International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161
Available at http://inpressco.com/category/ijcet

Research Article

Simulation of Soil Behavior Following the Passage of Tractors

Anis Elaoud[1,2*], Sayed Chehaibi[1] and Khaoula Abrougui[1]

[1]Higher Institute of Agronomy Chott-Mariem 4042 Sousse (Tunisia)
[2]Higher Engineering School for Rural Equipment Medjez Elbeb (Tunisia)

Accepted 10 Feb 2015, Available online 20 Feb 2015, **Vol.5, No.1 (Feb 2015)**

Abstract

In order to improve and develop the Tunisian agriculture, the government has encouraged the introduction of modern technologies and has also promoted the adoption of innovative practices cultures. Indeed, the extensive use of mechanization increases the crop productivity but its inadequate application also has adverse effects on the soil caused by the phenomenon of compaction. Which will cause the loss of soil fertility and increased production costs. This problem increases with increase the stress on contact wheel/soil. For this reason, the objective of this study is to simulate the footprint of the soil/tire three types of tractor after their passage on a sandy loam soil type contact. The analysis using was performed Specific database (TERRANIMO). Simulation parameters are based on the choice of tractors masses respectively 6500 kg, 4400 kg and 10500 kg. The main results obtained have shown that the tractor the heavier caused constraint wheel rear/soil caused which exceeds 100 kPa. As against, the second tractor wheel rear/soil has spawned a constraint 50 kPa. Comparing the two results showed that the tractor 6500 kg achieved a serious and excessive compaction which begat a negative impact on soil quality and crop yields. Simulation parameters were based on the choice of two inflation pressures of the rear wheels (1.6 bars and 2.1 bars) and those of the front wheels (0.8 and 1.6 bar). Main results shows an increase rear tire pressure by 31 % matches to an increase in the maximum stress at 27 %, and increase front tire pressure by 100 % matches to an increase in the maximum stress at 80 %.

Keywords: *Wheel traffic, Tractor, Soil compaction, Simulation.*

1. Introduction

Soil compaction causes a big problem in modern agriculture. Overuse of machinery and inadequate soil management leads to compaction. This compression increases the stress at the tire/soil (A. Elaoud *et al.,* 2013) and reduced the physical fertility of the soil by reducing the storage and supply of water and nutrients, leading to requirement of additional fertilizer and increasing costs production.

Thus, the feasibility of a soil reflects its ability to accept the passage of vehicles and action tools (tractors, plows, etc.) [J.F. Billot *et al.*, 1993]. The main causes of soil compaction are related to the development of mechanizations (O. Vitlox *et al.*, 2002).

A study of experimental aspect (A. Elaoud *et al.*, 2011; S. Chehaibi *et al.*, 2006; S. Chehaibi *et al*, 2013) soil compaction at the wheel track of the tractor used for conducting various cultural operations is effected in Tunisia which shows the degree of compaction of agricultural soils based of mechanical and water parameters.

This paper shows a simulation developed with a base (TERRANIMO) shows the constraints wheel/soil on a selected soil.

*Corresponding author: **Anis Elaoud**

2. Methods and Materials

2.1 Methodology

A platform used to evaluate settlements related to expenses in the soil profile the agricultural area. The methods of research, achievements and shortcomings associated with different components soil-machine including an evaluation compaction.

So, the objective of our research is to study the constraints on the soil produced by the weight of the machinery and by different inflation pressures wheels.

The evolution of the state of soil compaction has been followed by the theoretical behavior of the soil after passages of equipment.

2.2 Presentation of the parameters

The measurements will be performed initially to characterize soil conditions and parameters of tractors. In this context, the two tractors make a passage over the soil comprising 15 % clay, 75 % sand and 10 % of silt.

The first tractor T1 of 170 HP mass 6500 kg : 3900 kg rear axle and 2600 kg front axle.

The second tractor T2 of 90 HP mass 4400 kg: 2850 kg rear axle and 1550 kg front axle.

The third section tractor T3 of 330 HP mass 10500 kg : 6300 kg rear axle and 4200 kg front axle.

Table 1 Characterization of the rear wheels

Parameters	T1	T2	T3
Tyre Type	Driving wheel	Driving wheel	Driving wheel
Constructor	Michelin	Michelin	Michelin
Tire model	Omnibib	Omnibib	Omnibib
Tire size	580/70R38	520/70R34	650/85R38
Wheel load	1950	1425	3150
Inflation pressure [bar]	2	2	2 ou 1.6

Table 2 Characterization of the front wheels

Parameters	T1	T2	T3
Tyre Type	Driving wheel	Driving wheel	Driving wheel
Constructor	Michelin	Michelin	Michelin
Tire model	Omnibib	Omnibib	Omnibib
Tire size	480/70R24	420/70R24	600/70R30
Wheel load	1300	775	2100
Inflation pressure [bar]	0.8	0.8	0.8 ou 1.6

In the first place, the inflation pressures of the front wheels and rear three tractors are respectively 0.8 bars and 2 bars.

In the second series of works, the processing wheel inflations variation is recorded at T3 from 0.8 to 1.6 bar for the front wheels 2 and 1.6 bar for the rear wheels.

3. Experiments and Results

The objective of this section is to simulate the footprint of soil/wheel of three tractors (T1, T2 and T3) respectively weight 6500 kg and 4400 kg and 10500 kg.
Thus a variation in inflation pressure at the wheels of the tractor T3 is performed.

3.1 Variation the weight of tractors

Examination of the results of the theoretical effect of the passage of the first tractor T1 (Fig 1 and Fig 2) shows a fairly serious compaction at the rear wheel because of the constraints that exceed 100 kPa. This compaction can affect constraints that affect subsoil depth of about 50 cm.

Thus examining the results of Figures 3 and 4 shows the theoretical compaction after the passage of the second tractor T2. This decline is less severe because the stresses at the rear wheel does not exceed 50 kPa. Undergoes compaction affects stresses in the subsoil depth of about 25 cm.

Concerning the effect of the tractor T3, the stresses exceed 140 kPa by assigning a depth of about 75cm (Fig 5).

Indeed, we see a more intense compaction during the passage of the vehicle heavier.

Thus, the increased weight of the machine by 32 % between T1 and T2 (27 % on the rear axle) produces a stress increase at tire/soil of approximately 100 % contact.

Also, the increased weight of the vehicle by 58 % between T2 and T3 (55 % on the rear axle) causes an increase in constraints tire/soil of about 130 %.

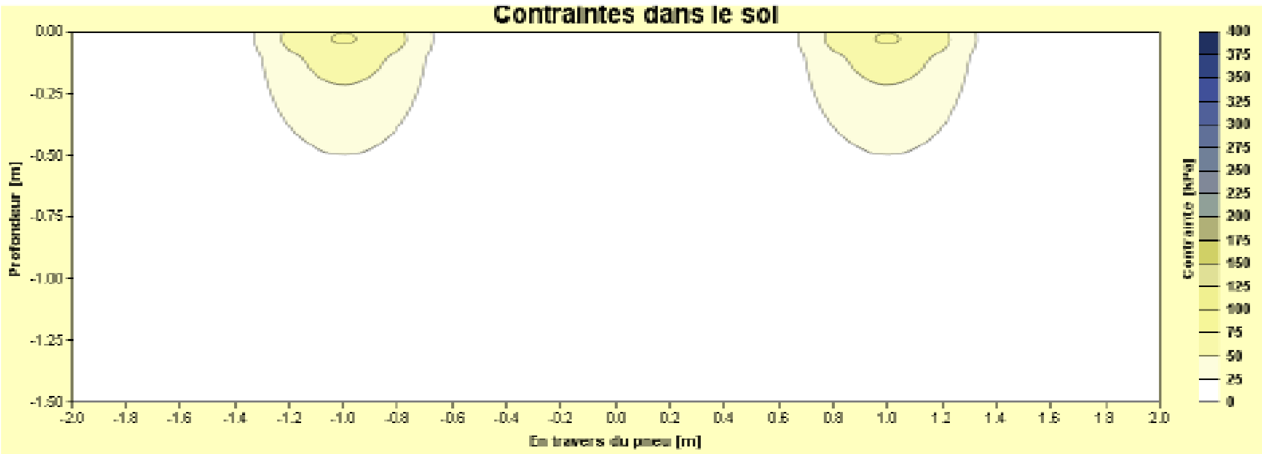

Figure 1 Stress in the soil affected by T1 (rear wheel)

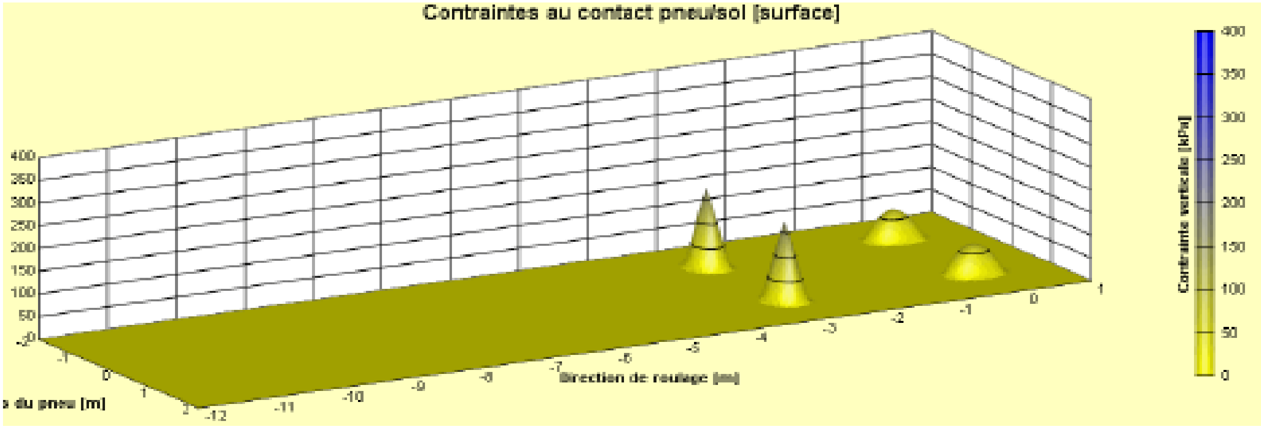

Figure 2 Stress at tire / soil contact 3D (T1)

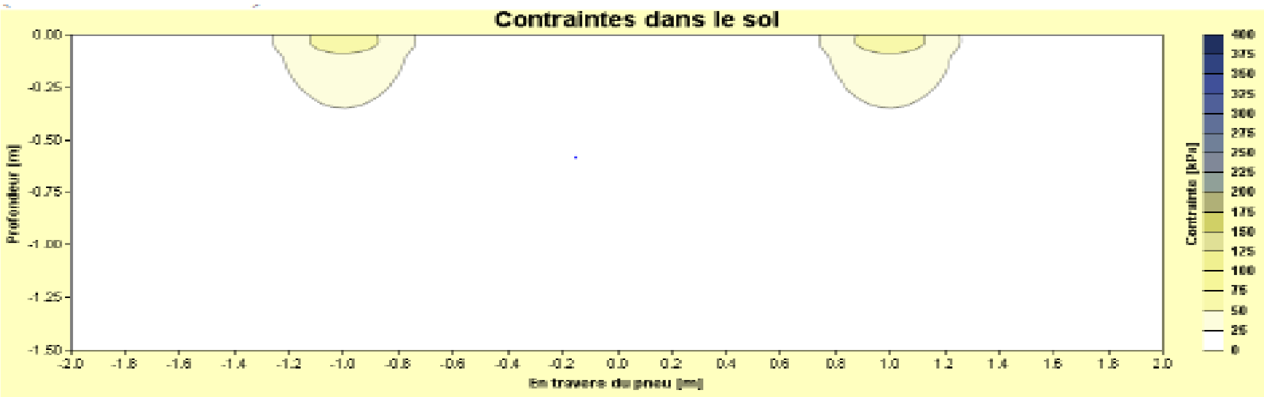

Figure 3 Stress in the soil performed by T2 (rear wheel)

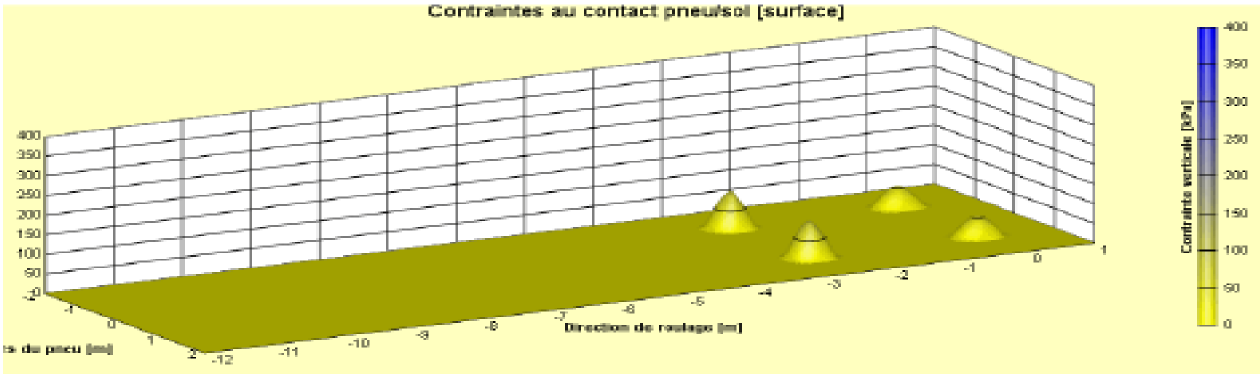

Figure 4 Stress at tire / soil contact 3D (T2)

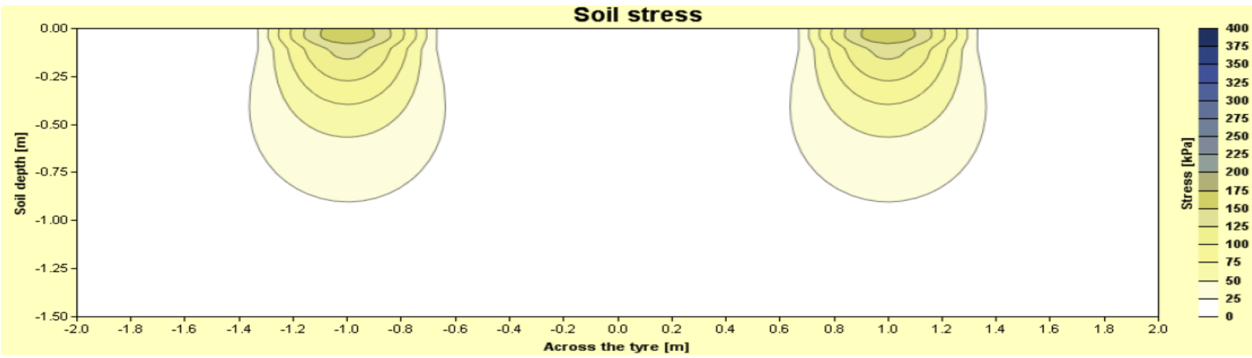

Figure 5 Stress in the soil conducted by tractor T3 (rear wheel: 2 bar)

3.2 Variation inflating wheels

Furthermore, a study of the soil behavior according to the variation in inflation of the tractor wheels in T3 is performed as follows.

This part is to simulate constraints the wheel/soil using a tractor total weight 10500 kg, and by varying the pressure of the rear wheels 1.6 bar to 0.8 bar and the front wheels from 2 bar to 1.6 bar .

In a first state, the rear wheels of the tractor are inflated to 1.6 bar and the front wheels and 0.8 bar (Fig.6).

For the second case, the rear wheels are inflated to 2 bars and the front wheels at 1.6 bars (Fig. 7).

To better examine the results, a simulation is performed at the front and rear wheels in 2D.

Examination of the results of the theoretical effect of the passage of the tractor with different inflation pressures of the wheels.

Figures 8 and 9 show the contact surface and the impact of changes in pressure of the rear and front wheels.

This shows that increasing the inflation pressure, the contact surface the decrease and penetration resistance increases function of depth. (Figure 10 and 5)

A pressure of rear wheel 1.6 bars generates a maximum stress approximately 110 kPa. Thus increasing the pressure to 2 bar max the stress corresponds to 140 kPa.

This shows an increase tire pressure by 31 % matches to an increase in the maximum stress at 27 %.

A pressure of front wheel 0.8 bar, generates a maximum stress approximately 50 kPa. Thus increasing the pressure to 1.6 bar max the stress corresponds to 90 kPa (approximately).

This shows an increase tire pressure by 100 % matches to an increase in the maximum stress at 80 %.

Thus, we find that the soil layers are sensitive by increasing tire inflation. So we increasing the inflation pressure is increased the risk of compaction according to the depth (Figure 8, 9, 10 and 5).

Also the surface layer (0-20 cm) is the most compacted than the other layers in depth.

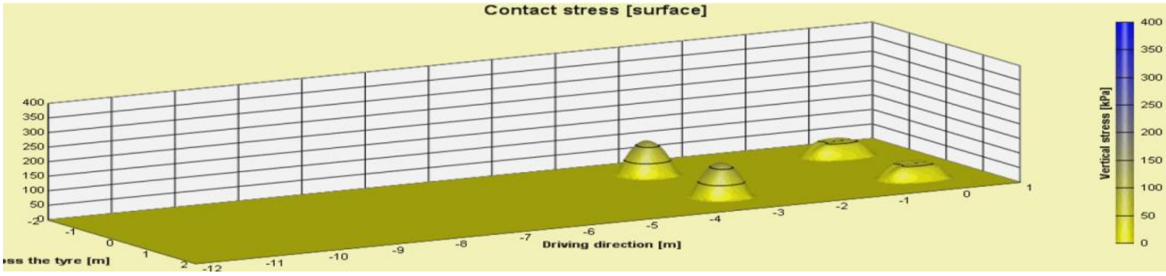

Figure 6 Stress at tire / ground contact in 3D: rear wheel inflated 1.6 bar and front wheel 0.8 bar (T3)

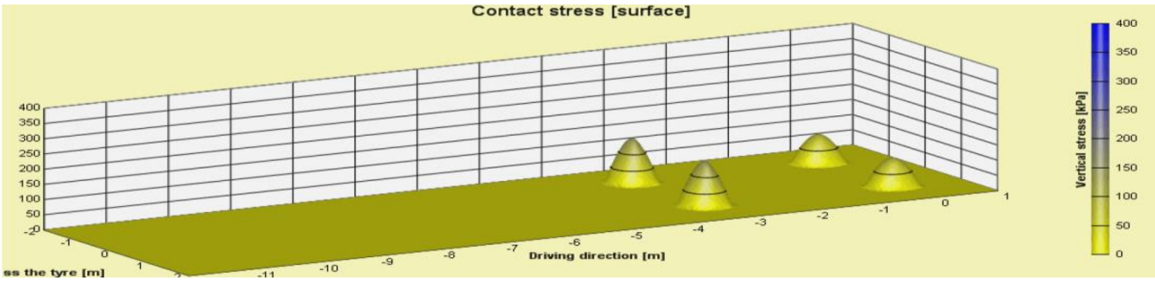

Figure 7 Stress at tire / ground contact in 3D: rear wheel inflated 2 bar and front wheel 1.6 bar

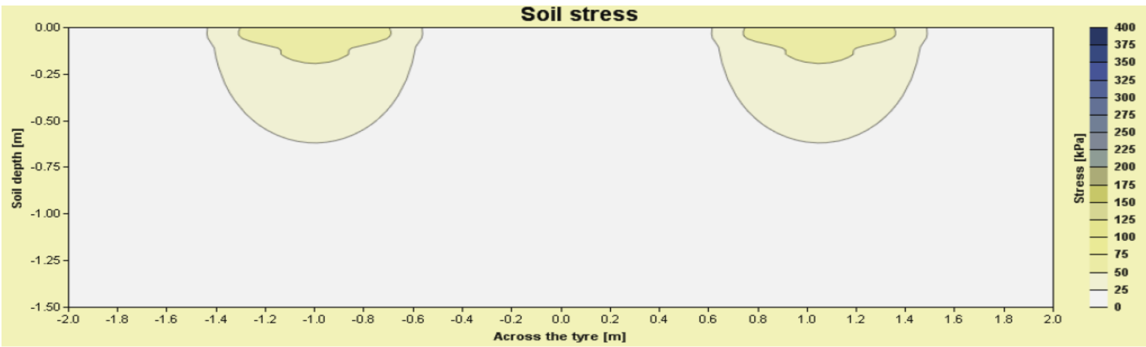

Figure 8. Stress in the soil conducted by the tractor for front wheel (0.8 bar)

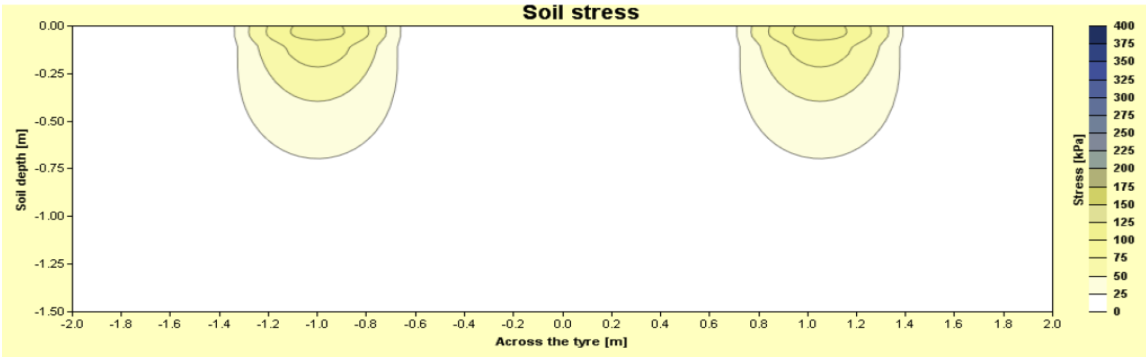

Figure 9 Stress in the soil conducted by the tractor for front wheel (1.6 bar)

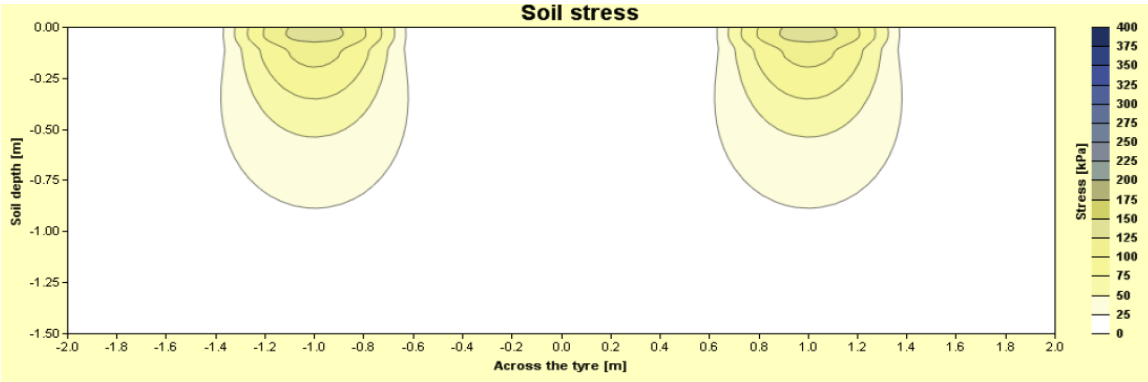

Figure 10 Stress in the soil conducted by the tractor for rear wheel (1.6 bar)

Conclusion

The theoretical study that we conducted on the effect of the mass of the vehicle, showed the influence of weight (on the rear axle and the front axle) on the degree of soil compaction.

Indeed, the increase in the weight of the vehicle 32 % (T1 and T2) causes an increase in stress to the contact tire/soil, and about 100 % of a 55 % increase (T2 and T3) results in increased constraints contact tire/ground about 130 %.

The theoretical study that we conducted on the effect of the mass of the vehicle, showed the influence of weight (on the rear axle and the front axle) on the degree of soil compaction.

Indeed, the increase rear tire pressure by 34 % matches to an increase in the maximum stress at 40 %.

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