The effect of different dynamic wheel loads on soil compaction using a soilbin and a wheel-tester

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Abstract

The increasing use of tractors and rising need for agricultural mechanization in order to obtain high farm efficiency obligates numerous passes of tractor in the farm and consequently causes enormous soil compaction beneath tractor wheels. Soil compaction has enormously attracted researchers' attention toward soil-wheel interactions because it is a key factor in preventing plant growth. Amongst effective parameters of creating soil compaction, dynamic load on wheel requires to be investigated thoroughly and precisely using a soilbin and a wheel-tester. Three dynamic load values of 2, 2.5 and 3 kN were implied on wheel to evaluate the influence of these dynamic loads on creating soil compaction. The soilbin was filled with clay-loam soil. A load cell was used to measure dynamic loads on wheel and a data acquisitioning system was used to receive result data. As the wheel-tester was traversing in the length of soilbin, the signals were sent by load cell and then the signals were received by data acquisitioning system. A penetrometer was used to measure soil compaction after traversing the wheel-tester of wheel footprint. The result data proved that increase of dynamic load causes soil compaction to penetrate into deeper soil levels.

Keywords: wheel load, compaction, soil bin, single wheel-tester

Introduction

Wheel is playing an important role in agricultural and off-road vehicles since it is always in contact with farm, nearly all of forces and moments influencing the motion of vehicle are applied to it, and also it has very noticeable impact on machine dynamics. Hence, soil-wheel interactions should be considered enormously regarding the fundamental role of wheels in traversing, steering, and traction. As tractor is one of major agricultural vehicles, much more attention should be paid on wheel- soil interactions of tractors. Rolling resistance, soil compaction, energy loss, and wheel slip are of both crucial and undesirable parameters produced by soil-wheel interactions. In recent years, the spectacular increasing weight of tractors due to heavier farming operations has caused superior forces applied to the ground and these forces directly induce severe soil and subsoil compaction, which in turn, lead into significant crop reduction, soil erosion, increasing fuel consumption of machines, wear of tillage implements drainage difficulty and further significant environmental damages.

Soil compaction is the result of stresses acting upon the soil. Wheel load is one of the options that farmers can chose to reduce soil compaction. Researchers stride to investigate the effect of vertical load in soil compaction. Çarman (2002) evaluated the characteristics of compaction inside soil bin facility. He concluded that the effect of increase in wheel load varying in the range of 3.5, 5.5 and 7.5 kN resulted in increase of compaction index and penetration resistance from 0.18 to 0.48 and 1470 to 2530 kPa, respectively. Thomas Keller and Mathieu Lamandé (2010) analytically investigated the compaction in soil and stated that amount of soil compaction is high at surface and reduces as depth increases. Keller (2005) developed a model to predict contact area and mean contact pressure creating soil compaction. Influence of wheel load on soil stress was investigated by Johan Arvidsson and Thomas Keller (2007). Measurements were made with the wheel loads 11, 15 and 33 kN. Alexandr Grecenko (2003) investigated soil compaction to be reduced by presenting rated loads.

The current investigation intends to find the role of various tested wheel loads on imposed soil compaction utilizing soil bin facility and a single wheel-tester.

Materials and Methods

A soil bin facility equipped with single wheel tester was manufactured in Urmia University (Mardani et al. 2010). The soil bin featured the ability to traverse the length of soil bin with various velocities. The channel was filled with clay loam soil and was leveled with levelers to re-simulate the previous condition of soil. The soil bin was filled with clay-loam soil. Particular equipments were used to organize soil bed including leveler and harrow since it’s very important to have well-prepared soil inside soil bin for acquiring reliable and precise results from this experiment. Fig .1 demonstrates the procedure of leveling the surface of soil bin.

Figure 1. The process of soil bin surface leveling

The facility to measure amount of vertical load acting on single wheel-tester were a calibrated load cell, indicator system and a computer to record the data. Fig. 2 illustrates the facilities applied for measuring vertical load.

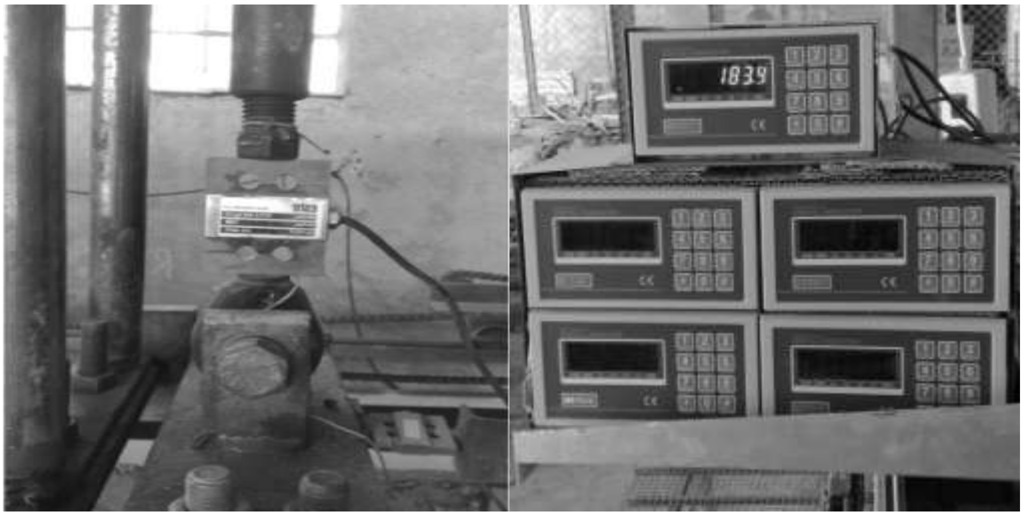

Figure 2. Load cell and indicators to measure vertical load acting on wheel

In order to measure soil compaction, a digital penetrometer (Rimik CP 20) was utilized. The digital penetrometer included a cone of 30 degrees at top, a bar attached to a load cell and a chipset. This penetrometer featured recording imposed soil resistance at various depths while penetrating the soil with constant speed at fixed applied force. The general process of data acquisitioning and utilized penetrometer is demonstrated in Fig. 3.

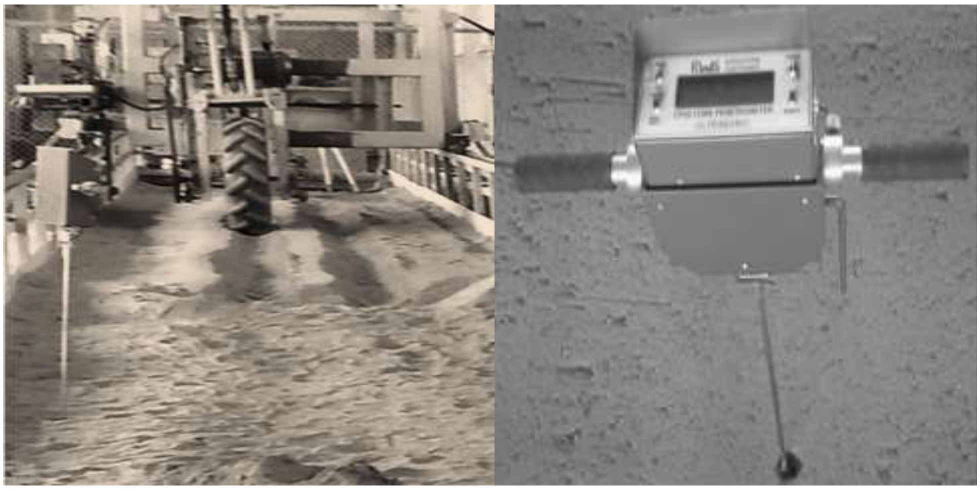

Figure 3. The general process of data acquisitioning and utilized penetrometer

Results and discussion

Fig.4 demonstrates the changes in amount of penetration resistance at various depths (each number from one to eight are representatives of 25 millimeters increase of depth). Obviously, increase of wheel load from 2 to 2.5 kN as well as 2.5 to 3 kN caused increase of penetration resistance (as a major criteria of imposed soil compaction).

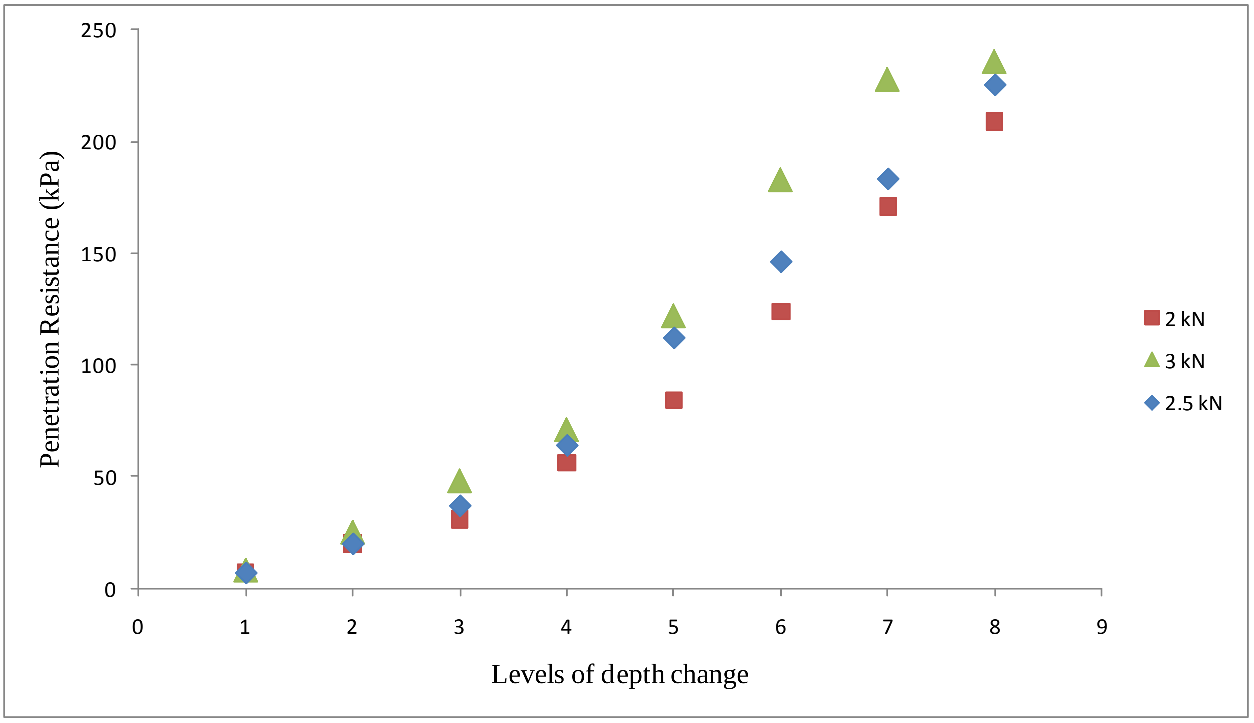

Figure 4. Changes in amount of penetration resistance

The difference between increased soil compaction due to increase of wheel load seems to be increased at higher loads, where wheel load is much more influential than other parameters. Almost identical amounts at topsoil parts is better interpreted while considering that contact pressure is mainly dependant to tire inflation pressure than wheel load at soil-tire interface.

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