QUALITY ASSESSMENT OF SELECTED TILLAGE MACHINES FOR SECONDARY SOIL TILLAGE

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Abstract
The aim of this paper is evaluate the quality of soil tillage with combinator for secondary soil tillage. Measurements of tillage quality parameters were performed on August 2017 in Nesperská Lhota near Benešov (Central Bohemia Region) on sandy-loam soil at an altitude of 390 m. This evaluation was carry out on three-row (working tools) pre-seed combinator for soil bed preparing. Quality of soil tillage was assessed after crossing machine. The evaluated parameters of the quality of work are surface covering by crop residues, size of soil aggregates, surface profile and surface roughness. After secondary tillage was observed small number of clods, low surface roughness and an appropriate spreading crop residues. The results demonstrate the effectiveness of the combinator to create a quality pre-seed bed.

Key words: *soil tillage; the quality of the machine work; depth of loosening.*

INTRODUCTION
Soil is a non-renewable natural resource that is the main means of producing food in agriculture *(Morgan & Nearing, 2011)*. Over the past hundred years, land has been increasingly used by machinery and technology. However, this is a risk to the sustainability of land use, as damage to the soil environment affects yields for several decades *(Kladivko, 2001)*.
The task of soil cultivation is to prepare the soil for the establishment of stands, for growth, development and yield of cultivated crops and for the proper course of soil processes. When choosing soil tillage, proper soil water management, biological and chemical soil conditions must be taken into account *(Titi, 2002)*.
The soil is threatened by a number of natural phenomena, but also by human activity. According to estimates, 50% of the total original area of productive land has already been destroyed by human activity on Earth, and 10 million square kilometers of cultivated land have been lost over a hundred years *(Morgan, 2005)*. This land is declining mainly in Africa and the Far East. The soil is threatened mainly by water and wind erosion *(Pimentel, 2006)*. The problem is the acidification of soils by acid rain. Another major problem for Africa, Asia and Latin America is desertification because of deforestation *(Lal, 1995)*.
The risk to soil fertility in the Czech Republic is also management at the expense of soil fertility in the future. The detriment to this is, for example, soil compaction in previous operations, inadequate soil organic matter care, extremely simplified crop sequences (lack of improving crops), soil overload with maize for energy purposes, and current water erosion in maize growing (*Kovaříček et al., 2008*).
About 50% of the total agricultural land is threatened by water erosion in the Czech Republic. This is largely due to the linking of agricultural areas to large units after the Second World War and the current trend of growing wide-row crops as maize without covering the soil surface with organic matter (*Javůrek et al., 2008*).
Choosing the right soil tillage system and the right machine is crucial to affecting these negative impacts on the soil. Therefore, this issue needs to be addressed. Thus the aim of this paper is evaluate the quality of soil tillage with combinator for secondary soil tillage.

MATERIALS AND METHODS
The measurement was carried out on October 21, 2017 in the area of Nesperská Lhota near Vlašim. The coordinates of the plot are 49 ° 41'30.2 "N 14 ° 48'37.8" E. The soil is loamy-sandy cambisoil, shallow and slightly rocky. The whole plot is located on a gentle slope, the average slope is 4.2°. The altitude is between 450 and 475 meters above sea level. Winter wheat was grown on the plot in

the year of measurement. Straw was baled and taken away. This was followed by medium plowing to a depth of 0.22 m with a ROSS plow. After plowing the land surface was processed by levelling bars and harrows. The soil cultivator Ostroj Saturn with a working width of 6 meters was used for measuring. Combined cultivator was pulled by Zetor Forterra 130 HSX 16V. Tillage was carried out on a contour line. Soil tillage speed was 10 km/h.

Soil roughness was measured by the chain method *(Klik et al. 2002).* The measurement of clods weight was performed by measuring the weight of the individual clod fractions. Determination of the weight of clods of different size fractions was always performed on an area of 0.25 m^2 (0.5 x 0.5 m). The soil was uncovered to the depth of soil cultivation. Subsequently, it was screened through a set of 100, 50, 30 and 10 mm sieves. Five measurements were made for both variants (before tillage, after tillage). The results were determined by calculating the arithmetic mean of the fractions weights from which the relative mass fractions were determined.

Measurement of surface coverage by plant residues was performed by image analysis. IrfanView 64.4.44 photo editing software was used for processing. Here, the create photos were edited with color correction and color replacement tools, adjusted to photos with black and white images, where black and white are marked in the bare surface of the soil.

RESULTS AND DISCUSSION

The calculated surface roughness values clearly demonstrate a significant reduction in soil roughness after soil cultivation by combinator. The roughness of the soil surface after tillage has decreased in the longitudinal direction by almost 70% compared to the original state. Soil surface roughness after processing in the cross direction has also decreased, but the difference is not so pronounced due to the surface profile created by the Crosskill rolls. The graphs in Figure 1 show ranges of calculated surface roughness values. According to the Tukey test with homogeneous groups, it is shown that there is a significant statistical difference between the surface roughness before processing and the longitudinal processing of the soil.

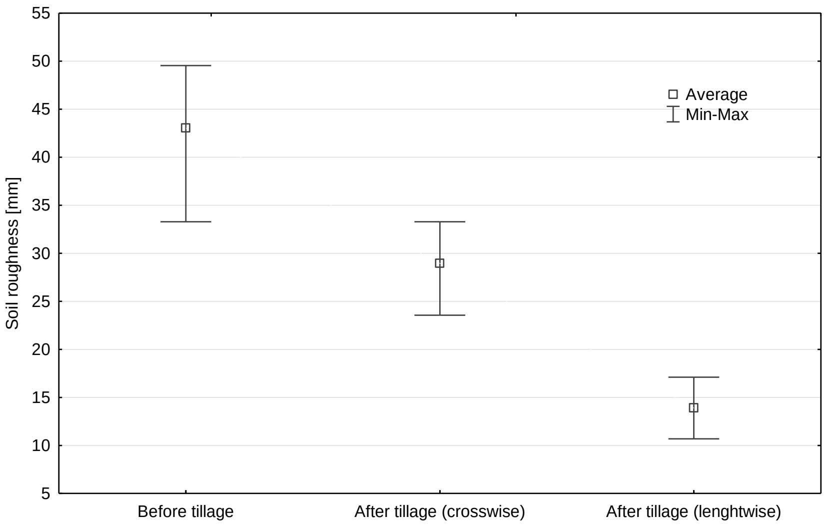

Fig. 1 The calculated surface roughness

The clods weight measurements provided values to generate the graph shown in Figure 2. The values were measured before soil cultivation and immediately after the soil cultivation with a combined cultivator. The results show that the soil is free-flowing and does not produce lumps larger than 100 mm. Even lumps larger than 30 mm are only 4.4% on the site. However, there is a noticeable difference in lumpiness before and after soil tillage. After soil tillage, the proportion of clods over 30 mm and lumps of 10-30 mm were reduced. As a result, the proportion of particles smaller than 10 mm has increased considerably.

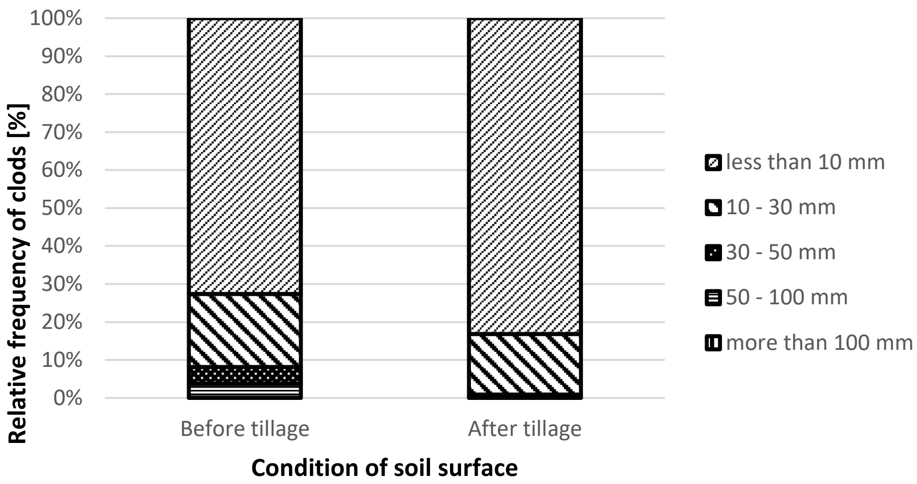

Fig. 2 Relative frequency of clods

The results of the recorded soil cover with plant residues clearly indicate that the vast majority of plant residues on the soil surface have been incorporated. This proves that a small amount of plant residues can reliably incorporate by combined cultivator. Figure 3 shows the ranges of measured values. From Tukey's analysis, there is a significant statistical difference between the pre-cultivation and post-culture values.

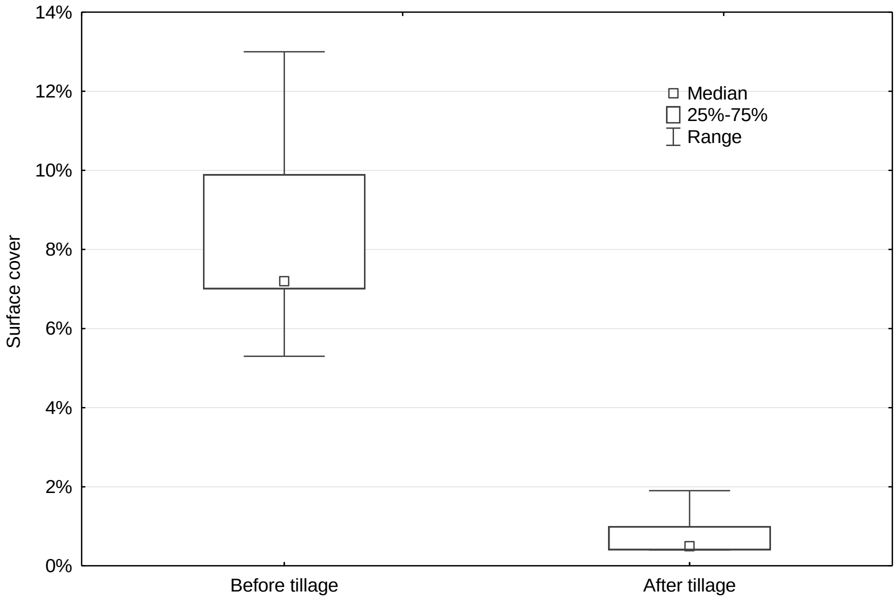

Fig. 3 Soil surface coverage by plant residues

Surface roughness measurements always have pitfalls associated with soil at the measurement site. Very much depends on soil condition, soil type, soil composition, soil moisture, stoniness, etc. When measuring the surface roughness of the chain method, we measured the surface roughness value of 28.96 mm with the transverse direction and 13.90 mm in the longitudinal direction. This significant difference is due to the texture of the soil surface after the Crosskill roll. For comparison, *Duma et al. (2017)* measured the surface roughness by the 2.54 mm chain method, for the Preciser 6000 disc harrow with rod rollers under similar conditions, for the Horsch Tiger 4AS cultivator with tire packer up to 10.36 mm and for Case III Ecolo- tiger 530B surface roughness 10.3 mm finished with gates. These values indicate that the ground surface measured by the Crosskill roller after the soil has been tilled produces a rougher surface when using the gates of the Case Ecolo-tiger or tire packer.

From the soil surface coverage measurements, it was measured that the combined cultivator incorporated 89.5% of the plant residues in the soil, with an average surface coverage of plant residues of 8.5%. This is a good result compared to the values measured by *Novák et al.* (*2013)* on the Horsch Terrano 3 and Lemken Karat 9/300 cultivators. Horsch Terrano incorporated 71.2% of plant residues and 70.1% of plant residues from Lemken Karat. However, we have to take into account that these measurements initially covered almost 100%, which makes the comparison very difficult.

CONCLUSIONS

The measurement was focused on evaluating the quality of the secondary tillage by the combined Ostroj Saturn cultivator. From the measurement of soil surface roughness by the chain method, we found that the stand creates a good and balanced soil surface suitable for soil preparation before sowing. However, problems occurred in the processing of the soil on a slope when traveling on a contour line, where the machine created some stairs on the land surface. The clods measurement shows that the machine has a good crumbling ability. The proportion of larger clod fractions decreased significantly after soil treatment. In terms of incorporation of plant residues, it was calculated that 89.5% of the plant residues were incorporated. This clearly demonstrates that the machine is able to reliably incorporate a small amount of plant residues.

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