Abstract: Changes in soil properties in arable layer under pressure of tractor outfit wheels. There are presented results of investigations on deformation of soil subjected to multiple loading resulted from tractor wheel passages. The investigations were carried out with the use of three agricultural tractors: MF 255, Ursus 1234 and Ursus 4512. The changes in bulk density of soil within the zone under the wheel track and next to it are presented.

Key words: soil bulk density, specific pressures, tractor

INTRODUCTION

Running of tractor outfit in the field results in the change of physical and mechanical soil properties. The highest soil compaction is usually found in the arable layer, containing about 80–90% of root mass of cultivated plants majority. Therefore, unfavourable changes in soil properties directly apply to environment, which finally affects the yield. According to common opinion, these changes result from application of heavy agricultural tractors and machines during tillage, fertilizing, plant protection and harvest operations, and also from intensification of cultivation (Carman, 1994, Grečenko, 2003). Each of these operations generates the side effects connected with excessive soil compaction by the wheels, leading to unfavourable changes in soil structure stability.

According to soil compaction definition given by Sommer and Petelkau (1990), the measures for soil compaction under the wheels, resulted from pressures exceeding the soil resistance to stress, are soil density, volume of pores and their configuration. Both to low and to high bulk density is not favourable. The excessive soil looseness deteriorates the soil-water conditions, thus, making difficult the contact between seeds and soil, and also the capillary ascent of water from profile depth. However, the excessively compacted soil makes difficult development of the root system, impairs access to nutrients and their utilization, leading even to crop yield reduction.

MATERIAL AND METHODS

The field investigations were carried out in the soil determined (according to its size distribution) as clayish sand. The field was ploughed prior to investigations to a depth of 0.35 m, and then left for 14 days to be settled down. The soil on particular measuring lengths was compacted with agricultural tractors: MF 255, Ursus 4512 and Ursus 1234, repeating the
tractors’ runs 1, 2, 4 and 8 times over the same track at speed 5 (±0.1) km·h⁻¹. The soil bulk density was measured with the use of 04.17 Eijkelkamp probe for soil sampling in undisturbed state, equipped with cylinders of volume 100 cm³ and the wall height 50 mm. During tests the probe was driven in soil on tractor wheel track and the field surface on the left-hand and right-hand sides, at distance of 150 mm from the wheel track. Therefore, soil samples of 0–300 mm profile were obtained.

RESULTS OF INVESTIGATIONS

The effect of wheel pressure on soil was found in the track (Fig. 1) and zones situated on both sides of the track. Basing on the obtained results it was found that an increase in wheel pressure resulted in increased soil density in the entire profile under the track; the highest compaction values were found in superficial layers, and these values decreased with the profile depth. Depending on wheel pressure resulted from tractor type and number of passages over the same track, and also on layer depth, the mean value of soil density ranged from 1317.6 g·cm⁻³ to 1657.5 g·cm⁻³. The least soil compaction was found in the layer 275 mm at specific wheel pressure 126 kPa, resulted from a single passage of tractor Ursus 1234. The highest soil density was found in superficial layer of track (25 mm) after 8 passages of tractor MF 255 with pressure of 1318 kPa.

Dry soil density characteristic for the soil state is an important parameter from the viewpoint of crop requirements; however, it does not reflect the intensity of wheel operation. Therefore, the basis for wheel action evaluation were changes in the soil state occurring under wheel pressures, related to the soil state prior

![Figure 1](image-url)  
FIGURE 1. Values of dry soil density in the track under wheel pressures: \( G_{ogs} \) – increase in dry soil bulk density, \( a \) – depth of soil parameter measurements, \( G_{ogs} \) – dry soil bulk density, \( P_k \) – total pressures of wheels on tractor front and rear axles after \( i \)-passage of tractor over the same track
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Considering changes in soil compaction one can find that even the least values of wheel pressure (125–137 kPa), corresponding to a single passage of tractor, resulted in an increase in average soil density under the track by about 17–20%. At the same time, this increase in compaction was equal to almost half of total change in soil density obtained after 8 passages of tractor MF 255 of total pressure 1318 kPa. Two passages of tractors resulting in total wheel pressure 264–293 kPa caused an increase in soil compaction by 22–26%. Four passages of tractors of total wheel pressure 551–622 kPa increased soil density in relation to its initial state by 29–31% (almost 80% of maximal soil compaction).

The effect of wheel pressure on soil was found also in the zones situated on both sides of the track. Due to the lack of significant differences in soil compaction measured on the left-hand and right-hand sides, the measurement values for particular depths of both sides were averaged (Fig. 3).

In the zones situated close to the track, the soil compaction values in the most superficial layers (25 and 75 mm) were greatly scattered. It may be explained by relatively small effect of the side compacting action of wheels in these layers, where soil was pushed aside during wheel passage over the loosened field. These layers were characterized by the least soil density (1005–124 g·cm⁻³) close to its initial state. The highest soil density was found for the layer of 175 mm (1236–1548 g·cm⁻³); these values were bigger than initial ones by 2.5–28%.

FIGURE 2. Effect of wheel pressure on changes in dry soil density in the track: \( \Delta G_{ogs} \) – increase in dry soil bulk density, \( a \) – depth of soil parameter measurements, \( G_{ogs} \) – dry soil bulk density, \( P_k \) – total pressures of wheels on tractor front and rear axles after \( i \)-passage of tractor over the same track
SUMMARY

The carried out investigations on the effect of tractor wheel pressure on soil compaction in arable layer proved that every passage of tractors over loosened field surface resulted in creation of pressure on the soil. Its highest values were found for the tractor of least total mass – MF 255. Changes in soil compaction expressed by dry soil bulk density under the track of tractor passages covered the entire profile 0–300 mm under the track, and in considered side strip 400 mm wide. The zone under the track in its entire cross-section was compacted even after first passage more, than the state considered as “normally compacted”. These values were higher than those considered as optimal ones with respect to the requirements of many crops. The results of measurements proved also that in places close to the track in the layers below 100 mm, the soil compaction caused by wheel pressures also exceeded the ranges favourable for the crops.

REFERENCES


Streszczenie: Zmiany właściwości gleby w warstwie ornej pod wpływem nacisków kół agregatów.
tów ciągnikowych. W pracy przedstawiono wyniki badań nad odkształceniem gleby poddanej wielokrotnym obciążeniom związanym z przejazdami kół ciągnika. Badania przeprowadzono z wykorzystaniem trzech ciągników rolniczych: MF 255, Ursus 1234 oraz Ursus 4512. Przedstawiono zmiany gęstości objętościowej w strefie pod koleinami i obok kolein przejazdu kół.

**MS. received September 2007**

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