METHODS OF CROP STAND ESTABLISHMENT IN TERMS OF RESISTANCE TO WATER EROSION

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Abstract: The paper focuses on evaluation of methods of establishing the maize crop and oat crop in terms of resistance to water erosion. For measurement of the field trial it was established on land with an average slope of 5.4 º. The land is located in the area Nesperká Lhota at an altitude of 420 m. The field trial consists of seven variants. Evaluation of variants with different tillage and land cover as well as plants or plant residues on the surface and surface soil layer. The plot of land for one variant 6 x 50 m in the length side is facing the fall line. For the conventional tillage and sowing maize tillage statistically significantly higher soil loss by water erosion in the erosion events was found than for other variants based crop corn and spring cereals. The results confirm the importance of soil conservation technologies of soil cultivation and sowing of maize to reduce the risk of land degradation by water erosion. The positive impact of crop soil cover in the space between maize rows was also confirmed.

Keywords: soil tillage, surface runoff, erosive wash.

Introduction

Pimentel stated that increasing soil erosion is a global problem today with high economic impact [1]. Lal also emphasized the environmental impact [2]. The economic impact is caused by a reduction of yield and the environmental impact is caused by damage to soil quality. Erosion due to human activity is a problem also because it is much faster than the process of soil. Loss of organic matter and associated biological activity cause adverse impacts on the physical properties for crop growth, reducing porosity and increasing the bulk density. Types of erosion processes are more, but in agricultural soils water and wind erosion are most evident [3].

The Czech Republic is characterized by a high average gradient of agricultural land. Tippl, Janeček and Bohuslávek report that more than 53 % of area in the Czech Republic is situated on land with an average slope greater than 3 º [4]. The high slope of land, combined with light soil and expanding wide-row crops (maize) have increased the risk of water erosion. The risk of erosion events, although it is not possible to completely eliminate, 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 there may be a relatively short time, revert to the unfavorable physical properties. Significant reduction of water infiltration into the soil and increase of the risk of water erosion of soil is caused by the soil surface crust [5]. Soil-tillage technology contributes to limiting the formation of soil crusts. Beneficial effects of soil conservation technologies to reduce surface water runoff and increase infiltration of water into the soil are shown by Truman, Shave and Reeves [6].

Rasmussen [7] stated that technology, minimization of soil erosion, have decreased soil loss by half to two thirds. What is important for reducing the risk of water erosion is a targeted retention of crop residues on the soil surface (previous crop harvest residues, biomass, intercrops). Plant residues on the soil surface and in the surface layer of the soil contribute to reduced evaporation of water, slow runoff and increase infiltration. Wischmeier et Smith [8] state that any increase in land cover in plant residues by 10 % will reduce soil erosion by 20 %. Johnson [9] states that the coverage of twenty to thirty percent of soil surface plant residues reduces water erosion by 50 % to 90 % compared with the bare soil surface.

Water erosion is an intermittent phenomenon, the process of erosion in the erosion events is difficult to follow. Relatively accurately determine the surface runoff during intense rainfall and soil washed down by the weight by using runoff on micro plots [5]. Bagarello and Ferro reported the use of drainage of micro plots with different surface at the experimental station Sparacia in Sicily [10]. This station is used to drain the micro plot areas from 0.04 m^2 to 5 m^2 and then drain micro plots from 11 m^2 to 352 m^2. On small micro plots the runoff is washing away soil, with larger plots it is accounted for a part of the volume of surface runoff, using the reducers.

Materials and methods

For measurement of the field trial it was established on the light land with an average slope of 5.4 º. The land is located in the area Nesperká Lhota at an altitude of 420 m. The field trial consists of seven variants. Plot of land for one variant is 6 x 50 m in the length side facing the fall line.

After harvesting of triticale (crush straw) the site in the second half of August was followed by shallow tillage with a disc tiller. In options 4, 5, 6 remained on the ground in autumn, without further processing, for options 1, 2, 3 – followed in October unilaterally plow tillage to a depth of 0.22 m (driving in the direction of contour sets, tilting to hunk slope). Tillage and seeding in the spring as indicated in each experiment variants. The field trial is repeated for several years since 2009.

Variants of the experiment are the following.

1. Conventional tillage technology for maize – plowing in the fall, winter left rough wake, spring sowing soil preparation with harrow, seed corn.
2. Variant of tillage, spring cereals – plowing in the fall, winter left rough wake, spring sowing soil preparation with harrow, sowing oats.
3. Variant of tillage, maize trade intercrop (winter cereal crop sown in spring) – plowing in the fall, winter left rough wake, spring sowing soil preparation with harrow, triticale seeding, sowing corn.
4. Option no tillage, corn free trade intercrop with spring sowing soil preparation – plowing the previous crop harvest by disc tiller, spring tillage tine cultivator to a depth of 0.10 m, sowing corn.
5. Option no tillage, spring cereals – plowing after harvest crop, sown in spring oats.
6. Option no tillage, corn free trade intercrop without spring sowing soil preparation – plowing the previous crop harvest by disc tiller in the autumn.
7. The "black fallow" – in the fall plowing, left rough over the winter wake, spring tillage by tine cultivator to a depth of 0.15 m is maintained without vegetation – 5 non-selective herbicide application (Roundup Rapid, 4 $l \cdot ha^{-1}$).

For each variant of the experiment after sowing 4 micro plots for runoff were installed. The area is defined by walls of sheet metal. The walls are 0.12 m high. It is 0.08 m below the surface and 0.04 m above the surface. The collector is located at the bottom of each micro plot. It transports water into the plastic container, which is buried below the catching micro plots. The area of each micro plot is 0.16 m^2.

Fig. 1. **Runoff microplot**

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

Results and discussion

The values of surface water runoff and erosion wash during the events between May and June 2010 and 2011 are shown in the graphs in Figure 3 to 5. Table 1 shows the rainfall in the period. The data were obtained from the weather station. Table 2 is indicated by infiltration of water into the soil in the period. Infiltration is shown as a percentage of the quantity rainfall.

Table 1

Rainfall in the periodS

Year	Precipitation in May, mm	Precipitation in June, mm
2010	72.8	25.6
2011	65.8	88.0

Table 2

Infiltration into the soil

Infiltration	Variant	1	2	3	4	5	6	7
May 2010	Percent of rainfall	7.62	7.20	7.88	8.77	10.00	9.97	6.93
June 2010		30.14	30.22	31.03	36.01	42.29	40.32	25.57
May 2011		7.62	7.52	8.46	7.62	12.31	12.59	8.02
June 2011		17.48	15.70	14.03	15.91	25.51	27.86	16.55

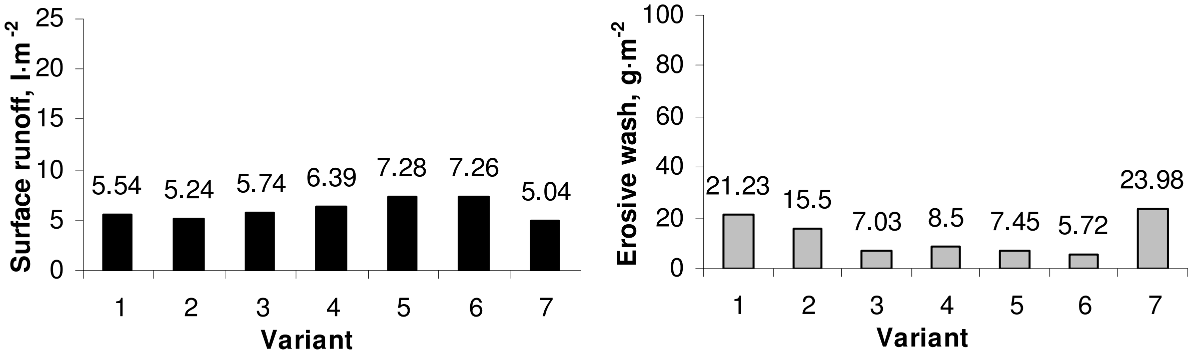

Fig.2. **Monitored parameters in May 2010**

Rainfall during this period represented 72.8 mm. It was rain with very low intensity, so there was a high water infiltration into the soil. Increased runoff was recorded in the second part of this period when saturated soil water. The graphs in Figure 2 show that the erosion of this first event was recorded, while the highest surface runoff rainwater was to variants 4, 5 and 6 (variant without plowing), but the soil that was washed off in these variants is low. The highest erosive wash was found in variants 1 and 7 - conventional tillage technology for maize and conventional tillage in maintaining soil without vegetation (black fallow). The weight of erosive wash difference between variants 1 and 7 was below statistical significance. Between these two variants and other variants of the field trial the difference was statistically significant.

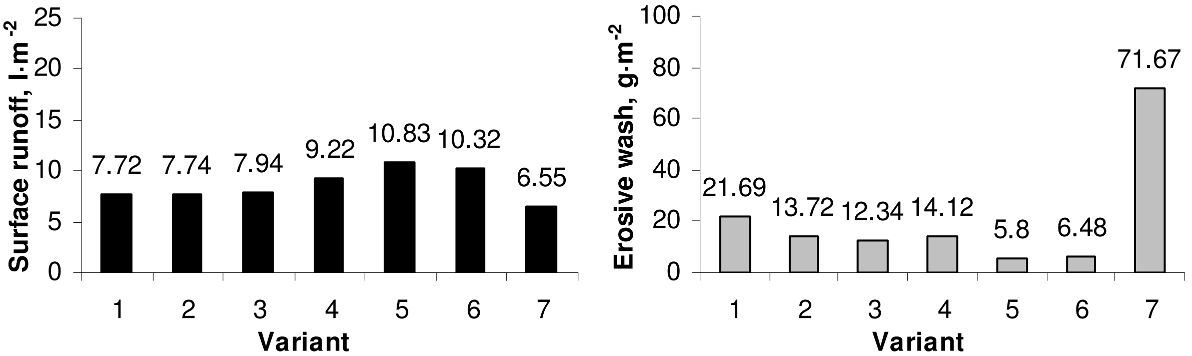

Fig. 3. **Monitored parameters in June 2010**

In June 2010, there were two short but very intense storms. When the storms were recorded with 25.6 mm rainfall, the intensity reached up to 50mm.h^{-1}. Statistically significant low surface runoff was observed in variant No. 7, but the soil washed off with this option was high. The weight of erosive wash in variant No. 7 was significantly higher than for all other variants. There was also statistically significantly higher weight of erosive wash in variant No. 1 (conventional tillage technology for maize) than in variant No. 2 to 6.This measurement demonstrates the risk of uncovered soil with organic matter during intense rainfall.

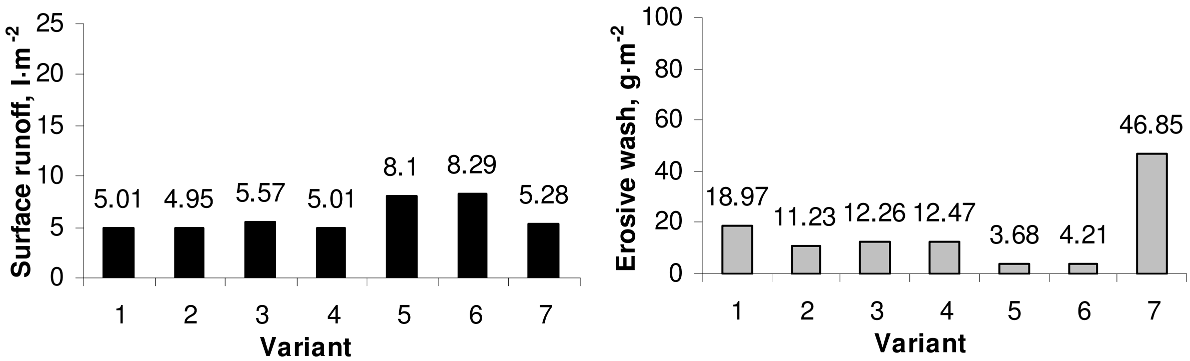

Fig. 4. **Monitored parameters in May 2011**

In May 2011, there were two slow and one short rain storm with medium intensity. Rainfall reached 65.8 mm. A significantly high surface runoff was observed in variant No. 5 and 6, variations of erosive wash in variant No. 7 were significantly higher than for all other variants. There was also statistically significantly higher weight of erosive wash in variant No. 1 (conventional tillage technology for maize). This measurement confirms the assumptions identified during the first year of measurement.

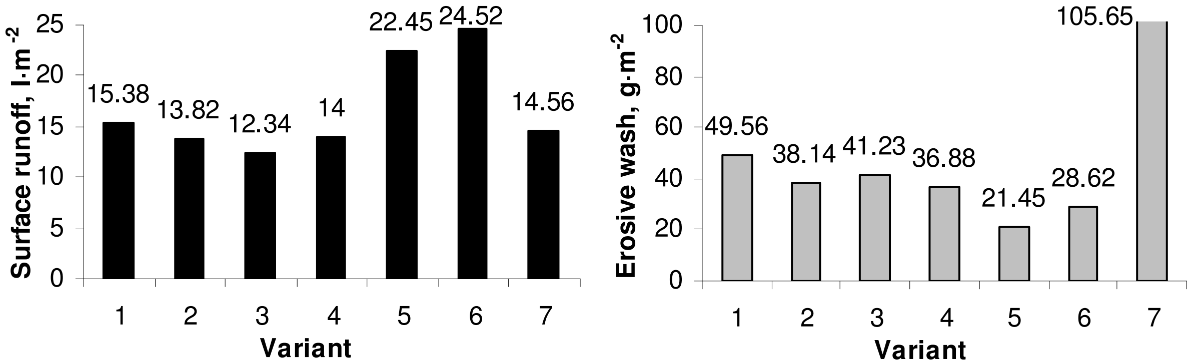

Fig. 5. **Monitored parameters in June 2011**

June 2011 was exceptionally rainy. 88 mm rainfall was recorded. Precipitation consisted of one intense storm and rainfall for several days. The results again confirmed the high risk of the conventional maize cultivation technology and improving the benefits of the reduction technology using organic matter on the surface.

The results from soil washed off during intense rains are consistent with the results of Rasmussen [7] and other authors [6]. This confirms the benefits of the technology without tillage in terms of significantly reducing soil loss by water erosion. The field trial confirmed the reduction of surface runoff water at the technologies without plowing, compared with alternatives that have been applied to plowing.

Conclusions

In measuring the erosion events caused by rain associated with storm activity showed an increased risk of soil water erosion in the cultivation of maize using the conventional tillage technology. The harmful effect of water erosion is manifested not only after sowing, but also the period when corn plants have obscured the soil surface. The results support the argument for using technology for growing maize, carrying signs of soil conservation technologies. The benefits can be seen mainly in the use of the protective effect withered biomass on the soil surface even the possibilities of using protective cover crops planted in the alleyway of maize, provided that the plant cover crops will not compete with maize plants.

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