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# COMPACTION PARAMETERS AND SOIL TILLAGE QUALITY IN SYSTEM WITH PERMANENT TRAFFIC LANES

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**Abstract**
In the field experiment were all machines passages concentrated in permanent traffic lanes at the module of machine working width 6 metres. The paper contains results of measurement of soil porosity in variants with traffic lanes and outside the traffic lanes. The results confirm a benefit of wheel traffic concentration to permanent traffic lanes aimed at protection of the most part of the field from soil compaction. Another confirmed advantage of concentration of passages into permanent tracks is an increase of soil tillage quality in the most part of the field. After a medium deep tillage in November 2012 were clods hardness and shearing strength of clods lowest outside the traffic lanes, in traffic lanes of wheels of a tractor during sowing, combine harvester and soil tillage were acceptable.

**Keywords:** traffic on fields; porosity of soil; clods hardness

## Introduction

Contemporary technologies of field crop cultivation are connected with wheel traffic on fields that causes undesirable soil compaction. In past years intensive researches on problems of undesirable soil compaction have been conducted (Håkansson, 1995; Unger, 1996). The wheel load may cause different reactions in the soil profile, first of all in relation with soil moisture and degree of preceding soil loosening or compaction. At present, there are great efforts to decrease the wheel traffic of machines in fields to permanent tracks in order to maintain a major part of the area under crops without negative influence of wheel traffic (Chamen et al., 2003; Tullberg, 2007). The system of controlled traffic farming (CTF) is now regarded as prospective also because satellite navigation systems are available that make it possible to ensure the required accuracy of passes during all field operations. In the farm, which has a high-performance agricultural machinery was established field experiment with CTF system. The influence of wheel traffic restriction to permanent lanes on soil properties and on soil tillage quality was tested.

## Material and methods

A field trial on a land of 10 ha in size was established in the spring 2010. Soil conditions in the field: loamy soil (content of particles smaller than 0.01 mm in the topsoil layer: 38.3% by weight). Content of combustible carbon in topsoil: 3.8%.

In 2011 after forecrop harvest (winter wheat) the field was worked by a sweep cultivator to a depth of 80 mm, in autumn the soil tillage by a combined cultivator to a depth of 200 mm followed. 18.10.2011 were sown winter wheat. All wheel traffic was organised within the CTF system using OutTrac (Chamen, 2006) – Fig. 1. It is typical of this wheel traffic system that the wheel tracks of a combine harvester that has a wider wheel gauge than tractors are on the outer side of common permanent traffic lanes.

Tab. 1 gives an overview of farm machines used for field operations in the field in 2012. Those machines were chosen whose working width corresponded to the basic module of 6 m. The field operations of soil tillage and sowing were performed at the working width of 6 m. The wheel rows established during sowing were used for the application of chemicals for plant protection while the working width of a sprinkler was 18 m. The same wheel rows were also used for the application of mineral fertilisers.

On this field the soil properties were evaluated in four variants of wheel effect:

1 Traffic lanes of tractors during sowing, application of chemicals for plant protection, application of mineral fertilisers, lanes of a combine harvester and during soil tillage.

2 Traffic lanes of wheels of a tractor during sowing, lanes of a combine harvester and lanes of a tractor during soil tillage (without lanes of tractors at chemicals for plant protection and mineral fertilizers application).
3 Outside the traffic lanes.
4 Part of the field with uncontrolled wheel traffic (area of 3 ha) - Random.

In the variants of the field trial measurements basic physical properties of soil were evaluated in the spring season. After soil tillage in autumn, the indicators of soil tillage quality were assessed. To measure the shearing strength of soil a CL-100 vane probe (Terratest) was used. Clods hardness was measured by pocked penetrometer. By sieving on sieves has been clods size detected after soil tillage in autumn 2012.
For the navigation of machines during soil tillage, sowing, application of chemicals for plant protection, application of mineral fertilizers and during harvest a GPS satellite system with the correction signal of RTK VRS was used. For machines steering an assisted steering system AgGPS EZ-STEER (Trimble) was used. The vehicles for transport during the operation of a combine harvester did not pass across the field the grain tank of a combine harvester was emptied to a tractor semi-trailer on the edge of the field near the road.
This paper contains the results of evaluation of wheel traffic impacts on the soil in a field trial in 2012 (the third year of the consistent application of controlled traffic farming in a field). In that year winter wheat was grown in the field concerned, after its harvest soil tillage for spring pea followed.

**Tab. 1 Field operations in 2012 and machines**

| Field operation | Time | Machines | Working width [m] | Distance of tracks [mm] | Tyre width [mm] |
|---|---|---|---|---|---|
| Sowing of winter wheat | 18.10.2011 | CASE 7140 + VÄDERSTAD Rapid 600P | 6 | 2000 | 500x2 |
| Mineral fertilizers application | 18.3.2012 | By airplane | - | - | - |
| Herbicide application | 27.4.2012 | CASE JX 1100U + AGRIO NAPA 18 | 18 | 1800 | 320x2 |
| Pesticide application | 11.6.2012 | CASE JX 1100U + AGRIO NAPA 18 | 18 | 1800 | 320x2 |
| Winter wheat harvest | 2.8.2012 | CLAAS Lexion 460 | 6 | 2750 | 650x2 |
| Shallow loosening (depth 120 mm) | 20.8.2012 | CASE 335 + FARMET Hurikan 600 | 6 | 2220 | 720x2 |
| Mineral fertilizers application | 20.8.2012 | ZETOR 10145 + AMAZONE 1000 | 18 | 1800 | 300x2 |
| Repeated shallow loosening | 19.9.2012 | CASE 335 + FARMET Hurikan 600 | 6 | 2220 | 720x2 |
| Medium deep loosening (200 mm) | 15.11.2012 | CASE 335 + Simba SLD 600 | 6 | 2220 | 720x2 |

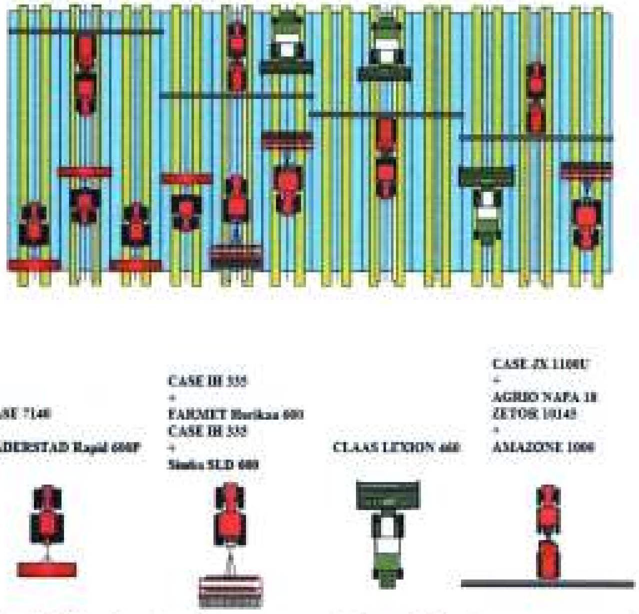


**Fig. 1 Wheel ruts of tractors and combine harvester on the field**

**Results and discussion**

The Fig. 2 and 3 illustrates the average values of soil total porosity on 26th April 2012. At a depth of 0.15-0.20 m the highest total porosity of soil was in variant 3 (Fig. 2). Among other variants, the differences of soil porosity were statistically insignificant. Statistically insignificant differences were in the depth of 0.25-0.30 m (Fig. 3). Because the wheel traffic in 2012 were after the collection of soil samples, these results indicate a relatively balanced soil porosity values. The increase of soil compaction due the tractor passes at winter wheat sowing (18.10.2011) was observed only in the surface layer of soil (Fig. 2).

In 2012 the field was run over a total of seven times, as in previous years passes were concentrated in permanent rolling tracks. After a medium deep tillage in November 2012 were measured shear stress in clods and hardness of clods on the soil surface. Measurements with vane probe on 15th November 2012 showed increasing differences between variants 1 (wheel rows) and 4 and the other variants (Fig. 4). Values of the shearing strength of clods in variant 1 were more than six times higher than in the variant 3 (outside wheel tracks), these differences were statistically significant. Highest values of the shearing strength of clods were found on variant 4 (Random).

The Fig. 5 documents the values of penetration resistance of clods in the surface layer of soil in November 2012 after autumn soil tillage. The highest penetration resistance of clods was on variants 1 and 4 (2.9 times more than on variant 3).

Average soil moisture of clods was 17.2% of the weight in variant 1 and 17.6% of the weight in variants 2, 3 and 4.

Graph in Fig. 6 documents the size clods after medium deep loosening (200 mm) on November 2012. The best size clods fractions were on variant 3. On all other variants were in the soil surface layer clods too big (over 100 mm). Too big clods make difficult the seedbed preparation for winter crops.

The existing results of pilot field trial show that the system CTF is useful in conditions of agricultural enterprises with good technical equipment and good organize of work operations. The system of controlled traffic farming with permanent separation of wheel tracks of machines from the production area of the field without traffic is used in the ZAS Podchotuci, a.s. agricultural enterprise in Krinec for 4 years on the land of 10 ha. Although the wheel gauge of combine harvester is wider than the wheel gauge of tractors, a relatively good situation was reached when the total area of wheel tracks in the field (with the exception of headland) accounted for 32% of the land area if the module of the 6-metre working width of machines was used. But it is realistic to decrease the area of wheel tracks to 20-25%

of the field area when the module of working width be wider (8 or 9 m). In conditions of the Czech Republic the monitoring of wheel traffic in fields showed that the wheel tracks accounted for 86% of the field area in the production system of winter wheat when conventional soil tillage was used (Kroulik et al., 2011).

Other decrease of the proportion of wheel tracks in the area of fields could be reached by unification of the wheel gauge of tractors and harvesting machines - these adaptations of machines for the CTF system are already implemented in some countries (Tullberg, 2010).

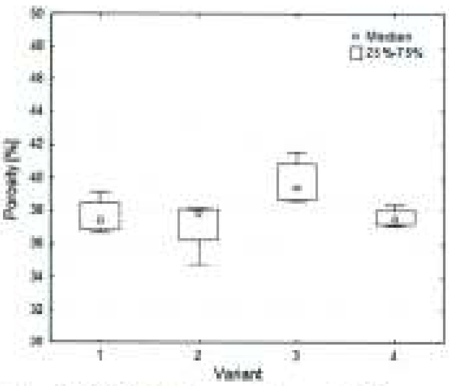


**Fig. 2 Soil total porosity on 26th April 2012 – 0.15-0.20 m**

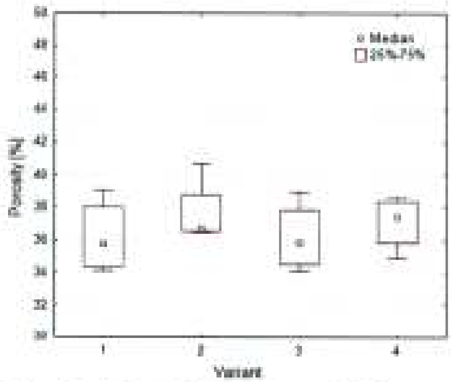


**Fig. 3 Soil total porosity on 26th April 2012 – 0.25-0.30 m**

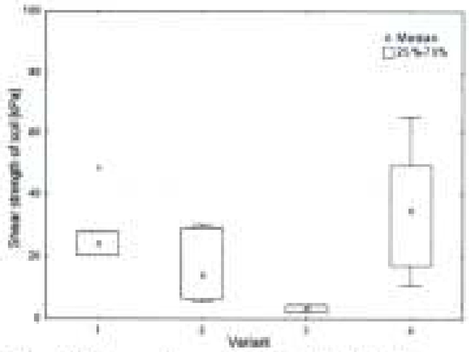


**Fig. 4 Shear strength of clods in the surface layer of soil after soil tillage (15th November 2012)**

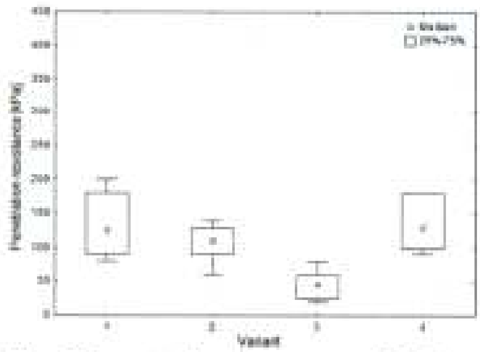


**Fig. 5 Penetration resistance of clods in the surface layer of soil after soil tillage (15th November 2012)**

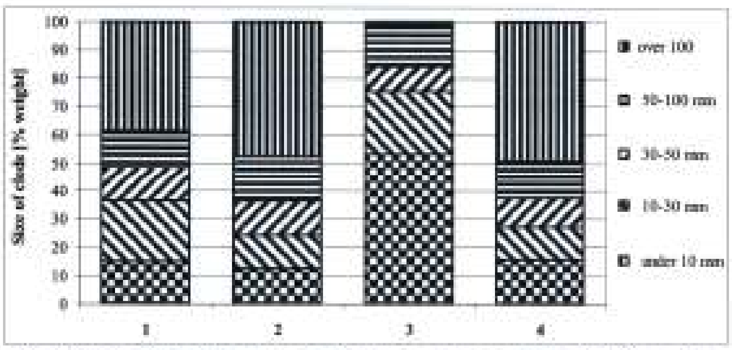


**Fig. 6 Size of clods after medium deep loosening (200 mm) on November 2012**

**Conclusions**

The research results of a pilot field trial obtained in 2012 show that the controlled traffic farming system can be realized in agricultural enterprise. The requirement is the use of a precise navigation satellite system with the correction signal with the assisted or automated steering of tractors and combine harvesters. The controlled traffic farming system can be used in minimum tillage and soil conservation technologies for the production of crops harvested by combine harvesters.

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