# INFLUENCE OF BIOLOGICAL TRANSFORMATION OF ORGANIC MATTER ON IMPROVEMENT OF WATER INFILTRATION ABILITY OF MODAL LUVISOL

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**Abstract**
Low level of soil carbon is one of the major soil issues in the Czech Republic. It results from a decrease in livestock production and from other factors too. Farmyard manure application is one of the ways to rectify this condition. The manure can be supplemented by biological transformation's activators of organic matter. The aim of paper is to verify the effect of fermented farmyard manure and of substances for soil amendment on the change of physical, physical-chemical and biological soil properties, on organic matter fixation, on improvement of water infiltration and retention, and on reduction of soil erosion susceptibility. In this respect, field trials have been established at locality Lázně Bělohrad in the North of Bohemia. Operational trial consists of six variants and is conceived as multi-annual. As the biological transformation's activator, PRP sol agent has been used. In order to verify the effect, soil infiltration abilities have been measured using a ring infiltrometer with a diameter of 0.15 meters. Cone index has been another measured item provided by the registration penetrometer. Soil physical properties have been evaluated using Kopecky's cylinders and subsequently analysed in the laboratories of the CULS Prague. The measurements proved favourable effect of the activator on the decomposition of soil organic matter with resulting change in soil properties. It can be assumed that the effect is going to be gradual and the verification should be carried out also in following trial years.

**Key words:** activator of organic matter, manure application, soil properties, water infiltration.

## INTRODUCTION

Threat to fertility of agricultural land in the Czech Republic is growing. This is due to several factors. This mainly concerns water erosion, which threatens more than half the agricultural land in the Czech Republic (HŮLA & KOVAŘÍČEK., 2010). A related fact is the problem of soil compaction. The soil compaction affects soil physical properties, for example increases soil bulk density which leads to a reduction of soil water infiltration rate (CHYBA ET AL., 2014). Combination of these adverse effects leads to soil erosion and may affect overall crop yields. Low level of soil carbon is one of the reasons related to those events (GUTU ET AL., 2015). This degradation indicator is caused by the decrease of livestock production and wrong cultivation of land.

Recently, there is a turn in conditions. Organic matter is applied to the soil as manure, compost and waste from biogas power plants. Decomposition of organic matter in soils with low levels of carbon may constitute a problem (AMES ET AL., 1984). This status can be improved with the use of activators of organic matter. The activators can have several forms. They may be used separately, or as a special fertilizer seed inoculation (DELČA & STERE, 2013). The studies of activators of organic matter are often focused on the impact on crop yield and soil environment. LESTINGI ET AL. (2007) reported beneficial effect of activators on root system of wheat, corn, sorghum and setaria that caused morphological changes in root starting immediately after germination. LESTINGI ET AL. (2009) also confirmed the positive effect in their further study where they showed a beneficial effect on alfalfa. DELČA & STERE (2013) reported that bacterial density increased significantly following the administration of specific fertilizers (activators). Classic fertilizers did not have any positive effect on microbial density values, which were more or less similar to those reported for the control.

Frequent use of the activators is the utilization of sewage sludge for compost production. PAZDA ET AL. (2005) used activators for the decomposition of wood chips and rice husk in the compost. Effect of the use of activators on soil properties is relatively unexplored phenomenon. Impact can be mainly expected on the physical and chemical properties of soil. KROULÍK ET AL. (2011) suggested a beneficial effect of

incorporation of organic matter on the physical properties of soil, on water infiltration into the soil and on partial elimination the consequences of soil compaction after the tracks. It can be also assumed that changes in soil properties will be reflected in the long term rather than immediately after application.

## MATERIALS AND METHODS

A field trial was established to demonstrate the influence of the activators of organic matter. The establishment of the experiment occurred in 2014 after the wheat harvest. A field trial has been designed to 6 basic variants.The land is located in Lázně Bělohrad in North of Bohemia (GPS N 50°27.253', E 15°34.208'). The topography is gently sloping, facing southwest, altitude is 360 m above see level. Soil type on the location Lázně Bělohrad is modal luvisol. The content of particles < 0.01 mm: 30% weight (depth 0-0.3 m). The trial plot was divided into individual variants where fertilizer application was carried according to plan and autumn plowing to a depth of 0.25 m was implemented. The fertilizers used were manure (breeding cattle) and NPK 15-15-15 (Lovofert, the Czech Republic). The soil activator used was PRP Sol (PRP Technologies, France). PRP Sol is formed by a matrix of calcium and magnesium carbonate, and mineral elements. Activator of the biological transformation of manure was PRP Fix (PRP Technologies, France). PRP Fix is a granular mixture of mineral salts and carbonates. It was added directly into the bedding. The variants differed by fertilizers used. Dosage of manure was 50 $t.ha^{-1}$, of PRP Sol 200 $kg.ha^{-1}$, and of NPK 200 $kg.ha^{-1}$. Both PRP Fix and PRP Sol activators should not be taken as fertilizer. They are ment to improve conditions for the transformation of organic matter. Fertilization of individual variants is shown in Tab. 1.

The soil was prepared by seedbed combinator during the spring. Maize was sown on all variants. In May 2015 after germination of maize, measurements were taken (after BBCH 10). There were three basic methods of measurement. Soil infiltration abilities have been measured using a ring infiltrometer with a diameter of 0.15 m. The method used was simplified falling-head (BAGARELLO ET AL., 2004). BAGARELLO ET AL. (2006) converts infiltration into saturated hydraulic conductivity. Infiltrometer was poured into a known amount of water and soak time was measured (20 repetitions on each variant).

**Tab. 1.** – Fertilization of individual variants of field trial

| Variant | Fertilization |
|---|---|
| 1 | Manure+Fix+Sol |
| 2 | Manure+Fix |
| 3 | Manure+Sol |
| 4 | Manure |
| 5 | NPK+Sol |
| 6 | NPK - control |

Cone index has been another measured item provided by the registration penetrometer. PN-10 penetrometer with cone having an angle 30° (area of 100 $mm^2$) was used. Soil physical properties have been evaluated using Kopecky's cylinders with volume 100 $cm^3$ and subsequently analysed in the laboratories of the CULS Prague. Moisture was measured by Theta Probe (Delta Devices). Yield measurement was carried out in September 2015. Samples were taken and analyzed subsequently in the laboratories of the CULS Prague. Data were processed by the programmes MS Excel (MICROSOFT CORP., USA) and Statistica 12 (STATSOFT INC.,USA).

## RESULTS AND DISCUSSION

Fig. 1 is a graph of saturated hydraulic conductivity. There are noticeable differences among each of the variants. These are however lower than the initial forecast. This is probably due to the short exposure of activators and applied manure. It is not possible to clearly demonstrate a beneficial effect of activators on saturated hydraulic conductivity. Even favorable impact of manure application on this parameter cannot be proven.

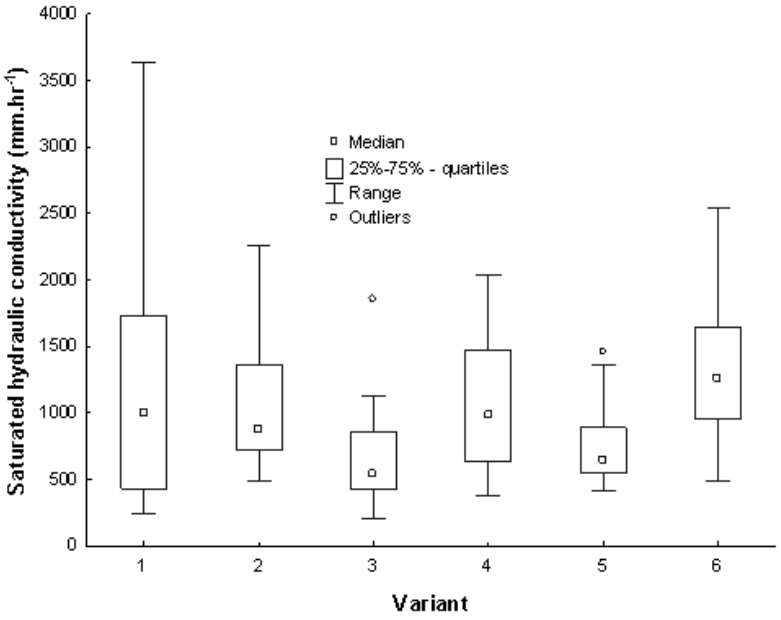


**Fig. 1.** – Saturated hydraulic conductivity of all the variants at Lázně Bělohrad in May, 2015

The graph outcomes are confirmed by the results of Fisher's LSD test (see Tab. 2). It is possible to find some statistically significant differences among the variants. It is not possible though to establish a causal link between the differences and configuration options. This is probably due to the light-textured soil of the trial plot. Saturated hydraulic conductivity in all variants has reached very high levels. Subsoil beneath the topsoil drained water quickly into the lower layers. Subsoil probably contains a lot of sand particles and low levels of organic carbon. These conclusions correspond to the change of moisture on the soil surface after measurement (see Tab 3). Measurements may have been affected by precision of manure application. In general, the experiment is placed on a very permeable soil.

**Tab. 2.** – Results of Fisher LSD test (homogenous groups) of saturated hydraulic conductivity at Lázně Bělohrad in May, 2015

| Variant | Average ($mm.hr^{-1}$) | 1 | 2 | 3 |
|---|---|---|---|---|
| 3 | 669.94 | | | **** |
| 5 | 761.69 | | **** | **** |
| 4 | 1065.26 | **** | **** | |
| 2 | 1091.86 | **** | **** | |
| 1 | 1175.08 | **** | | |
| 6 | 1317.04 | **** | | |

**Tab. 3.** – Moisture on the surface beforfe and after saturated hydraulic conductivity measurement at Lázně Bělohrad in May, 2015

| **Moisture on the surface (% vol.)** | | | | | | |
|---|---|---|---|---|---|---|
| **Variant** | **1** | **2** | **3** | **4** | **5** | **6** |
| Before measurement | 11.9 | 11.8 | 13.0 | 12.2 | 11.9 | 13.1 |
| After measurement | 42.1 | 42.8 | 43.8 | 41.8 | 42.3 | 41.5 |

Tab. 4 shows the values of bulk density of the soil in three depths. These figures confirm the initial hypothesis, i.e. the apparent beneficial effects of manure in the soil, but also improved effect using activators of organic matter. From these results, a decrease of density of the soil in relation to the application of manure can be discern. The results suggest beneficial effect of the activators in terms of incorporation of organic matter. Bulk density values are low within all the variats, which influenced the saturated hydraulic conductivity.

**Tab. 4.** – Bulk density at Lázně Bělohrad in May, 2015

| Variant | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **Depth (m)** | **Bulk density ($g.cm^{-3}$)** | | | | | |
| **0.05-0.1** | 1.35 | 1.46 | 1.33 | 1.33 | 1.53 | 1.55 |
| **0.1-0.15** | 1.51 | 1.47 | 1.46 | 1.35 | 1.53 | 1.50 |
| **0.15-0.2** | 1.55 | 1.52 | 1.55 | 1.37 | 1.60 | 1.61 |

Fig. 2 demonstrates cone index values of individual variants. The graph shows a similar pattern of cone index, depending on the depth. At a depth of about 0.24 m, a sharp increase in cone index may be seen. This interface is caused by the respective depth of tillage (loosening). This phenomenon could also affect the measurement of saturated hydraulic conductivity. Cone index values in 2015 were more affected by the previous way of farming on the land prior to the fertilization and the use of activators. Simultaneously, cone index values showed absence of compacted layers that could affect the conditions of water infiltration into the soil.

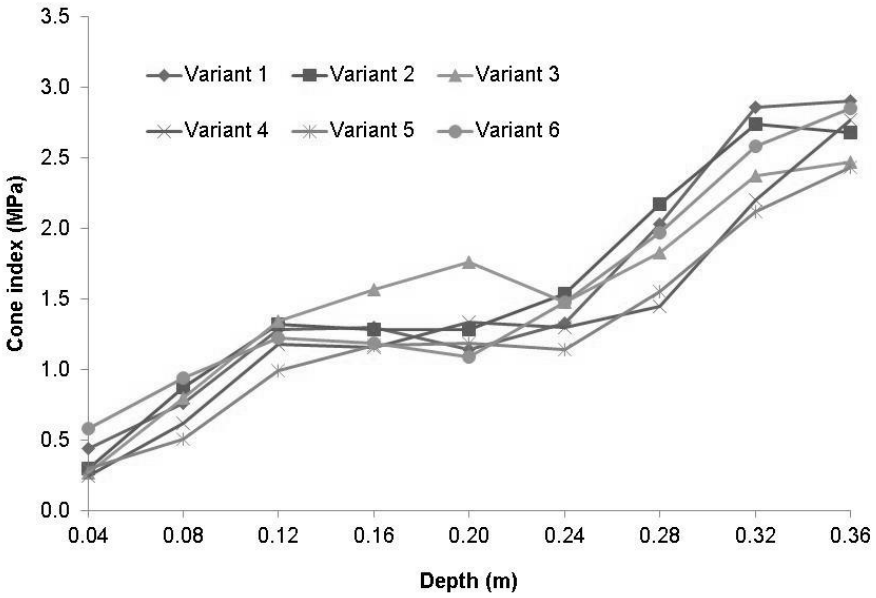


**Fig. 2.** – Cone index of all variants at Lázně Bělohrad in May, 2015

Tab. 5 shows the basic indicators of the yield of maize in 2015. The differences are mostly below the threshold of statistical significance. Trend of the values showed positive influence of manure fertilization and use of activators to plants. The highest yield was achieved by the variant 1, which used manure as well as both activators. Lowest yield was recorded in the variant 6, which was fertilized with NPK only. In dry summer conditions of 2015, higher water retention in the soil due to increased organic carbon content probably helped. Plant water supply had a direct impact on the yield of maize. The impact could be caused by the gradual mineralization of organic matter and increasing nutrient uptake by plants.

**Tab. 5.** – Yield parameters at Lázně Bělohrad in September, 2015

| Variant | Dry matter (whole plants) (%) | Yield at given dry matter ($t.ha^{-1}$) | Yield (conversion to 38% dry matter) ($t.ha^{-1}$) |
|---|---|---|---|
| 1 | 38.7 | 34.5 | 35.2 |
| 2 | 39.2 | 32.5 | 33.5 |
| 3 | 38.9 | 33 | 33.8 |
| 4 | 37.1 | 32.8 | 32.0 |
| 5 | 39.7 | 30.5 | 31.8 |
| 6 | 41.4 | 27.6 | 30.1 |
| **Average** | **39.2** | **31.8** | **32.7** |

Initial research assumptions were confirmed only partially. Variations in the values of saturated hydraulic conductivity were minimal. This is contrary to many other studies. HŮLA & KOVAŘÍČEK (2010) emphasize the beneficial effect of organic matter to infiltration of water into the soil. Conversely BAGARELLO ET AL. (2006) reported the difficulty of measuring saturated hydraulic conductivity on light soils. At high levels of conductivity, the effects of soil tillage, fertilization or the influence of cultivated crops cannot be clearly demonstrated. Measurement was certainly affected by the short duration of the experiment. It can be assumed that the effect is going to be gradual and the verification should be carried out also in following trial years. The necessity of exploration of the long-term effects also emphasizes FERRI ET AL. (2004). Changing soil structure is always a long-term issue. Application of organic matter and activators was done only a few months before the measurement. It confirmed the conclusions drawn by FERRI ET AL. (2004) about great differences in the decomposition of organic matter in the soil by various influences. This is also confirmed by DELČA & STERE (2013). PAZDA ET AL. (2005) emphasizes the need to support bacterial activities for decomposition of organic matter. LESTINGI ET AL. (2009) also mention the risk for bacterial activity caused by agricultural activities.

The practical impact of the use of an activator should lead to increase in crop yield. The presented results are consistent with the conclusions of LESTINGI ET AL. (2007) about the yield and quality composition of triticale. Similar effect can be expected even on other crops. Overall, the effects of activators of organic matter are among the less explored topics. In connection with changing composition of organic fertilizer (fewer manure and slurry but more compost and waste from biogas plants), the increased importance of activators of organic matter can be expected.

## CONCLUSIONS

So far, the work has been unable to clearly demonstrate the beneficial effect of activators of organic matter on parameters of water infiltration into the soil. This is probably due to the short duration of the experiment. Another possibility is the influence of soil parameters of the selected plot to the measurement. Especially light soil infiltration parameters are always strong, even without further intervention. For future measurements, it will be convenient to use other methods. A brilliant blue dye tracer method looks perrspective in this respect.

During the measurement of physical properties of soil, favorable effect on the bulk density of the soil could be observed. However, this was not confirmed by the cone index values measured. The yield results again suggest a beneficial effect of activators of organic matter in order to improve the soil environment. It may also be due to prolonged action of an activator in the soil for other several months. It will be necessary to see the influence of activators on yield of more common crops with different root systems than the maize. Again, the necessity of long-term examination of the effects of activators of organic matter should be emphasized. Research needs to be validated in more locations in order to eliminate the influence of the local environment.

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