IMPACT OF SOIL TILLAGE TECHNOLOGY ON EROSION PARAMETERS IN CENTRAL BOHEMIA REGION

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Abstract. The paper is focused on evaluation of methods of establishing corn crop and oat crop in terms of resistance to water erosion. Water erosion and its symptoms represent a worldwide problem. In the Czech Republic conditions are at risk by water erosion more than half of the agricultural land. Very often beneficial effects of soil conservation technologies to reduce water erosion are described. Organic matter partly covers the surface of the soil and reduces surface runoff and erosive wash away. The field trial was established for measurement in central Bohemia at an altitude of 420 m. The field trial consists of seven variants based on corn and spring cereals. This paper includes data from 2015. Using the method retention microplots were evaluated by surface runoff and soil wash during intense rains sowing the crops. The results confirm the importance of soil conservation technologies of soil tillage and sowing of corn to reduce the risk of land degradation by water erosion. The positive impact of cover crop soil cover in the space between the corn rows was also confirmed.

Keywords: soil tillage technology, water erosion; surface runoff, erosive wash.

Introduction

Water erosion is a worldwide problem. Every year, water erosion causes destruction or damage to vast areas of agricultural land [1]. Agricultural land in the Czech Republic is largely exposed to the risk of water erosion due to habitat and agro technical reasons. The actual water erosion causes soil degradation, which reduces the production capacity of the soil [2]. The Czech Republic is characterized by a high average gradient of agricultural land. Janeček reports that more than 53 % of area in the Czech Republic is situated on land with an average slope greater than 3° [3]. The high slope of land, combined with light soil and expanding wide-row crops (corn) increase the risk of water erosion. Due to the growing need of organic matter for biogas plants across the EU, these issues will take greater importance. It is advisable to do further research, particularly with regard to the behavior of different types of soils.

Erodibility of soil depends on many soil physical properties, chemical and mineralogical natures, which are relatively easy to measure [4]. Apart from these, there are natural and difficultly controllable parameters as soil erosion is also affected by the technological system management. Relatively high risk is wide-cultivation of crops (in conditions of the Czech Republic especially corn) on land threatened by water erosion. It is not possible to completely eliminate the risk of erosion, but it may be reduced. Interventions usually consist of direct management of crop residues and using reduced soil tillage. Protection against water erosion of soil consists mainly of creating conditions to increase infiltration of water into the soil and reduce surface runoff rainwater. Annual tillage increases soil porosity, although immediately after the operation with the surface layer it may be in a relatively short time leading to unfavorable physical properties.

Very often beneficial effects of soil conservation technologies to reduce water erosion are described. For soil conservation tillage reduced tillage by reducing the number of operations, merging them while protecting the surface of soil plant residues is essential. Rasmussen reported that soil conservation technology tillage reduced soil loss by erosion by half to two-thirds [5]. Soil protection tillage can increase the capacity of the hydraulic conductivity of the soil and thus subsequently water infiltration into the soil. For this reason, it may contribute to the reduction of surface water runoff and soil erosion risks. On the other hand, conventional tillage produces a homogeneous layer of soil, which can reduce the absorption of water into the soil [6].

The choice of a suitable system for processing soil in the given location is a complicated process, which is required to apply both deep theoretical knowledge and also a long experience. After selection of the appropriate technology the given tillage system should follow. It is advisable to practically evaluate the quality of work corresponding to the chosen system of local circumstances. The choice of the technological system in terms of protection against soil erosion is currently affected also by the GAEC standards.

Materials and methods

The field trial was established on light cambisol with an average slope of 5.4°. The plot is located in the area Nesperká Lhota in central Bohemia Region at an altitude of 420 m. The field trial consists of six variants. The plot of land for each variant was 6m x 50 m in length, the side is facing the fall line.

After the harvest of triticale (crush straw) the site was in the second half of August 2009 followed by shallow tillage with a disc tiller. In variants 4, 5, 6 the post-harvest residues remained on the ground in the autumn without further processing Three options followed in October 2009, unilaterally plow tillage to a depth of 0.2 m (driving in the direction of the contour sets, tilting the hunk of the slope). Then tillage and seeding in spring as indicated in each experiment variant below. The field trial is repeated for several years since 2009. Tillage and seeding were repeated for each variant every year.

Variants of the experiment:

1. Conventional tillage technology for corn – ploughing in the fall, winter left rough wake, spring sowing soil preparation with a harrow, corn sowing.
2. Variant of tillage, spring cereals - ploughing in the fall, winter left rough wake, spring sowing soil preparation with a harrow, oats sowing.
3. Variant of tillage, corn with inter row crop (winter cereal crop sown in spring – triticale) – ploughing in the fall, winter left rough wake, spring sowing soil preparation with a harrow, triticale sowing, corn sowing.
4. Variant of reduced tillage- in the fall without tillage, spring tillage by a tine cultivator to a depth of 0.10 m, corn sowing.
5. Variant no tillage, spring cereals – only spring oats sowing.
6. Variant conservation tillage- corn without spring sowing soil preparation – loosening into the depth of 0.2 m, sowing intercrop in the autumn (white mustard), corn sowing in spring.
7. The “black fallow” – in the fall plowing, left rough over winter wake, spring tillage by a tine cultivator to a depth of 0.15 m is maintained without vegetation – 5 non-selective herbicide applications (Roundup Rapid, 4 $l \cdot ha^{-1}$).

On each variant of the experiment after sowing cereals and corn there were 4 runoff microplots installed (see Figure 1). The microplot is defined by walls of steel sheet with a thickness of 1.5 mm. The sheet walls were pressed into the soil so that the 0.08 m height of the wall is found in soil and protrudes 0.04 meters above the ground. The lower part of the microplot is drained into a drain collector and further conveyed to the buried-lying plastic collecting container (a canister with volume of 10 dm^3).

Fig. 1. **Drain microplot with drip area 0.16 m^2**

Capture runoff from the microplots is solved similarly, as presented by Bagarello, Ferro and Hudson et al. [7; 8].

To measure the size and intensity of precipitation the weather station Vantage Vue is located near the experiment site. Measurement of surface runoff followed every time after intense rainfall. Surface runoff was detected by measuring the volume of runoff water, the amount of soil washed by filtering runoff and subsequent soil drying at 105 ºC in the laboratory dryer and weighing the soil on a laboratory scale.

Results and discussion

This paper includes data from 2015. This year has been very dry with little rainfall in the Czech Republic. The first recorded event of 2015 was rain from 13 to 15 June (see Fig. 2, 3). Total rainfall was 17 mm. Rain intensity was minimal and that about 10 mm·h^{-1}. The values of surface runoff were minimal. Differences in the values of runoff were below the limit of statistical significance. Significant differences were found according to Tukey test for the values of erosive wash. Variants 1 and 7 had more washes than other variants.

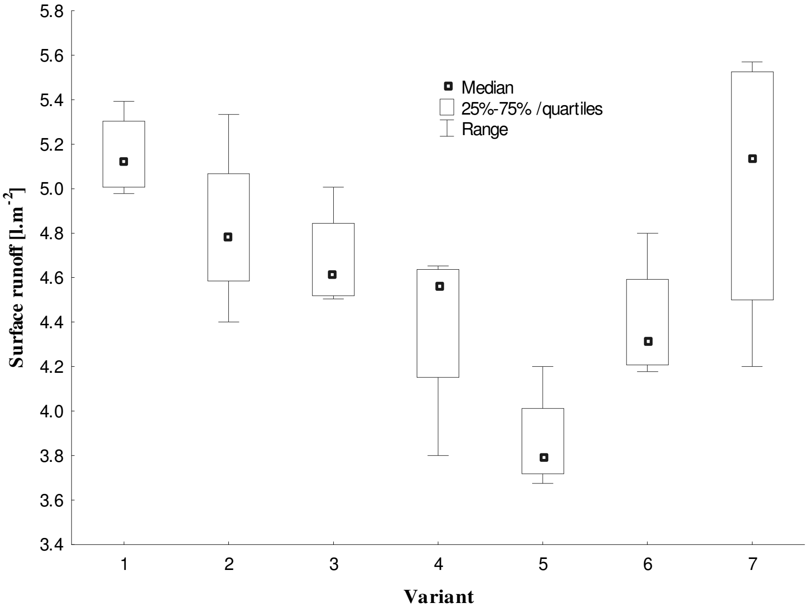

Fig. 2. **Surface runoff for rain from middle of June 2015**

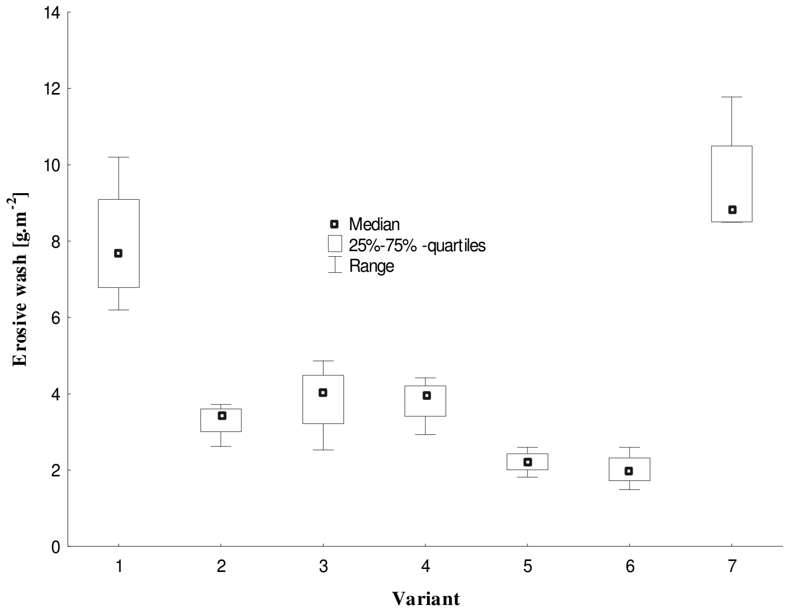

Fig. 3. **Erosive wash for rain from middle of June 2015**

On 8 August storm occurred accompanied by torrential rain over the measured plot. Rain of low intensity was followed after the storm (see Fig. 4 and 5). Total rainfall was 28 mm. Higher surface runoff was in variants 7 and 1, but it was below the threshold of statistical significance. Conversely eroding of intense rainfall effect was showed in interlinear area even at higher corn crop. The highest erosive wash was again recorded in variant 7 (statistically significant difference from every other). Significantly higher erosive wash was in variant 1 (Tukey test). The harmful effect of water erosion is manifested not only after sowing, but also in the period, when corn plants have obscured the soil surface. Necessity for interlinear area cover can be seen.

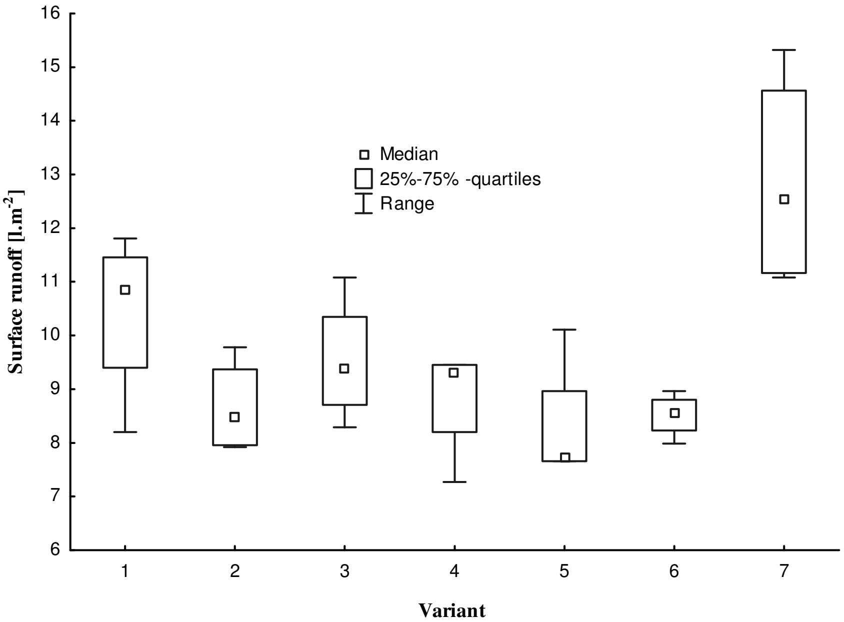

Fig. 4. **Surface runoff during storm on August 8, 2015**

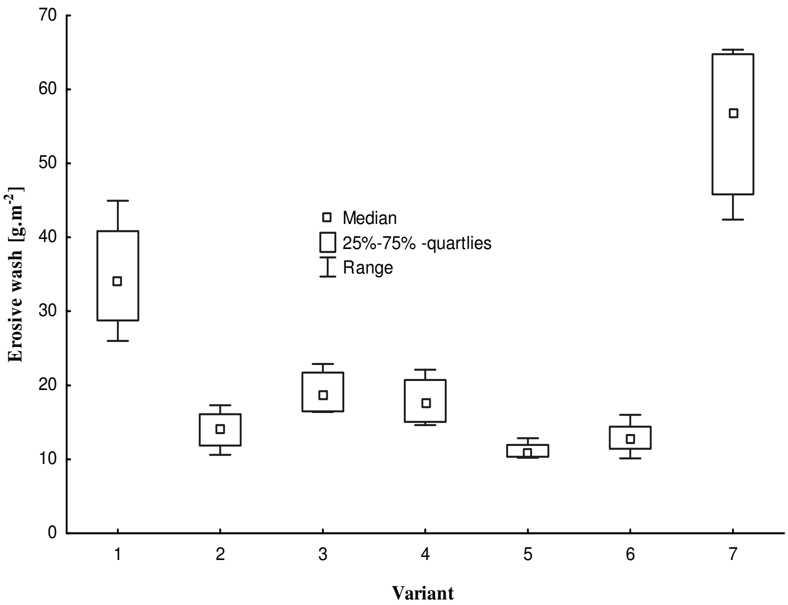

Fig. 5. **Erosive wash during storm on August 8, 2015**

The last rated event of the season in 2015 was the rain dated at the end of August. The cumulative precipitation was 36 mm. Rain intensity was 20 mm·h $^{-1}$. The results of the measurements of surface runoff showed minimal differences between the versions. A statistically significant difference was only between variant 2 and 4 (Fig. 6). Higher values of surface runoff compared to previous measurements were shown by variants 2 and 5. Erosive wash is shown in Figure 7. The highest erosive wash was again recorded in variant 7 (statistically significant difference from every other). Significantly higher erosive wash was again in variant 1 (Tukey test).

The results of evaluation of soil washed off during intense rains are consistent with the results of other authors. Rasmussen confirmed the benefits of the technology without tillage in terms of a significant reduction in soil loss by water erosion [5]. In terms of the field trial we confirmed a reduction in surface water runoff by use of technologies without plowing only partially in comparison with alternatives, where plowing was applied. During the growing season, for corn and spring cereals, however, the discrepancies between the variants decreased during intense rainfall, indicating a higher adsorption capacity fading effect of soil water, which can be recorded after plowing. For this issue, however, different behavior of different soil types cannot be excluded.

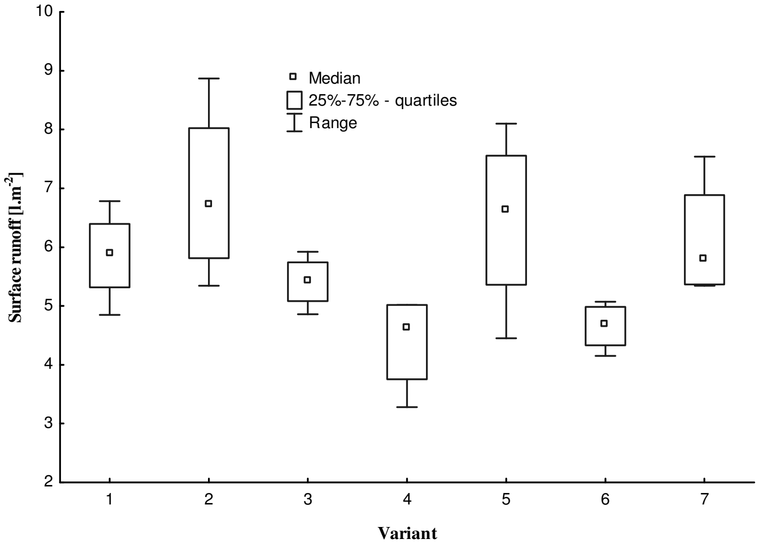

Fig. 6. **Surface runoff for rain at the end of August 2015**

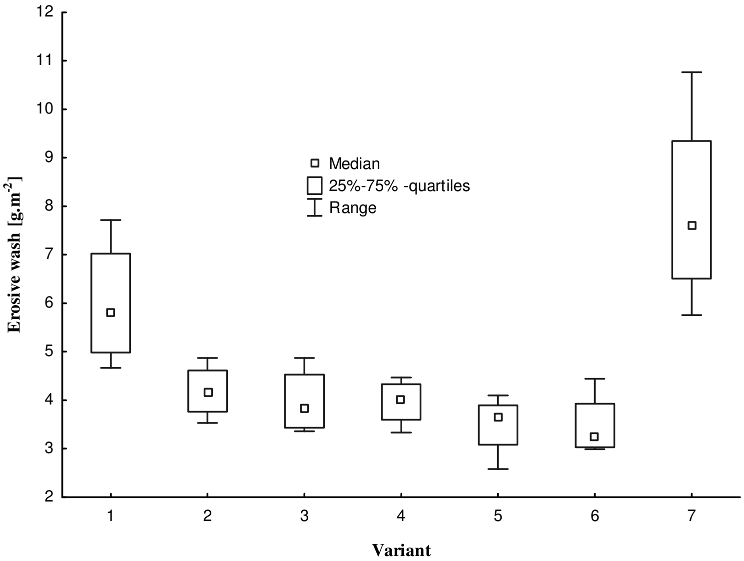

Fig. 7. **Erosive wash for rain at the end of August 2015**

On the other hand, Novák et al. did not find any differences on sandy soils with surface runoff and soil wash away with plowing and conventionally processed soils or even the opposite effect, better results with conventional surfaces [9].

Conclusions

Selection of an appropriate system of tillage, especially on sloping land, can reduce the risk of excessive soil wash, which can be considered as the most pernicious manifestation of water erosion on agricultural land. Nevertheless, in no case it can be expected that any method of tillage can be eliminate erosion processes. In measuring the erosion events caused by rain associated with storm activity showed an increased risk of soil water erosion in cultivation of corn using the conventional tillage technology. The harmful effect of water erosion is manifested not only after sowing, but also in the period when corn plants have obscured the soil surface. The results support the argument for using the technology for growing corn, carrying signs of soil conservation technologies. Benefits can be seen mainly in the use of the protective effect of withered biomass on the soil surface, even the possibilities of using protective cover crops planted in the alleyway of corn, provided that the plant cover crops will not compete with the corn plants.

After seven years of research, it can be concluded that reduced tillage technologies restrict the effects of water erosion in the Central Bohemia Region. Erosive wash (soil loss) was the lowest (in cultivation of corn) in the variant that utilized the conservation tillage technology. Soil loss was lower by more than 60 percent compared to the conventional technology of corn cultivation during the 7 years of the research. However, decreases in the yield of corn at using the reduced technology for the duration of the experiment were observed.

Acknowledgements

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