INFLUENCE OF DIFFERENT SOIL TILLAGE TECHNOLOGIES ON CROP RESIDUE MANAGEMENT

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Abstract. Conservation tillage technologies where mouldboard plough ploughing is replaced by tillers and shallow soil loosening are increasingly used as soil treatment. It is typical for shallow soil tillage that all plant residues are left on the soil surface, or in the treated (tilled) upper soil layer. The plant residues can play a very important role by the next plant cultivation. Leaving crop residue on the soil surface year around, before and after planting provides soil surface protection at critical times to protect the soil against wind and water erosion. Reducing tillage operations improves soil surface properties, including improved soil aggregation accounting for increased infiltration and percolation; less compaction due to less usage of field implements; and more biological activity due to an increase in organic matter. Adding soil surface cover increases water infiltration, reducing soil drying and maintains more moisture for crop utilization. In the experimental section the aim of the research was described which is possible to summarize briefly as follows – evaluation of soil physical properties on the work quality of tillers, evaluation of sweep tillers and disc tillers work quality by stubble ploughing. In the methodology part of the thesis there are the measurement techniques explained. The results of this work are important because conservation (minimal) soil tillage technologies play an important role in plant production around the world. Especially conservation tillage systems with their modification are increasingly being introduced under the economic pressure on the fields of the Czech Republic.

Keywords: soil tillage, conservation, erosion.

Introduction

Ways of farming change notably the structure of soils and conditions for crop growing, too. The structure is changed above all by external pressure mechanization agents, the way of fertilization, weather conditions and last but not least it has significant influence also on different ways of soil tillage systems [1; 2]. In the conservation systems soil tillage is the main tool limiting destruction and compression of soil textures and soil conservation before erosion effects take place. The main reasons of minimum soil tillage exploitation are crossing after soil tilling, especially shortly after its loosening, soil protection against water and windy erosion, facilitation and speeding of soil tillage, limiting aeration on drying soils with high-powered mineralization organic masses and movement restriction with soil at unfit dampness. Minimum soil tillage includes cultivation [3], which is based on jointing or reduction of the number of single operations, progress with dull processing soil, when there is dull depth or intensity processing or when the soil processed only in the zone treatment or only in a certain layer soil profile.

In the experimental section the aim of the research was described which is possible to be summarized briefly as follows – evaluation of soil physical properties on the tiller work quality, evaluation of sweep tillers and disc tillers work quality by stubble ploughing. The field plots were chosen at different parts of central Bohemia. The first field was in VÚRV Ruzyně and on this field the soil physical properties and their influence on work the quality by stubble ploughing were evaluated. On the second field (in Bratřínov village) at first the straw distribution quality after harvesting winter wheat and winter rape by conventional and axial combine harvesters was evaluated and secondly the effect of the plant residues irregular on-surface placement after harvest on residues placement in soil profile after treatment by shovel tiller. The third measurement was on the field in Nechanice village. The difference between the sweep and disc tillers work quality was evaluated with the accent on the plant residues distribution and the size of clods after shallow ploughing.

Materials and methods

On the VURV field there were sixty check points located and sighted by the GPS system on a field with a acreage of 16 ha. The soil properties and characterization of the plant cover were measured at these points. The aim of the measurement was to evaluate local heterogeneity of the soil properties and the influence of the heterogeneity on the plant cover. The part of the measurement was to obtain the quality of soil workability indices after single tillage operations. The bulk density, clod

hardness and the size of clods and their influence on the work quality by soil tillage were evaluated. On the second field the straw distribution quality after harvesting by a combine harvester and crop residue management after shallow tillage by a sweep tiller were evaluated.

The quality of scatter straw and chaff was investigated with the help of iron-plate boxes intermediate to the picking growth before crossing by the combine harvester. Subsequent withdrawal of samples from all boxes captured took place and every box was divided on two halves. The achieved record was numerically assessed by the help of the Christiansens coefficient. The plant residue uniformity and quantity were evaluated. For evaluation it is necessary first to determine the quantity of the plant rest on the top of soil after harvest, when this value presents 100 %, and subsequently after fulfillment of the work stages. For sweep disc tillers comparison a field in Nechanice after winter wheat harvest was chosen. For the research of the soil cultivation technologies for the soil conservation systems it is significant to obtain information how individual machines used within the operational processes affect the crop after-harvest remainders and the inter-crop biomass [4; 5]. After each operation of soil cultivation colour photographs of the land surface were made. After the photographs were made the crop residue was withdrawn from the land surface and consequently weighted. The colour photographs were processed by the picture analysis. During processing of the picture the land surface covering rate by the crop residue was obtained.

Results and discussion

The formation of large and hardly processed clods from compacted soils by primary tillage is an important cause of higher energy consumption during soil processing and furthermore the worst quality of the soil. The intensity of slice breaking more notably declined during the compacted soil tillage; nevertheless, the tillage energy consumption presents a part of compacting influence on soil workability only. The presented results show great difference in soil workability commensurate with soil compaction caused by machine overpasses mainly under higher soil moisture conditions. There is the heterogeneity of soil penetration resistance within the drilling depth after the tillage and winter wheat seeding. There are localities with a specific soil penetration resistance. It has proved that localities with statistically important differences in values of soil penetration resistance have occurred on the field.

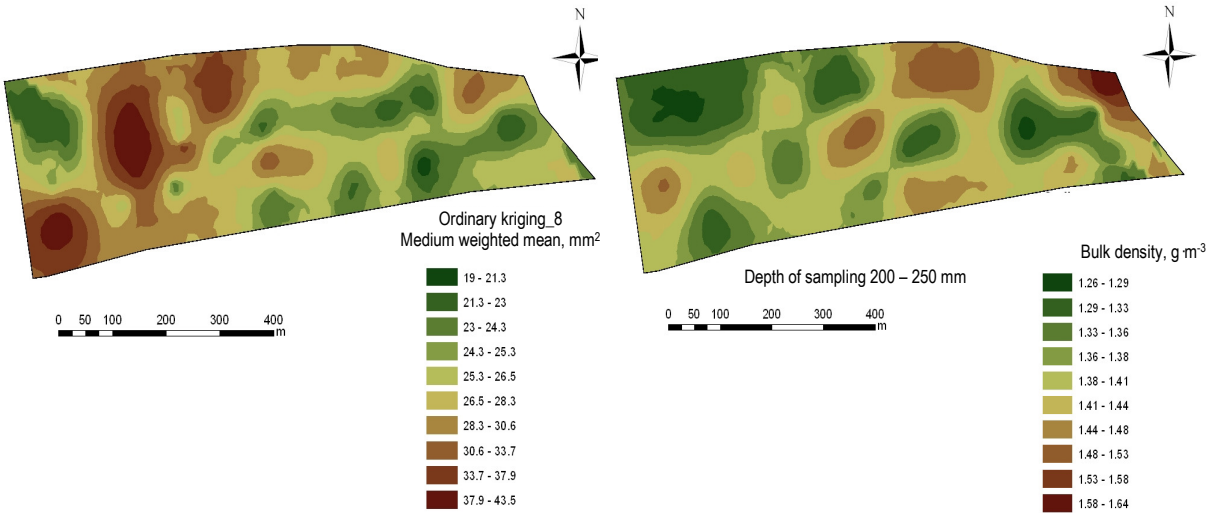

Fig. 1. **Median weighted average of clods (left), soil bulk density (g·cm^{-3}) (right)**

The important condition for establishing of new high productive plant cover of field crops is to reduce the soil compaction during former working operations to the lowest possible measure. There is dependence between the penetrometric resistance, soil bulk density and size of clods. Evaluation of the straw distribution quality was observed by winter wheat harvest by axial and tangential combine harvesters. In both cases with higher throughput worse quality of straw distribution was observed.

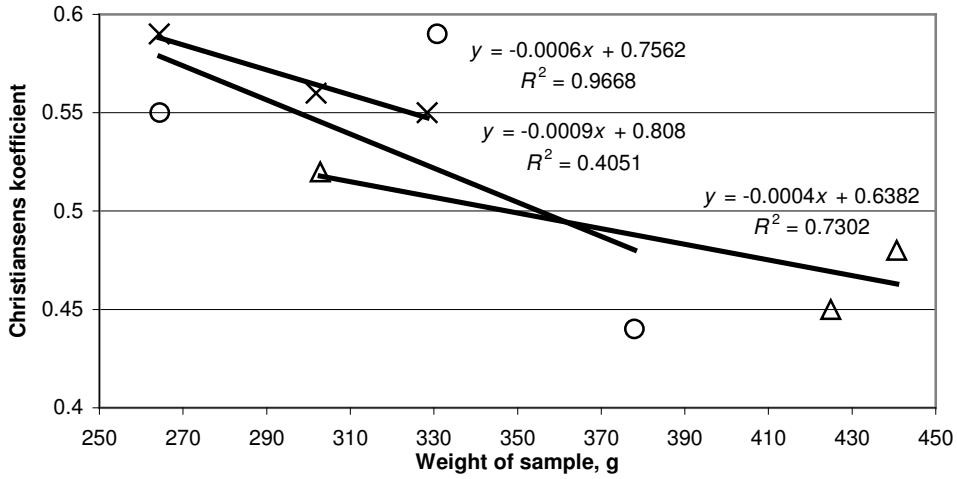

Fig. 2. **Christiansen coefficient for straw distribution by harvest:**
x – CASE, Δ – CASE without modification, o – John Deere

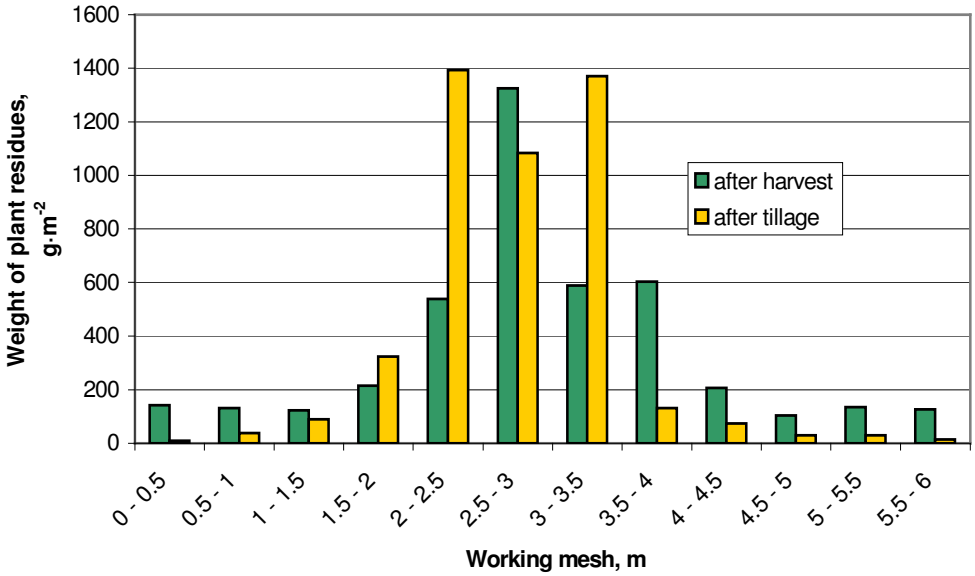

Fig. 3. **Distribution of plant residues after stubble ploughing (bed spreading)**

In Figures 3 and 4 the effect of the plant residues irregularity on-surface placement after harvest on residues placement in soil profile after treatment by shovel tiller can be seen. The plant remains mixed into soil after tillage were placed as irregularly as they were before tillage. The plant remains left on the soil surface were placed more evenly, but the separation of small and big particles took place. The long and big particles stayed on the field surface and the majority of the small ones were mixed into soil. The irregularity of small plant remains in the treated soil profile and so their great concentration at the particular place could affect the next plant germination and growth.

On the next field differences between the sweep and disc tillers work quality with the accent on plant residues distribution and the size of clods after shallow ploughing were evaluated. On the field 6 variants of soil tillage were created (1R – sweep 1x, 2R – sweep 2x, 1R2D – sweep and then disc, 1D – 1x disc, 2D – 2x disc, 1D2R – disc then sweep), depth processing was adjusted on 70 mm. The sweep tiller left more plant residues on the soil surface than the disc tiller (Fig. 5). By the second treatment by the disc tiller the number of plant residues on the surface increased. There are not statistically significant differences between the versions of soil treatment.

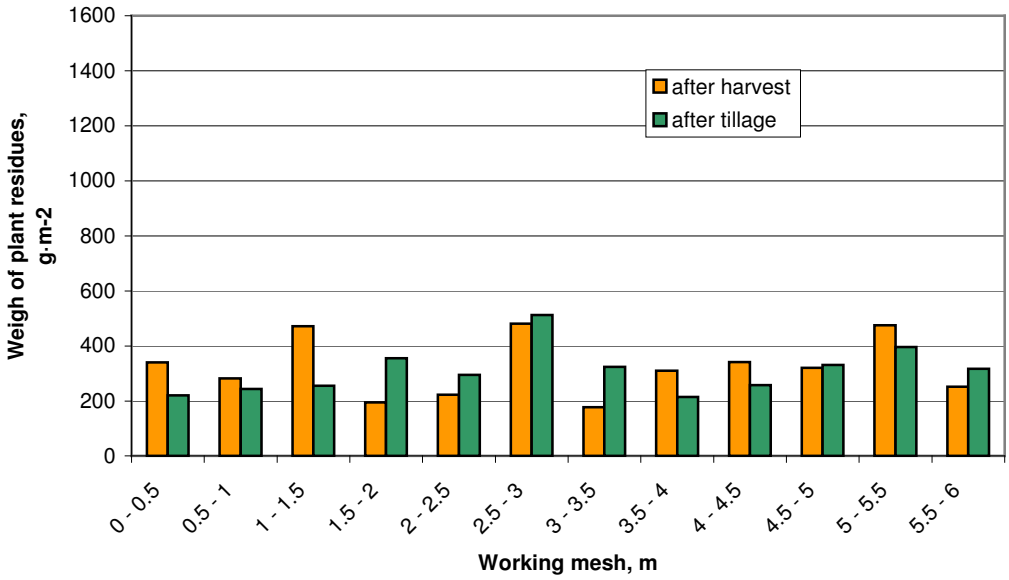

Fig. 4. **Distribution of plant residues after stubble ploughing (good spreading)**

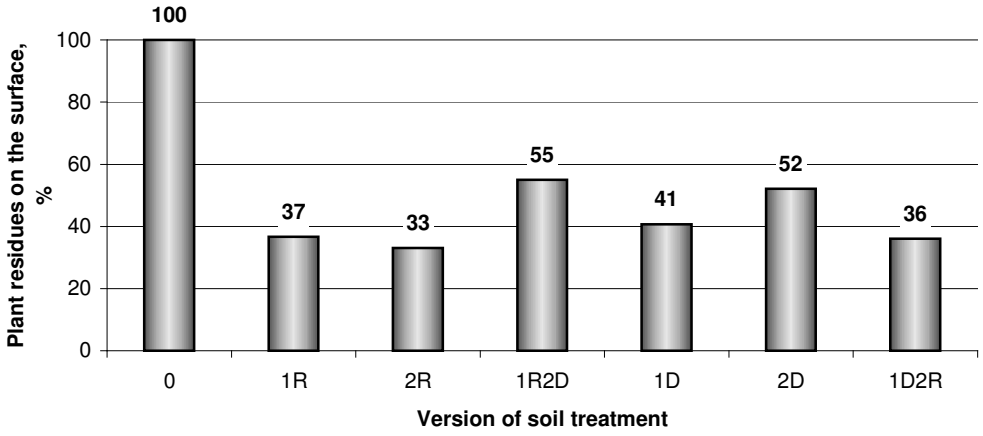

Fig. 5. **Rate of plant residues on the surface by different variants of soil tillage**

The map in Fig. 7 represents the actual working speed, during soil tillage with the disc tiller Preciser Classic 6000. These data were recorded by the GPS 35-PC Garmin. The actual working speed is present from the GPS at km·h^{-1}.

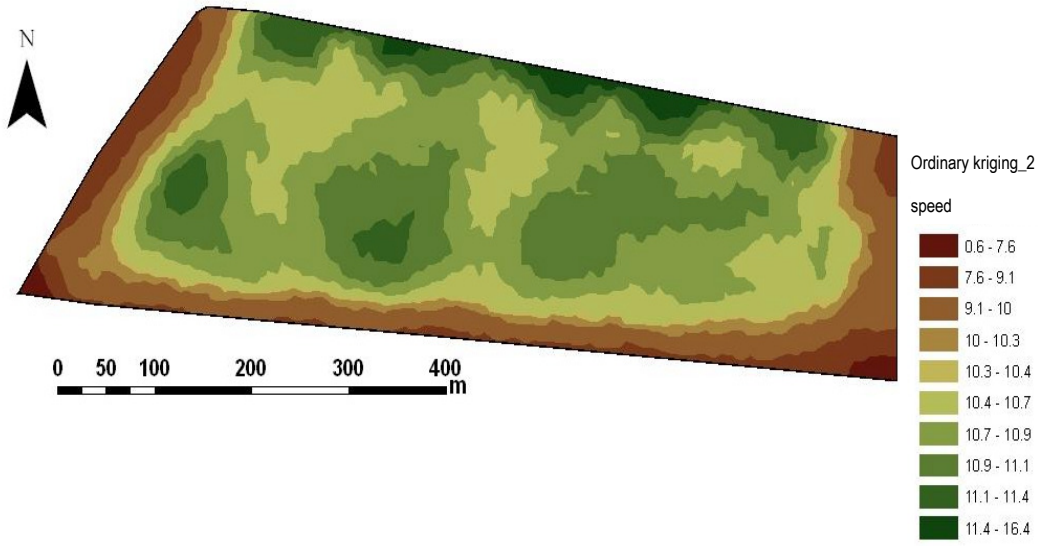

Fig. 6. **Map of actual working speed by soil tillage (km·h^{-1})**

The graph in Fig. 7 express relationship between the soil covering and weight of crop residues after working operations of soil cultivation for all of variants. The results of evaluation have shown regular distribution of the after-harvest remainders on the soil surface. Between soil covering by the crop residues and weight of these residues on the soil surface there is dependence (from medium to strong dependence). From these results there is a possibility to use the method based on the soil surface photograph analysis (image analysis) for the machine effect evaluation on the crop remainders and evaluation of the site heterogeneity of the soil covering by the crop remainders.

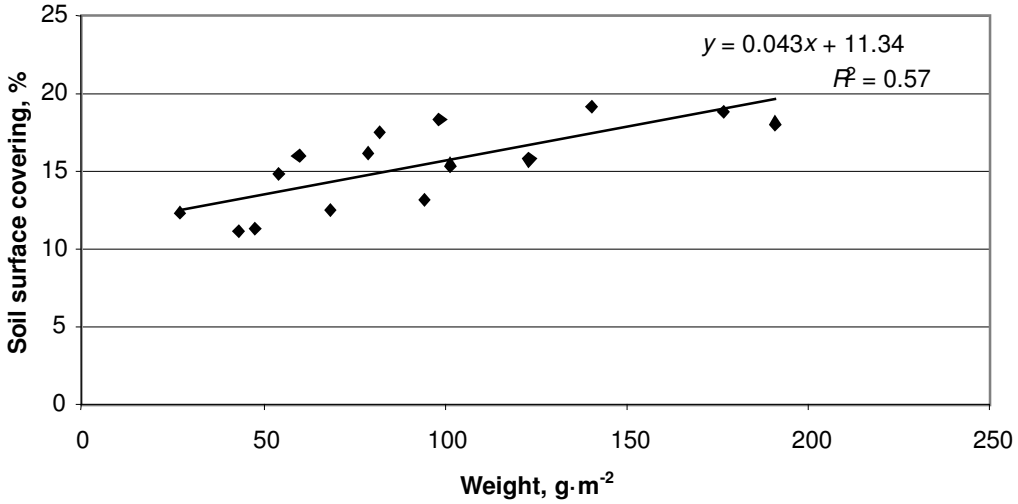

Fig. 7. **Relationship between soil covering and weight of crop residues after working operations of soil cultivation**

Conclusions

The field trial proved important decrease in the soil tillage quality. The decrease is a reason of former soil compaction caused by machine overpasses. The carried out measurement on the field with 16 (ha) acreage enabled to evaluate the differences in soil tillage caused by heterogeneity of topsoil part physical properties of soil horizon. The main reason of irregularities of the soil properties was the different grade of topsoil compaction caused by machine overpasses on the field. The map of clod hardness and map of soil penetration resistance on the seeding bed depth were created. The results are contributions to evaluation of heterogeneity of the soil technological properties on fields and influences that have an impact on the tillage quality and plant cover establishment.

Different physical properties were recognized and it was evaluated as dependence (correlation) between the concerning grain size distribution, bulk density of soil, penetration resistance and work quality of tillers by stubble ploughing.

The plant remains mixed into soil after tillage were placed as irregularly as they were before tillage. The plant remains left on the soil surface were placed more evenly, but the separation of small and big particles took place. The long and big particles stayed on the field surface and the majority of the small ones were mixed into soil. The irregularity of small plant remains in the treated soil profile and so their great concentration at the particular place could affect the next plant germination and growth.

By evaluation of differences between the sweep and disc tillers work quality with the accent on plant residue distribution it was recognized that the sweep tiller left more plant residues on the soil surface than the disc tiller. The observation of diesel consumption and work speed according to the soil heterogeneity properties provided very strong influence on these characteristics. This influence and its trend are supported by very different physical properties of soil. On the map of the work speed we can see very important points that are light soil because there it is possible to work with higher work speed by low or average diesel consumption. By observation of the total soil covering of plant residues the relationship between the weight of crop and grad of the soil surface covering were evaluated. Between the soil covering by the crop residues and the weight of these residues on the soil

surface there is dependence (from medium to strong dependence). This dependence we can describe by a linear trend and it is a very strong trend because the coefficient of determination is 0.57.

Acknowledgements

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