# EFFECT OF MINERAL NITROGEN AND ORGANIC CARBON ADDITION ON SOIL HYDROPHOBICITY AFFECTED BY RAINFALL VARIATIONS

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## ABSTRACT

This work deals with the influence of mineral nitrogen and organic carbon addition on soil hydrophobicity affected by rainfall variations. The changes of soil hydrophobicity are very important, because they have a direct influence on soil fertility and leaching of nutrients from soil. This study presents the first results of a long-term pot experiment, which has been carried out in a climate chamber (under controlled conditions). Three groups of the treatment A, B and C with different regime of irrigation were prepared. The water content in soil was maintained at 70% of the Maximum Capillary Capacity (MCC), in the group A and at 40% of the MCC in the group B. Soil water regime was maintained in the range of wilting point and lento-capillary capacity in the group C. These groups were divided into three variants (A1 = B1, C1; A2 = B2, C2 etc.). Variants A1 (B1, C1) have represented the control without addition of another fertilizer. Variants A2 (B2, C2) were fertilized with nitrogen fertilizer DAM 390. Recommended doses of nitrogen ($N_{min}$) were applied there (0.140 Mg N/ha). Variants A3 (B3, C3) have contained arable soil with addition of compost (50Mg/ha).

High soil hydrophobicity slows water infiltration (hydraulic conductivity is lower) and conversely. Therefore, saturated hydraulic conductivity ($K_{sat}$) may indicate a degree of soil hydrophobicity. Hydraulic conductivity was measured by Mini Disk Infiltrometer. The highest values of $K_{sat}$ were found in variants with addition of organic carbon (compost was a source of carbon). Conversely, the lowest values of $K_{sat}$ were found in variants with addition of $N_{min}$. Moreover, all variants with organic carbon addition showed lower amount of mineral nitrogen leaching than variants without (in individual groups; ANOVA, $P<0.05$).

Based on these results, we can conclude, the addition of organic carbon with recommended dose of water has a positive effect on microbial activity, on decrease of leached mineral nitrogen and on hydrophobicity of soil.

**Key words:** soil hydrophobicity, mineral nitrogen, organic carbon, microbial activity

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## INTRODUCTION

Soil hydrophobicity is caused by organic compounds which remain on the surface of soil particles after the death of microorganisms. Gautam & Ashwath (2012) state that a number of factors contribute to hydrophobicity of soil or potting media. However, it is commonly accepted that the soil hydrophobicity is caused by the organic compounds that are released from living or decomposing plants or micro-organisms.

Soil water repellency is a widespread phenomenon, which affects infiltration as well as soil water retention and plant growth. It can be responsible for enhanced surface runoff, erosion and preferential flow (Schaumann et al., 2007). Soils with a high content of hydrophobic compounds show an increase of surface water runoff and the reduction of water available for plants arises there (Mataix-Solera & Doerr, 2004). Soil hydrophobicity has a direct impact on soil properties, stability of soil aggregates and soil fertility. For example, soil hydrophobicity can be influenced by the way of farming (Shakesby et al., 2000; Mataix-Solera & Doerr, 2004; Šimon et al., 2009). Therefore, the influence of mineral nitrogen ($N_{min}$) and organic carbon ($C_{org}$) addition on soil hydrophobicity is the main topic of this paper.

There is a hypothesis: The addition of mineral nitrogen and organic carbon has a direct impact on soil hydrophobicity and loss of nutrients from soil. This hypothesis was tested with soil from area of our interest. Area of our interest is the protection zone of underground drinking water source "Březová nad Svitavou". This protection zone is located in the northern part of the Czech-Moravian highland and it is responsible for the protection of underground source of drinking water against contamination by pollutants. We expect a long period of drought in future in this area. This change in weather can affect the microbial activity in the soil and soil hydrophobicity. Only changes of the farming may prevent the negative phenomena of soil hydrophobicity.

## MATERIAL AND METHODS

The experiment was established on the 1st of July 2013 and consists of two periods (the first period: July – August, the second period: September – October).

### Experimental design

Experiment was performed in experimental containers with a model plant. Twenty seven containers (lysimeters) from PVC were used for this experiment. Each lysimeter was the same size and it was filled with 3 kg of topsoil and 7.5 kg of subsoil. Soil was sampled from the area of our interest. Soil sampling was done on the 25th of May in accordance with ČSN ISO 10 381-6 (ČSN – The Czech Technical Standard). The samples of compost were taken on the 15th of March in accordance with ČSN EN 46 5735. Before using soil and compost, samples were sieved through a sieve (grid size of 2 mm). *Deschampsia caespitose* was used as a model plant to determine the effect of $N_{min}$ and $C_{org}$ addition on plant production. During whole experiment, plants were kept in a climate chamber at 24°C (day temp.), 20°C (night temp.), 65 % humidity (for all 24h) with a day length of 12 h.

*Tab. 1 Overview of the laboratory experiment*

| Group | | Variants | Characteristic |
|---|---|---|---|
| **A** | 70% MCC | A1 | Control |
| | | A2 | 0.140 Mg N/ha |
| | | A3 | 50 Mg $C_p$/ha |
| **B** | 40% MCC | B1 | Control |
| | | B2 | 0.140 Mg N/ha |
| | | B3 | 50 Mg $C_p$/ha |
| **C** | Wilting point | C1 | Control |
| | | C2 | 0.140 Mg N/ha |
| | | C3 | 50 Mg $C_p$/ha |

Comment for the Table 1: The water content in soil was maintained at 70% of the Maximum Capillary Capacity (MCC) in the group A and at 40% of the MCC in the group B. Soil water regime was maintained in the range of wilting point and lento-capillary capacity in the group C. These groups were divided into three variants differing in addition of $N_{min}$ and $C_P$ (compost).

**Measurement of the leached mineral nitrogen**

Mineral nitrogen ($NH_4^+$-N and $NO_3^-$-N) leached from the soil was captured by special discs with mixed IER (Ion Exchange Resin) by Elbl et al. (2013). Mixed IER was performed from Cation Exchange Resin (CER) and Anion Exchange Resin (AER) in ratio 1:1. This mixture was placed into each disc. For the quantification of $N_{min}$ trapped by the resin, the IER were dried at 20 °C. Captured $N_{min}$ was extracted from resin using 100 ml of 1.7 M NaCl (Novosadová et al. (2011). Released $N_{min}$ was determined by distillation and titration method according Peoples et al. (1986). The results obtained from the IER Discs were expressed in mg of $N_{min}$ per $m^3$ of soil.

**Determination of hydraulic conductivity**

Hydraulic conductivity was measured by Mini Disk Infiltrometer (MDI) according Elbl et al. (2013). The measurement is based on the recording of the infiltrated volume of water over the set time. High soil hydrophobicity slows water infiltration (hydraulic conductivity is lower) and conversely. Therefore, hydraulic conductivity may indicate a degree of soil hydrophobicity. Saturated Hydraulic Conductivity ($K_{sat}$) was calculated according Elbl et al. (2013).

## RESULT AND DISCUSSION

This work presents the results of saturated hydraulic conductivity and leaching of mineral nitrogen, which were determined during the second period of present experiment. Mineral nitrogen is an important indicator of the soil state. Saturated hydraulic conductivity may indicate a degree of soil hydrophobicity.

**Leaching of mineral nitrogen**

The Figure 1 shows the concentration of $N_{min}$ in individual variants. This graph indicates a significant difference ($P<0.05$) of detected $N_{min}$ between variants with $C_{org}$ addition (A3; B3, C3) and variant without.

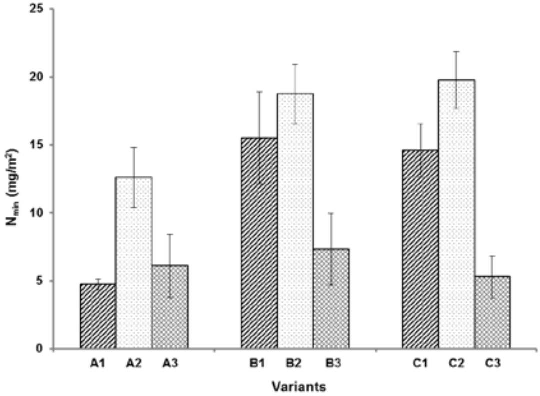


*Fig. 1 Mineral nitrogen contents (mean values ± standard error, n =3)*

All variants with $C_{org}$ addition showed lower amount of nitrogen than variants without (in individual groups; ANOVA, P<0.05). Conversely, values of leached $N_{min}$ were significantly higher in variants with mineral nitrogen addition than in variants without.

**Hydraulic conductivity**

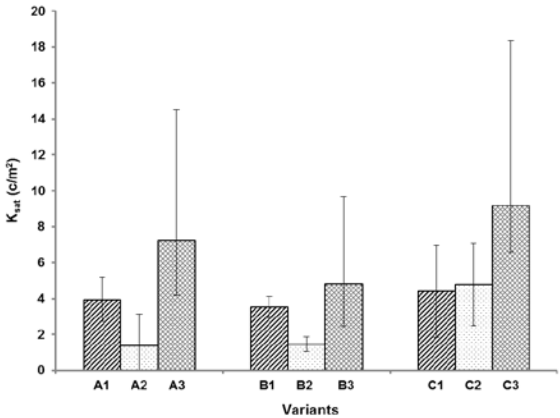


*Fig. 2 The impact of $N_{min}$ and $C_{org}$ addition and rainfall variation on hydraulic conductivity $K_{sat}$*

The Figure 2 presents the values of saturated hydraulic conductivity ($K_{sat}$ – mean values · $10^4$ ± standard error, n =3). The highest values of $K_{sat}$ were found in variants with addition of $C_{org}$. Conversely, the lowest values of $K_{sat}$ were found in variants with addition of $N_{min}$ (A2 and B2). Low values of $K_{sat}$ indicate an increased level of hydrophobicity.

## CONCLUSIONS

This contribution presents the first results of a long-term pot experiment. The measured values indicate the influence of fertilization on soil hydrophobicity and leaching of mineral nitrogen. The influence of rainfall variations on soil hydrophobicity has not been demonstrated yet.

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