INFLUENCE OF ORGANIC FERTILIZERS ON SOIL EROSION PARAMETERS IN MAIZE CROP

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Abstract. Every year, large amounts of agricultural land are threatened by water erosion. Fields with sloping land are particularly at risk. The impact of water erosion on soil and fine soil particles is very serious. Water erosion is a natural process and cannot be stopped. It can only be reduced or slowed down. To reduce the impact of water erosion, erosion control measures are used to protect the soil surface and fine soil particles. The most risk crops from the view of water erosion are wide-row crops. The aim of this research was to assess the effect of organic fertilizers on soil erosion parameters in maize crop. To achieve the results, a field experiment focusing on three organic fertilizers (manure, digestate, compost), was established on a sloping plot with an average slope of 5.29º. Each fertilizer was represented in two variants at different rates. Two variants were added as a control. One with maize cover without fertilizer application and the second without vegetation. Surface runoff and erosive wash were measured using the micro-parcel runoff method. Based on the results from the measurements, a positive effect of organic fertilizers on water erosion mitigation can be demonstrated, primarily reducing erosive wash and surface runoff. Both are associated with improved soil infiltration. It is therefore possible to consider the use of infiltration strips with extreme doses of organic fertiliser on erosion-prone areas of land. Furthermore, there was no confirmation of the expected reduction in soil water infiltration for the option where digestate was applied.

Keywords: erosive wash, surface runoff, infiltration, organic matter, maize.

Introduction

In the Czech Republic, soil is a key factor in crop production, and it is therefore intensively studied in terms of its quality and properties. As a complex mixture of mineral and organic substances, soil has a slow regenerative capacity. Violation of this regeneration cycle, caused for example by inappropriate cropping practices, leads to a reduction in soil organic matter content and subsequent erosion. A reduction in biological activity due to a lack of organic matter also leads to soil compaction. The soil also loses its ability to resist erosion due to a decline in organic matter [1].

The strategy of returning organic matter, e.g. through crop residues or organic fertilizers, is key to maintaining soil fertility [2]. Water erosion, as one of the main factors of soil degradation, needs to be actively monitored and addressed through appropriate erosion control measures [3]. However, inappropriate choice of erosion control measures may also contribute to undesirable soil degradation [4]. The repeated action of water erosion causes more soil degradation due to the entrainment of fine soil particles. By measuring surface runoff per unit time over a predefined area, the magnitude of soil shear can also be determined. One of the most risk groups is wide-row crops [5]. In the earlier vegetative phases of the crop, the inter-row space is unprotected, and it is very susceptible to intense rains with high kinetic energy of water drops. After impact, water carries away fine soil particles more easily [6].

The aim of the study was to evaluate a field experiment dealing with the effect of organic fertilizers on water erosion in maize crop. Three types of organic fertilizers were used at two diametrically opposed rates. This was followed by an evaluation using surface runoff readings and the amount of sediment washed over a predefined area [5; 7].

Materials and methods

The evaluation of the effect of organic fertilizers on the anti-erosion capacity of maize crop was measured in 2022 in the locality of Nesperská Lhota. The experimental field was located at an altitude of 447 m. Winter wheat (*Triticum aestivum*) was harvested as a pre-crop at the field experiment site. It was ploughed to a depth of 0.2 m in the autumn. This was followed in spring by preparation using levelling bars and field harrows. The experimental site was divided into 8 experimental plots of 3x3 m. The slope in each plot was from 4.5 to 8.7º. Organic fertilizers (manure, digestate, compost) were chosen for the experiment. The organic fertilizer rate was chosen to be realistic (40 $t \cdot ha^{-1}$) and extreme (200 $t \cdot ha^{-1}$) values in Table 1. The European Nitrates Directive 91/676/EEC prohibits the use of such a high dose (200 $t \cdot ha^{-1}$). This directive does not take into account the localised and targeted use of high rates of organic fertiliser as an anti-erosion measure. For comparison, the variants without fertilizer and without vegetation (black fallow). The incorporation of organic fertilizers was done with a coulter cultivator. The travel speed during incorporation was 12 ± 0.2 km·h^{-1} with a set cultivation depth of 15 cm. The incorporation of fertilizers took place 2-6 hours after application.

Table 1

Type and rate of organic fertiliser on individual plots

Plots	Fertilizer	Fertiliser rate, t·ha^{-1}	Name
1	Manure	40	M40
2	Manure	200	M200
3	Digestate	40	D40
4	Digestate	200	D200
5	Compost	40	C40
6	Compost	200	C200
7	Without fertilizer	0	WF
8	Without vegetation (Black fallow)	0	WV

The properties of the fertilizers that were determined from samples evaluated by laboratory analysis according to the compost standard CSN 46 5735 are shown in Table 2.

Table 2

Properties of organic fertilisers

Fertilizer	Manure	Digestate	Compost
Dry weight, %	6.18	22.58	32.88
Ct in dry weight, %	38.27	37.79	23.65
N in dry weight, %	16.021	2.341	1.829

The medium early hybrid maize KWS was selected for the experiment. The sowing density was 80 000 seeds per hectare with a sowing depth of 50 mm, a seed spacing of 0.17 m per row and a row spacing of 0.6 m. For better plant emergence, the surface of the experimental plots was rolled with Cambridge rollers. After sowing, the herbicide Akris was applied at a rate of 2 dm^3·ha^{-1}.

After germination of the maize crop, runoff measuring micro-plots were installed in the inter-row space. Three runoff micro-plots were installed for each variant. The runoff micro-plots are bordered by a 1.5 mm metal sheet. The sheet is partially embedded in the ground so that the measured results are not affected by the environment. The edge of the microplot is embedded 0.08 m into the ground and 0.04 m above the ground. The internal surveyed area of the microplot is 0.16 m^2. The runoff water from the micro-plot is diverted into a collector, which subsequently discharges the water into a pre-buried 10 dm^3 plastic collection container.

Control measurements of rainfall were taken in the vicinity of the field experiment using a Vantage Vue weather station. The weather station recorded both rainfall amount and intensity during the field experiment. Storage of the recorded data occurred only after rainfall events that eroded the soil surface.

The checking and measurement of rainfall and sediment volume data captured by the runoff micro-plots in the collection containers was carried out immediately after the end of rainfall events that eroded the soil surface. The volume of surface runoff captured in the catch basins was measured using graduated cylinders. The amount of sediment contained was determined by subsequent filtration of the captured surface runoff. The final measuring of the weight of the captured soil can only be determined after drying at 105 ºC.

Results and discussion

A total of 7 erosive events were recorded during the observation period. Three erosive events were recorded during June. The first recorded event was a storm in early June. The total rainfall was 17 mm. This was a heavier rainfall event with short-term intensity of up to 50 mm·h^{-1}. Figure 1 shows the strong effect of organic fertilizers on soil water infiltration. Quite surprising is the effect of digestate, especially at higher rates. Digestate is sometimes referred to as the origin of “clogging” of pores in the soil. This cannot be demonstrated in our case. The sandy soil on the site seems to have had an influence, which actively prevented this phenomenon. There are also small differences between fertiliser doses. It is true that the M200 variant was the most effective, but the difference is not very large. Minimal difference was seen between the no fertiliser and no sowing (black fallow) variants. This is not surprising - the stand was at a low developmental stage at this time and did not have a major effect on the event. In addition, the micro-plots are primarily located in the inter-row, which partially suppresses the influence of vegetation.

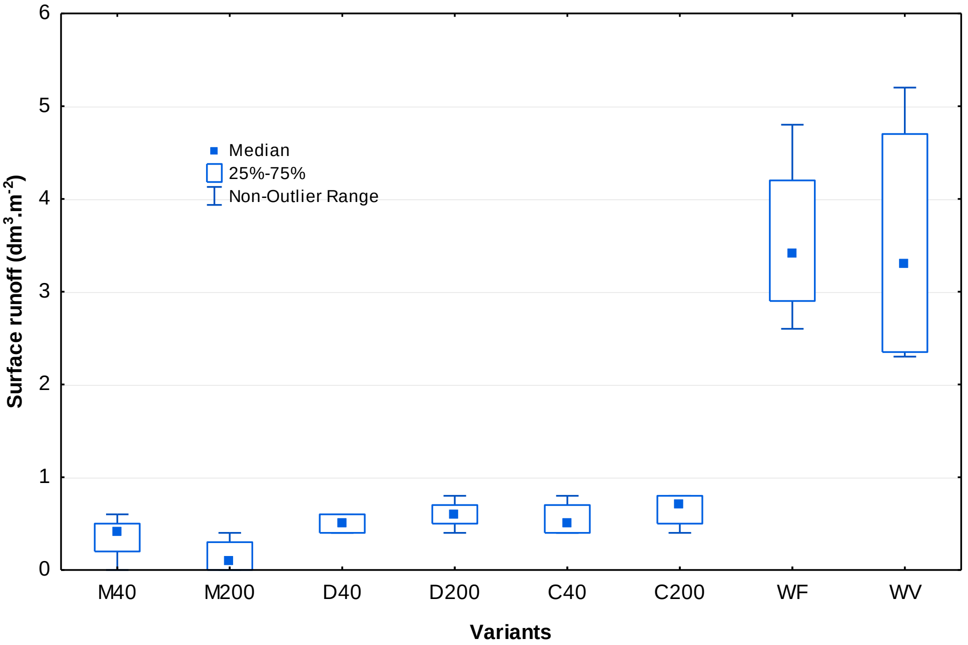

Fig. 1. **Surface runoff during the 1st erosion event**

Figure 2 shows the differences between the variants. The differences are smaller than in the case of surface runoff, but the basic trend has been maintained. Due to the relatively low rainfall totals, the total erosive wash is also relatively low. No leaching of macro fertiliser particles from the surface and subsurface soil layers can be observed. Thus, soil loss was highest in the last two variants.

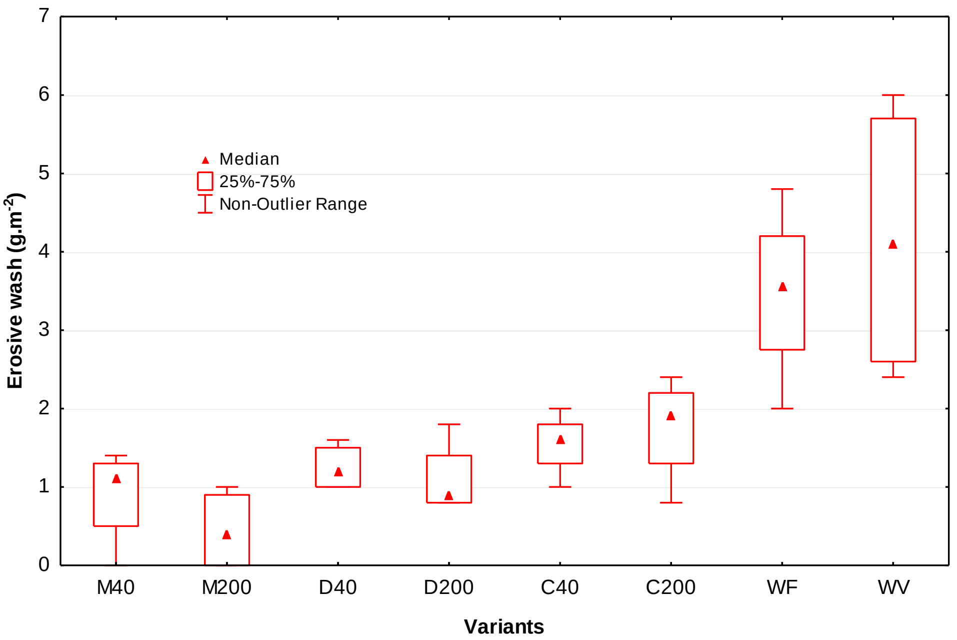

Fig. 2. **Erosive wash during the 1st erosion event**

The last erosion event was recorded on 8.8.2022. It was a short torrential rain of high intensity. The rainfall total was 16 mm with an intensity of up to 95 mm·h^{-1}. The surface runoff values in Figure 3 show the increasing influence of maize cover on the values. This is particularly true for variant WF. Here, also due to the rapid increase in maize biomass, the inter-row space is covered more by maize leaves and thus the erosive effect of falling droplets is reduced.

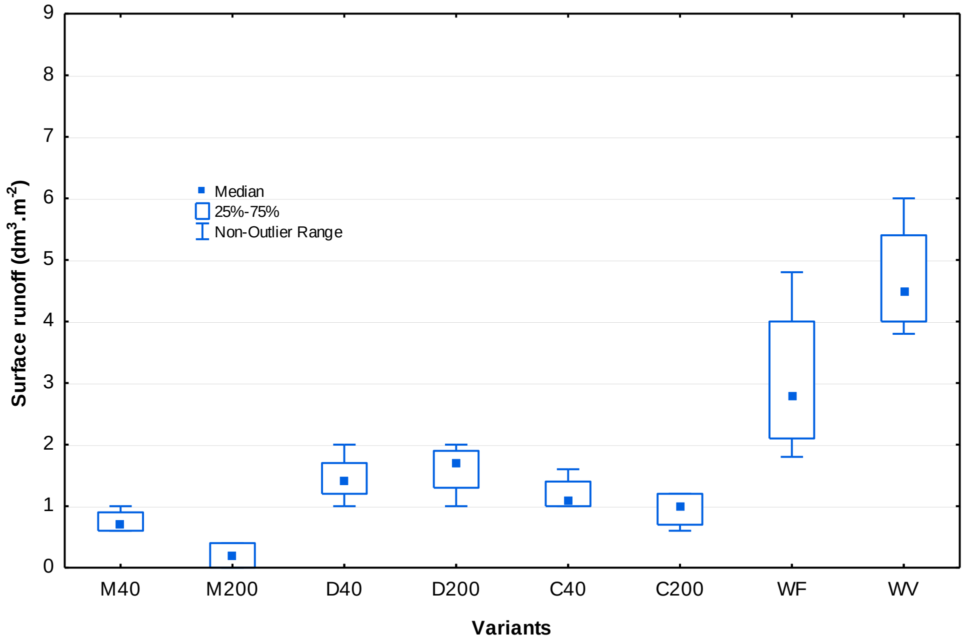

Fig. 3. **Surface runoff during the 7th erosion event**

Erosive wash also followed the trend of increasing the leaf area, with the overall erosion effect gradually decreasing, see Figure 4. Thus, the falling droplets do not erode as large number of soil particles as in the case after the establishment of the experiment.

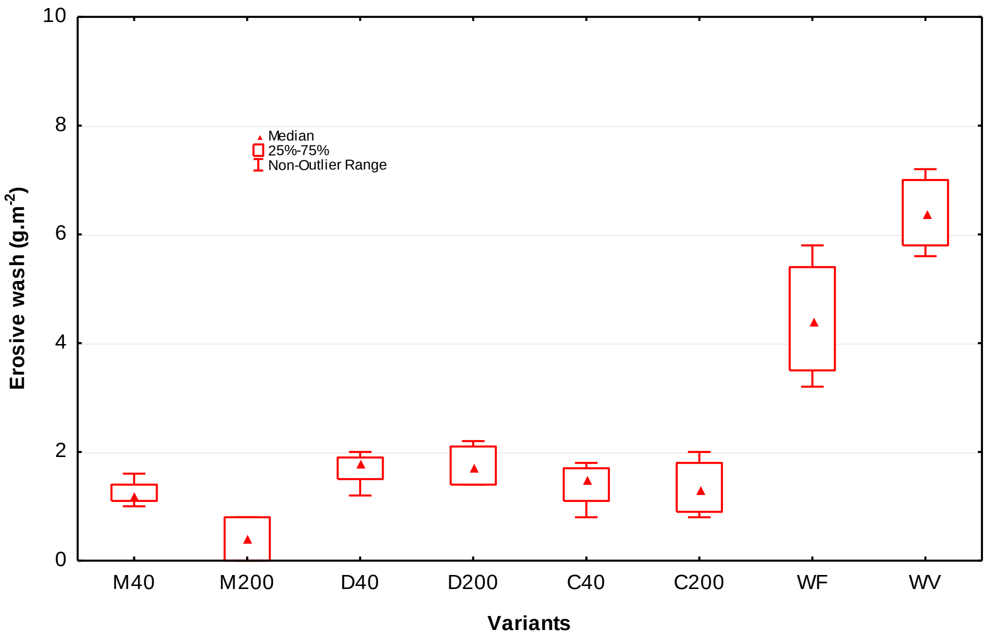

Fig. 4. **Erosive wash during the 7th erosion event**

Research on large doses of organic fertiliser is not quite usual. Commonly researched fertiliser rates are in the lower tens of tonnes per hectare. This is also due to the rather general perceived shortage of fertiliser worldwide [8]. Conversely, certain locations may show surpluses of the applied fertiliser, e.g. due to increased concentrations of livestock production. Veeramani et al [9] describe the multifaceted benefits of organic fertilization on the soil environment. Of course, fertilizer application also has its pitfalls. For example, threats to groundwater have been described [10]. Newly described risks and surprising connections include the possible spread of antiresistant bacteria from poultry farms into the soil environment [11].

Gilley et al [12] made a similar measurement, but the measurement was not based on natural rainfall. The rainfall was generated using a simulator. The experiment reached a result confirming a significant decrease in surface runoff up to tens of percent. With regard to water infiltration, manure or digestate, i.e. liquid organic fertilizers, are often perceived as problematic. Sewage sludge is also problematic [13]. In our case, digestate from a biogas plant was used. A significant reduction in the infiltration capacity of the soil was expected, which did not prove to be the case. On the contrary, this claim is supported by, for example, [14].

Conclusions

The results confirm the positive effect of organic fertilisers on the soil ability to resist erosion processes. A significant improvement in water infiltration occurred even with a lower standard dose of organic fertiliser. The most differences could be observed at the beginning of the experiment, when the soil crust was still not formed on the surface and there was also no influence of vegetation, see Fig. 1 and Fig. 2. In the later part of the experiment, when the corn stand gained volume, the leaves of the plants started to act as protection and hindered the large water droplets of the summer storms. It can be seen in Fig. 3 and Fig. 4.

Based on the evaluation of the measurements, it can be seen that manure performed best. The digestate (200 $t \cdot ha^{-1}$) partially sealed the soil pores. This reduced the soil ability to infiltrate water. Compost (200 $t \cdot ha^{-1}$) infiltrated water less well than the manure variants. This is probably due to the absence of larger macroparticles.

In the future, this measure could be applied, for example, within several contour strips on the property. These strips could serve as soakaways. Locally differentiated application of organic fertilisers is not yet anywhere near as widespread in practice as it is for industrial fertilisers.

Author contributions

The entire author team contributed equally to this research in all its aspects. All authors have read and agreed to the published version of the manuscript.

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