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D. Miclet, E. Piron, F. Pinet

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Soil compaction: track induced soil stress isn't so positive in comparison with tyre

Ingeniors **Denis Miclet, Emmanuel Piron,**

Irstea, Clermont-Ferrand, TSCF, France;

Ingenior **François Pinet,** MICHELIN, Clermont-Ferrand, France

Abstract

This study concludes that, from the soil compaction point of view, using tracks does not confer an advantage, because of irregular contact pressure induced by the roller presence and the overall higher load of the track system. Conversely, tyres distribute uniformly the load on all the contact area and induce overall less stress on the soil.

Introduction

As agricultural machines sizes and weights are always greater, rubber tracks are often presented as an alternative equipment to maximise the power transmission to the soil, but also to reduce the stress applied on soils. Considering the easy to obtain contact area surface of the track -or tyre- with the soil, the interface pressure is supposed to be less important for tracks than for tyres. However, this study shows that the reality is different, as true as there aren't a lot of studies in the literature.

The objective of this study was to measure the stress induced by tracks and tyres on the soil, when a combine harvester is used. The contact pressure with a hard soil is investigated, as well as the increased hardness of an agricultural soil. Protocol used is first explained, before giving major results of the study.

Used protocol

The same combine harvester has been used alternatively equipped with tyres and tracks, and stress induced at the soil interface was evaluated on two different soil types: hard soil – as it could be on a road for example during transport- and agricultural soil –as it is the case during the harvester works in the field.

Stress induced on a hard soil

In order to evaluate the contact pressure at a hard soil interface, the linear force along the contact area has been measured, considering the force distribution along the transverse direction was uniform. A great weighing system, equipped with electronic load cells allowing 50

grams of precision, has been used. During a slow displacement –measured using a laser telemeter- of the harvester from its initial horizontal place to the weighing horizontal device, the force and position values were recorded using a 100 Hz frequency rate. Ten successive measurements were repeated allowing a mean value calculation of the interface pressure.

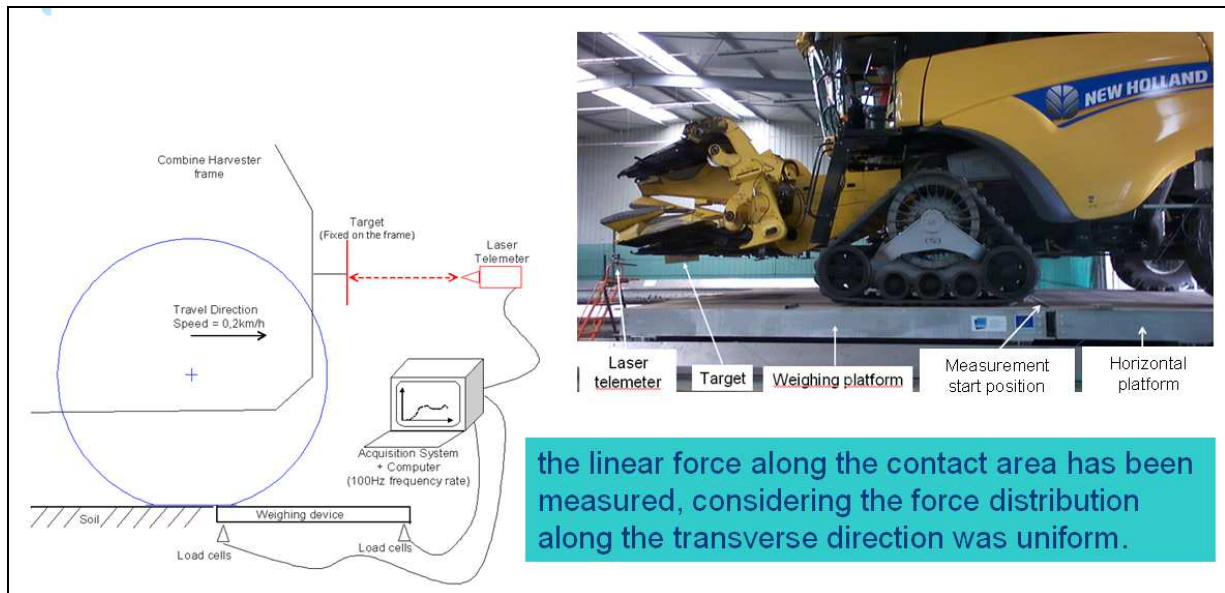


Fig. 1: Measurement schema for hard soil interface pressure evaluation.

Stress induced on agricultural soil

On agricultural soils, the consequences of combine harvester footprint on the soil compaction induced were measured.

The same combine harvester, successively equipped with tyre –under two different pressure- and tracks has been used (cf. fig 2). Successive runs were done into a large field, following a random distribution in order to minimize natural soil field effects.

Perpendicularly to the combine harvester following parallel runs, a soil hardness resistance measurement has been performed using a specific Irstea device. Displaced into the field, this device allows measuring the hardness force opposed to each of three different steel blades cutting the soil at three depths (10, 20 and 30 cm). Values were registered using 100 Hz frequency.

Both of these field operations were geo-localized using a dGPS allowing a very precise spotting of 1 cm.

Three different modalities were investigated, using a combine harvester with a total weight of 28 tons: 900/60 R38 Michelin tyre successively inflated with 2,2 and 1,4 bar, and a 3 roller track. Rear tyres inflation was 1.4 bar.

Globally, 100 repetitions for each of the 3 tested modalities were performed, using the random distribution in the field.

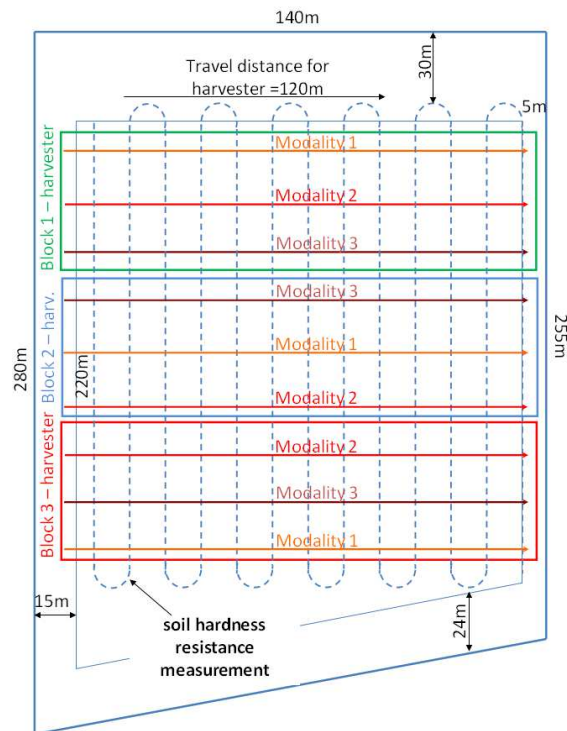


Fig. 2: Field organisation of the agricultural compaction evaluation following combine harvester work.

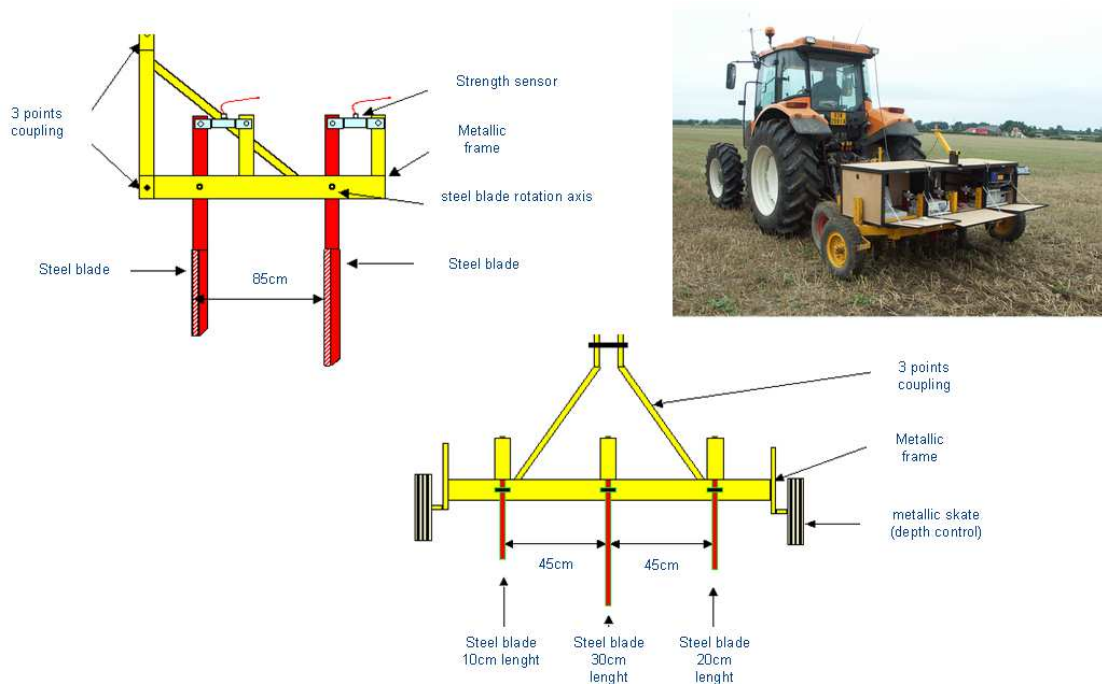


Fig. 3: Scattering device used to measure the soil hardness everywhere in the field.

Results and discussion

Stress induced on a hard soil

The registered values are computed with the dimensional information of the tyres and tracks. The graph (cf. fig. 4) represents the contact pressure with the soil for the 3 different modalities.

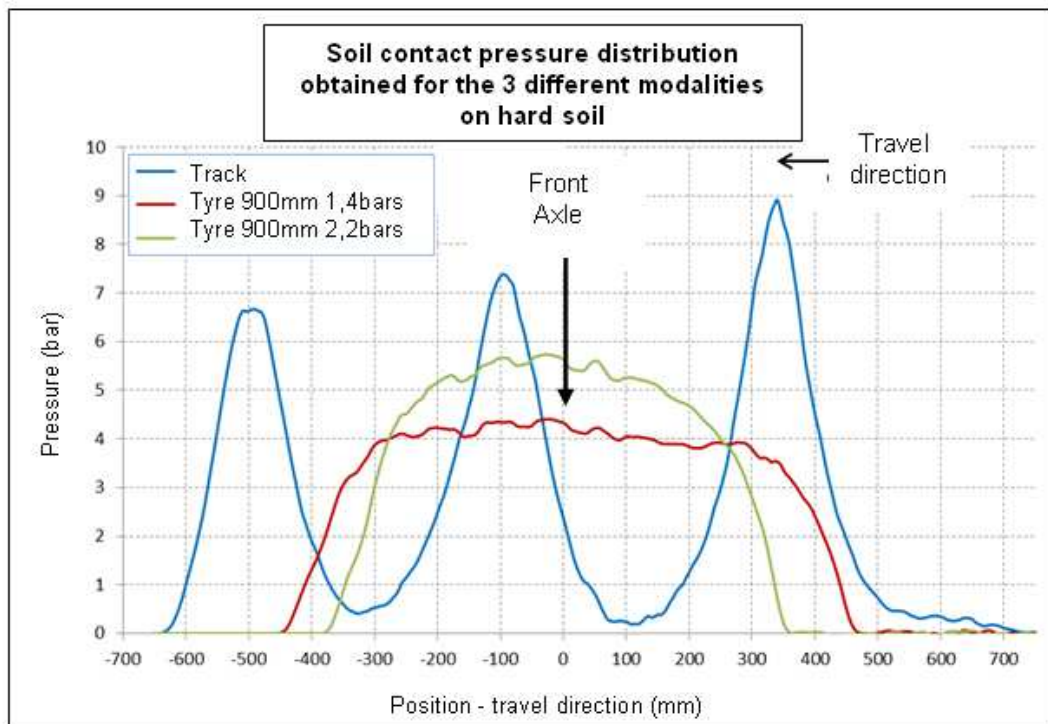


Fig. 4: Soil contact pressure distribution obtained for the 3 different modalities on hard soil. Data are given in bar using an uniform pressure distribution along the transverse axis. The abscisse 0 is the vertical position for the harvester front axle.

This graph demonstrates that a tyre, with its air inflation, distributes more uniformly the stress under the whole contact area. The soil stress decreases when inflation decreases, due to the tyre deformation which can be seen by a longer contact zone on the graph. Contact pressure peaks are respectively around 5,7 and 4,3 bar for 2,2 and 1,4 bar tyre inflations.

At the opposite, soil pressure contacts for the track system are not uniformly distributed at all. 3 pressure peaks can be seen, which are located exactly at the vertical position of the track rollers. The contact pressure peak is around 9 bar, which is twice the pressure measured for the tyre inflated with 1,4 bar. It also demonstrates that the contact interface with the soil isn't the commonly used value simply obtained by multiplication between length and width of the track.

Stress induced on agricultural soil

As a precise dGPS was used to geo-localize the following steps of the experiment, the soil compaction induced by the combine harvester successive runs have been computed and added together in order to obtain the soil hardness distribution transversely, and along 7 metre distributed on each part of the centre of run (cf. fig. 5). The scattering hardness is represented in daN along the 7 meter. It allows calculating, for each modality, 3 witness values of the soil hardness (not impacted by the vehicle runs) and 2 packed area (one for each of the right and left tyre). As 100 similar distributions are measured for each of the 3 modalities, the standard deviations for these different mean values have been calculated.

The ratio between the mean hardness in the packed area and in the witness area represent the modality impact on the soil (cf. fig. 6).

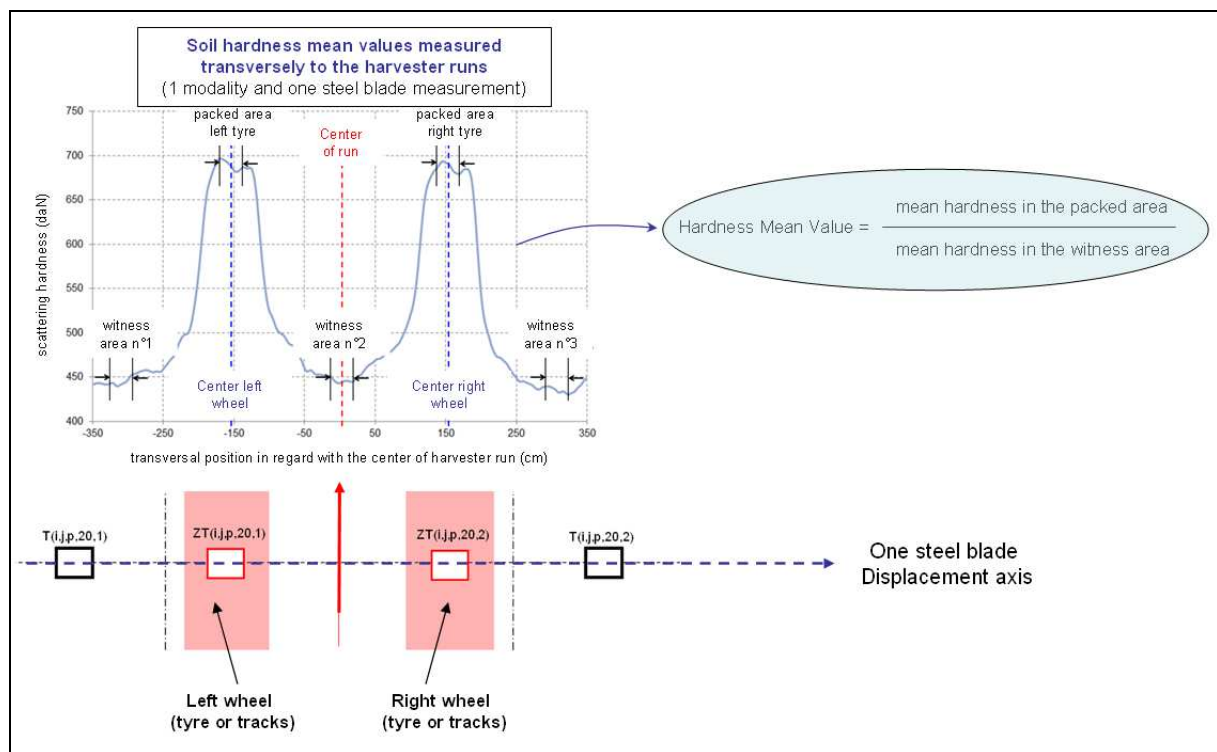


Fig. 5: Soil hardness mean values measured transversely to the harvester runs. The graph represents 7m measurement.

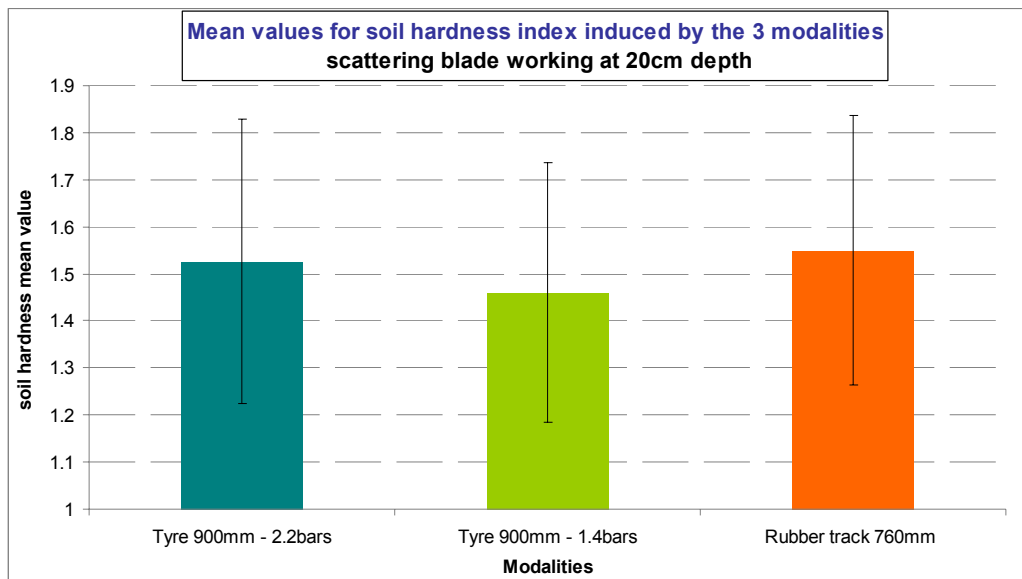


Fig. 6: Mean values for soil hardness index induced by the 3 modalities –example of the scattering blade working at 20cm depth.

Even if a lot of repetitions have been performed in order to minimise the random soil and experiment effects, standard deviation are very important (see the error bar on the fig. 6). As a consequence, the obtained visible differences between modalities mean values were not significant. Consequently, the impact of the track wasn't observed as so interesting regarding the hardness modification impact on the soil, as it's commonly expressed.

Conclusion / perspectives

This study demonstrates that the tracks systems are not better than tires in terms of compaction. On hard soil like a road for example, the differences between tires and tracks are the more significant. Indeed, for tracks, the efforts of the vehicle are only transmitted to the ground by rollers unlike tires which distribute the stress more uniformly on the contact area. The contact pressure peaks for tracks can be twice the pressure measured for tyres in these conditions. On agricultural soil, no significant difference has been measured between the tires and the tracks though a visual constant tendency show a slight benefit for the tires on the soil compaction.

Next step is to measure more accurately the distribution efforts of the machine on agricultural soil and better understand what really happens. The goal of this study is to limit the variability we meet for measures on agricultural soil and help to conclude for the benefit of one system over the other in terms of compaction.