

Survey of the Mean Pressure Exerted by a Wide Range of Tractors on the Soil

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Abstract

In order to predict the mean pressure exerted by a vehicle tyre on the soil, in 1984 Plackett suggested measuring the contact area of a tyre on a hard surface.

The model proposed by Hallonborg in 1996, based on the “super ellipse theory”, provided the best results in terms of prediction of the tyre-soil contact area.

In this study 82 4WD tractors with different power, mass and age of manufacture were surveyed. Relying on their technical features, the contact area of the front and rear tyres of each tractor and, therefore, their pressure on the soil was calculated, in order to assess the attention paid by manufacturers to soil compaction.

The results of this survey showed that the mean pressure exerted by the front tyres of a tractor is higher than that applied by the rear ones.

In addition the pressure of each tractor tyre was compared to the threshold value of 100 kPa, defined by Vermeulen and Perdok (1994) as the maximum pressure that a tyre could exert on the ground to prevent soil compaction and, relying on this value, the “threshold allowable load” was calculated.

Manufacturers seem to pay scarce attention to soil compaction caused by the tyres, especially when implements are fitted to the rear and/or front power lift.

Keywords: soil compaction, tyre-soil contact area, threshold allowable load

Introduction

Soil compaction caused by the traffic of agricultural machines has been a problem since the beginning of agricultural mechanisation. As a consequence of technological development, the power and, therefore, the mass of agricultural machines has increased, so that the soil structure is often at greater risk than the past.

In order to predict the effects of the traffic of agricultural machines on the soil, tyre-soil contact area (difficult to be measured) and tractor mass are needed.

In 1984 Plackett suggested measuring the contact area of a tyre on a hard surface. This area is different from the tyre-soil contact area, being this last one affected by highly variable factors, like soil-texture, gravel, moisture content, crop roots, plant cover, etc.

Other authors studied prediction models taking into account the tyre parameters. The model proposed by Hallonborg (1996) for calculating the tyre-soil contact area on a hard surface, based on the “super ellipse theory”, provided the best results in terms of prediction of the tyre-soil contact area (Febo et al., 2000; Febo, Pessina, 2002; Febo et al., 2002; Febo et al., 2003).

This work is aimed at assessing the attention paid by tractor manufacturers to soil compaction caused by the tyres, surveying tractors of different power, mass and manufacture age.

Materials and methods

82 4WD tractors of five different manufacturers, belonging to four power categories (<50, 50-

80, 80-110, 110-140, >140 kW) and four manufacture decades (1970s, 1980s, 1990s, 2000s) were surveyed.

According to the model proposed by Hallonborg, based on the tyre parameters and tractor mass, the contact area of front and rear tyres of each tractor and, therefore, their pressure on the soil was calculated.

Results

The results of this survey showed that the mean pressure exerted by the front tyres of tractors is higher than that applied by the rear ones (Fig. 1). In addition the tractors of maximum power, marketed in any decade, generally cause the highest pressure on the soil.

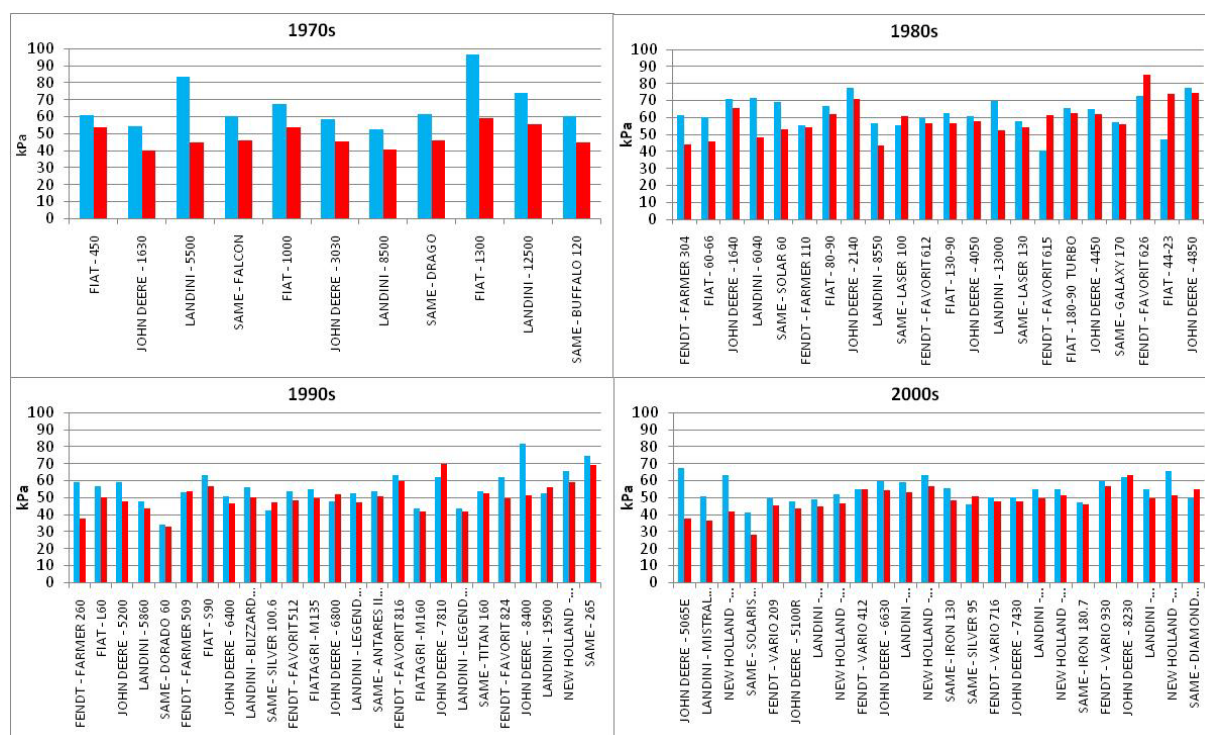


Figure 1. Pressure exerted by the front (blue) and rear (red) tyres of the tractors marketed during four decades.

The minimum, maximum and mean pressure on the soil caused by the front and rear tyres of the tractors marketed over the above decades is shown in Table 1.

Table 1. Pressure (kPa) exerted on the soil by the front and rear tyres of the tractors marketed during four decades.

	Front tyres			Rear tyres		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
1970s	53	97	66	40	59	48
1980s	41	78	63	44	85	59
1990s	34	82	56	33	70	51
2000s	41	68	55	28	63	48

The above values for each manufacturer are shown in Figure 2. The mean pressure on the soil exerted by the front and rear tyres of the tractors marketed by the five manufacturers over the four decades generally tends to slightly decrease. In the 1970s the variation range is generally low, because of the limited number of models offered by the manufacturers. For each manufacturer the variation range tends to decrease from 1980s to 2000s.

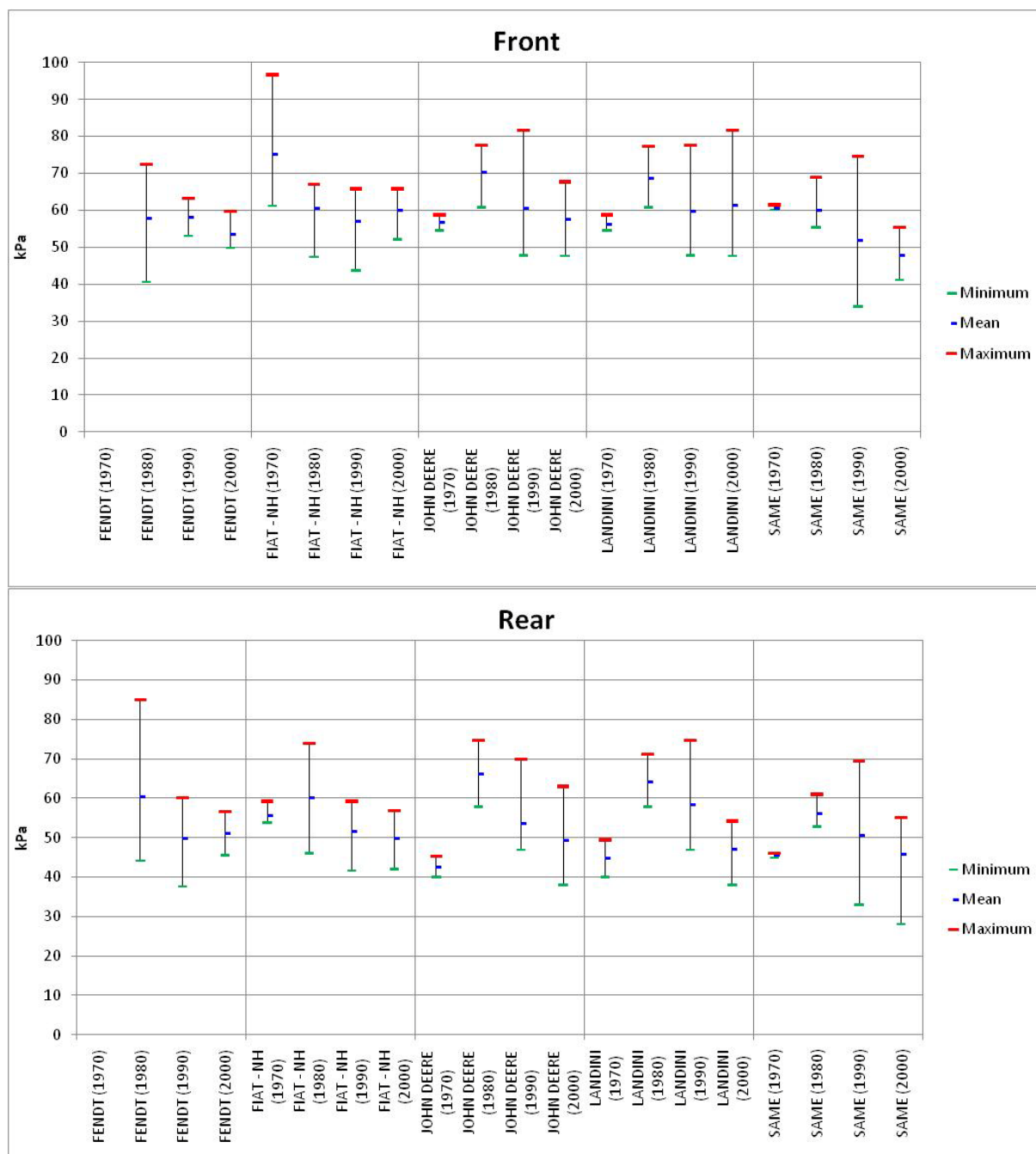


Figure 2. Pressure exerted on the soil by the front and rear tyres of the tractors marketed by five manufacturers during four decades.

The pressure of each tractor tyre was also compared to the threshold value of 100 kPa, defined by Vermeulen and Perdok (1994) as the maximum pressure that a tyre could exert on

the ground to prevent soil compaction. Therefore, relying on this figure, the “threshold allowable load” was calculated.

Figure 3 shows, for each manufacture decade and power category, the load (minimum, maximum and mean) which, if added to the front and rear tyres, determines the mean pressure of 100 kPa on the ground. In the 1970s the variation range is low, because tractors in the two highest power categories (110-140 and >140 kW) were not marketed. However the “threshold allowable load” increases with increasing power.

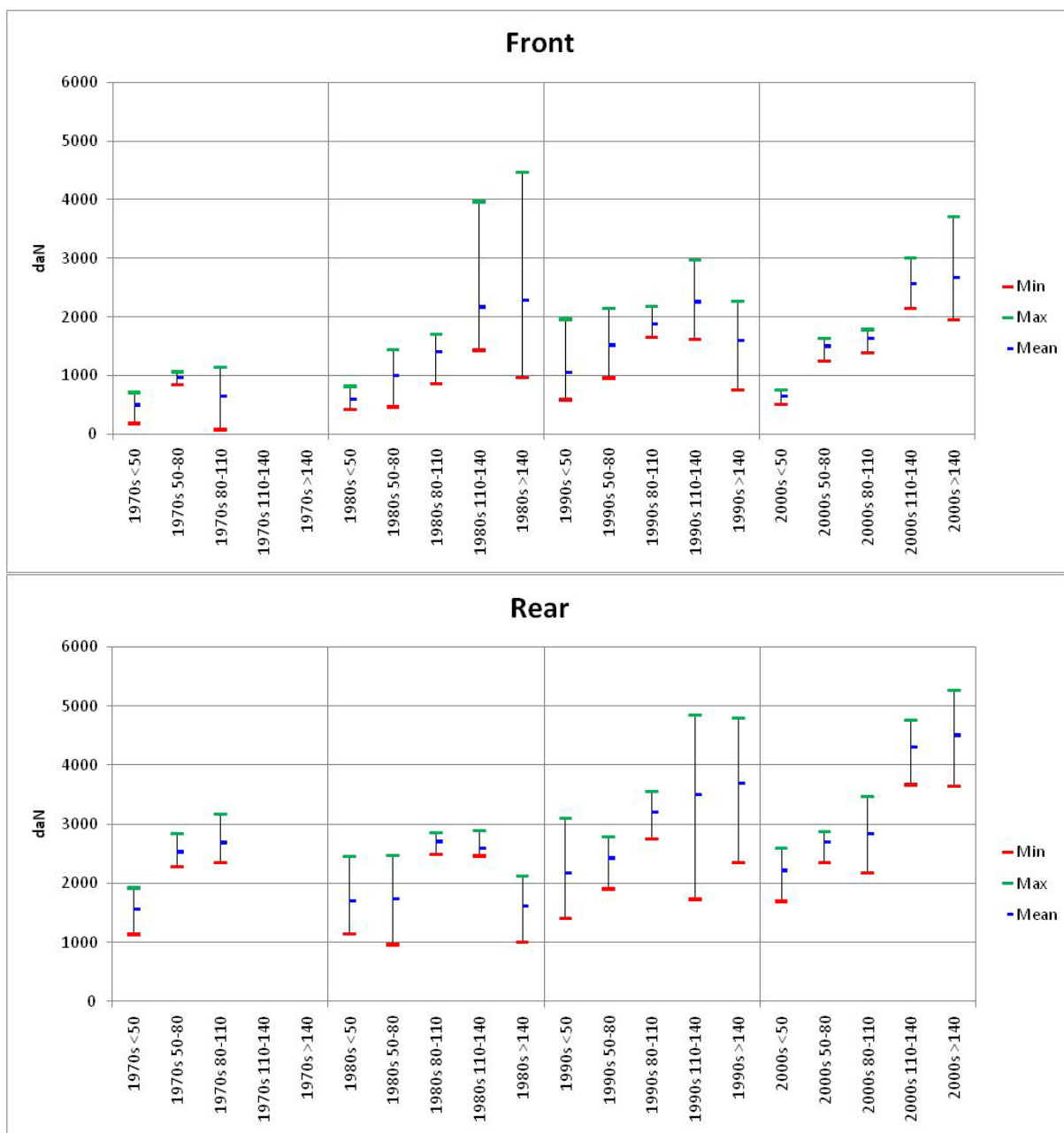


Figure 3. Load which, if added to the tractor front and rear tyres, determines the mean pressure of 100 kPa on the ground, for each manufacture decade and power category.

Conclusions

Many manufacturers advertise the amount of load that can be applied to the tractor power lift, without taking into account the soil compaction caused both by this load and the load transfer from the implement to the tractor.

This survey shows that manufacturers seem to pay scarce attention to soil compaction caused by the tyres, especially when implements are fitted to the rear and/or front power lift.

This is also demonstrated by the absence of the front tyre size in the brochures of the tractors marketed over the last decade.

It would be useful if manufacturers provided information not only on the size, but also on the mean pressures exerted on the ground both by the standard and optional front and rear tyres of their tractors.

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