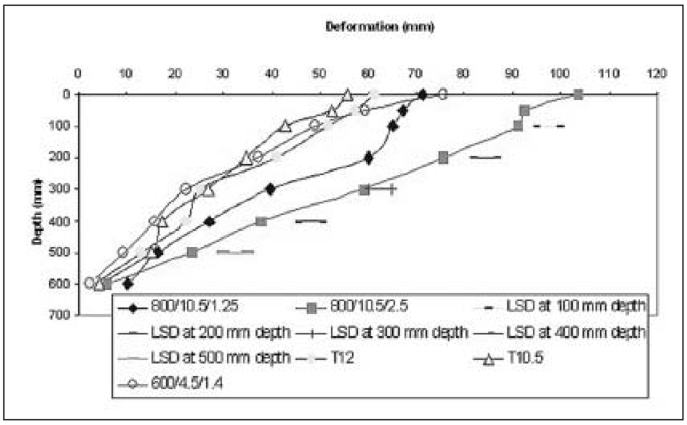

Fig. 4: Soil deformation vs. depth for tires and tracks on uniform soil conditions

carrying the drawstring transducers are shown in *Figure 2* for the control section after the passage of a tire. *Figure 3* shows the vector diagram of the soil deformation after the passage of a 800/10.5/2.5 whereby the key for tire sizes, loads and inflation pressures is listed in *Table 1*. The average soil deformation in the center of the wheel rut can be calculated from the length of the central four vectors. A soil deformation profile can be gained when plotting this average vector length vs. depth as in *Figure 4*.

The track has been investigated with both the same load as a tire and the same field conditions, i.e. with 1.5 t more load. Additionally the 600/4.5/1.4 was tested with 4.5 t, which represents approximately 1/3 of the load of the track unit.

The dry bulk density of the soil was very low (1.4 g/cm^3) representing a low bearing capacity of the sandy loam and was particularly chosen to pronounce the differences between the single treatments.

Results

The vertical soil movement from *Figure 3* is interesting to note, whereby the soil has not measurably moved sideways. The greatest soil displacement takes place in the center of the rut and decreases with depth and to the outside.

As apparent from *Figure 4* the largest soil deformation is caused by the 800/10.5/2.5. At half the recommended inflation pressure soil displacement decreases significantly. Both the T12- and the T10.5- tracks cause even less soil deformation, which is considerably different from the 800/10.5/1.25. The weight difference of 1.5 t causes a stronger soil compaction for the T12, but the difference is not significant. A 600/4.5/1.4 causes the same soil displacement as a track with 2 to 3 times the load.

Correlation coefficients of 97 to 99 % justify putting a linear regression line through the data results. The reciprocal of the slope of this linear function is the relative increase in soil density. Hence for this soil with a very low bearing capacity the soil density increases due to the pass of the 800/10.5/2.5 tire on average by 15 %. In comparison, the increase in soil density at half the recommended inflation pressure of the 800/10.5/1.25 is 12 % and for the track 10 %. A tire with approximately 1/3 of the load causes about the same soil deformation as a track.

Conclusions

The Terra Trac track causes significantly less soil compaction than a tire with the same load and with the same working conditions. This is in agreement with the findings of a field trial by [2]. A lower inflation pressure reduces soil deformation and consequently soil compaction compared to tires at normal inflation pressure, but not as much as a track does.

A 600/4.5/1.4 causes similar soil deformation and hence compaction compared to the track T12 and T10.5 reflecting the importance of the undercarriage system. For the soil deformation it is important how the load is transferred onto the soil. In this context the absolute axle load is less important.

Undercarriage System	Load (t)	Inflation Pressure (bar)	Abbreviation
600/55-26.5	4.5	1.4	600/4.5/1.4
800/65 R32	10.5	2.5	800/10.5/2.5
800/65 R32	10.5	1.25	800/10.5/1.25
Claas Terra Trac	10.5	-	T10.5
Claas Terra Trac	12	-	T12

Table 1: Tire and track specifications in the investigations and their abbreviations

Literature

[1] *Alakukku, L., P. Weisskopf, W.T.C. Chamen, F.G.J. Tijink, J.P. van den Linden, S. Pires, C. Sommer and G. Spoor*: Prevention strategies for field traffic – induced subsoil compaction: a review. Part 1. Machine/Soil Interactions. Soil and Tillage Research 73 (2003), no. 1-2, pp. 145 – 160

[2] *Brandhuber, R., R. Geischeder und M. Demmel* : Effects of heavy agricultural machines for sugar beet harvesting on subsoil physical properties. Proceedings of the 17th Triennale Conference of the International Soil and Tillage Research Organisation, Kiel, Germany, August, 28th – September, 3rd 2006

[3] *Raper, R.L.*: Agricultural traffic impacts on soil. Journal of Terramechanics 42 (2005), no. 3-4, pp. 259 – 280

[4] *Trein, C.R.*: The Mechanics of Soil Compaction Under Wheels. PhD – Thesis in Ag. Eng., Cranfield University, Silsoe College, GB, 1995