Track versus Ultra Flexible Tire, impact on subsoil compaction

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Introduction
Subsoil compaction is one of the soil threats mentioned in the European Soil Strategy. In dry periods the limited rooting depth can cause severe yield reduction by draught damage. In wet periods a heavy rain can result in waterlogging and a too long period with anaerobic conditions for the roots or storage organs e.g. potatoes, which can result in a complete loss of the yield. Too wet conditions can also be a problem for trafficability and soil tillage. The completely saturated topsoil results easily in run-off and contributes to erosion and flooding. According to Schjönning et al., (2015) at least 25% of the subsoils in agricultural use in the EU are compacted. A main cause of subsoil compaction is too high soil stresses exerted on the subsoil by heavy agricultural equipment. Nowadays the highest wheel loads in agriculture are around 150 kN (15 tonnes). However, on the other hand flexible low pressure tires and tracks are developed for use under heavy agricultural equipment. A test was performed by Wageningen Environmental Research, CAH Vilentum, the Swedish Agricultural University (SLU) and the farmers magazine Boerderij, to compare the effectiveness of flexible low pressure tires and tracks to reduce the exerted soil stresses on the subsoil and to prevent subsoil compaction.

Materials and Methods
The focus of the field test is on the subsoil of a marine silty clay soil with 26% clay. The test was performed end of November on a very moist soil, however, it was still possible to harvest the sugar beet. Three pressure transducers were installed at a depth of 20 cm, with upper side of the transducers in the interface between topsoil and subsoil. One transducer was situated in the centre below the tire or track during driving over. One at a distance of 45 cm out of the centre below the sidewall of the tire or the edge of the track and one transducer at a distance of 22.5 cm of the centre half way the centre and sidewall of the tire or track edge. Two 4-wheeled Vervaet 617 harvesters fully loaded with sugar beet were used in the tests. One harvester was equipped in the front with Zuidberg-tracks and the other harvester with ultra flexible Michelin CerexBb-IF 900/60R38 tires with an inflation pressure of 170 kPa according to the recommendation of the tire manufacturer. In the rear both harvesters were equipped with the regular Michelin 900/60 R32 MegaXbib-tires, with an inflation pressure of 130 kPa, which is well below the recommended inflation pressure of 210 kPa. During the tests the harvest equipment was lifted. The width of tire and track were both about 90 cm. Soil stresses were calculated with the SOCOMO model (Van den Akker, 2004). Soil samples with a diameter of 10 cm and a thickness of 3 cm were collected at a depth of 20, 30, 50 and 70 cm nearby the test site, however, at a place of which we were sure that the soil was not wheeled during the harvest operation. The samples were tested in the lab in an uni-axial test with a loading speed which is the same as the loading speed in the field.

Results and Discussion
The measured weight on the track proved to be 16.76 Mg (load 167.6 kN) and the weight on the tire 14.15 Mg (load 141.5 kN). The foot-print of the track was 90 x 195 = 17,550 cm² and of the tire 92 x 117 = 10,795 cm². The figure presents the results of the stress measurements at a depth of 20 cm. Left the results of the measurements underneath the track with a load of 167.6 kN. The stresses exerted by each roller can be seen clearly.
Soil pressures at a depth of approximately 20 cm underneath the centre and at 22.5 cm and 45 cm out of the centre of the track (left) or ultra flexible tire (right).

The maximum soil pressure is underneath the centre and is 142 kPa; at 22.5 cm out of the centre 121 kPa and at 45 cm out of the centre 42 kPa. This shows that the soil pressure distribution in a cross section under the track is certainly not even and has a more or less parabolic shape. Note that the maximum soil pressure underneath the rear tire is somewhat higher than underneath the track. In the figure right the soil pressures underneath the ultra flexible tire with an inflation pressure of 170 kPa and a load of 141.5 kN. The maximum soil pressure in the centre is 209 kPa; at 22.5 cm out of the centre 182 kPa and at 45 cm out of the centre 74 kPa. Also the soil pressure distribution in a cross section under the tire has a more or less parabolic shape. The soil pressures underneath the track are about 2/3 of the soil pressures underneath the tire.

With the SOCOMO model the maximum soil stresses underneath the centre of the track and the tire are calculated up to a depth of 100 cm. Calculated stresses at a depth of 20 cm agreed well with the measured values. A limit for soil pressure often used in the Netherlands is 100 kPa. Schjönning et al., 2012 proposed a 50-50 rule, which means that the traffic on agricultural soil should not exert vertical stresses in excess of 50 kPa at depths >50 cm. Considering these two rules of thumb, then both the track and the tire exceed the limit of soil pressure of 100 kPa at a depth of 20 cm and the 50-50 rule is exceeded more than 2 – 3 times. This suggests that although the track performs significantly better than the tire, the subsoil will still suffer severely from subsoil compaction.

The uni-axial test was performed on all soil samples collected at a depth of 20, 30, 50 and 70 cm with the soil pressures calculated with SOCOMO. All soil samples compacted and increased in dry bulk density.

Conclusions
Both the ultra flex tire and the track have a large footprint which makes it possible to use heavy equipment on agricultural soils. Although the track is performing better than the ultra flex tire both will compact the subsoil considerably. The loads of 142 respectively 168 kN are just extreme and too heavy and exceed the bearing capacity of the subsoil.

References
