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Influence of soil parameters on the efficiency of the new nitrification inhibitor DMPP (ENTEC®)

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Abstract

The influence of soil properties on the efficiency of 3,4-dimethylpyrazole phosphate (DMPP) as nitrification inhibitor was investigated in long term (25d) and short (5h) incubation experiments. The efficacy of DMPP was explained by a multiple regression analysis with the parameters soil clay and silt content, supplemented by additional factors (i.e. soil catalase activity and potential nitrification). Clay and silt content were related to the DMPP adsorption in soil ($R^2 = 0.64$). The adsorption of DMPP to inorganic soil surfaces is supposed to play a major role in DMPP efficiency.

Introduction

Nitrification inhibitors retard the first step of the oxidation of NH_4^+ to NO_3^-. The application of these inhibitors, like the recently developed 3,4-dimethylpyrazole phosphate (DMPP), represents a tool to increase N-fertiliser use efficiency, reducing N losses by NO_3^- leaching and by gaseous emissions from nitrification and de-nitrification (Linzmeier *et al.*, 1999; Weiske *et al.*, 1999).

Field studies gave evidence, that the efficacy of DMPP to inhibit the nitrification of ammonium fertilisers is soil influenced by conditions. Stabilisation of NH_4^+ (Linzmeier *et al.*, 1999) as well as positive yield effects (Pasda *et al.*, 2001) were more pronounced in light textured soils.

This study aims to investigate the influence of soil parameters on the nitrification inhibitory effect of DMPP.

Materials and methods

Long term (25 days) and short term (5 h) incubation experiments were conducted to study the influence of soil properties on the effect of the nitrification inhibitor DMPP on ammonium conversion.

Forth long term incubation experiment soil sampled from a loamy sand and a silty loam were equilibrated (1 week) to a soil matric potential of -50 kPa (non limiting for nitrifier activity), equivalent to water contents of 0.123 kg kg^{-1} (loamy sand) or 0.255 kg kg^{-1} (silty loam). Thereafter, fertiliser granules of ammonium-sulfate-nitrate with or without DMPP (Entec®) were added. Samples were incubated for 25 days at 25°C. NH_4^+ was determined colorimetrically by an indophenol blue method after extraction with 1 M KCl (1:2; w:v).

Short term incubation experiments were conducted with 22 soils covering a wide range of soil types (soil parameters see Barth *et al.*, 2001). The potential nitrification was determined according to Barth *et al.* (2001). The efficiency of the nitrification inhibitor DMPP was calculated by the formation of NO_2^-, (stabilised by $NaClO_4$) from added NH_4^+ (at a DMPP concentration of 5 mg DMPP kg^{-1} soil) compared with the NO_2^- formation without DMPP (termed "relative NO_2^- formation" in Figure 2).

DMPP adsorption to soil components was determined by shaking soil samples (20 g dry weight) with 100 ml 0.01 M $CaCl_2$ containing 0.2, 2.0, or 20.0 mg DMPP (Barth *et al.*, 2001) and was calculated as difference between initial and equilibrium DMPP concentrations, and related to soil dry weight (mean of three concentrations).

Coefficients of multiple regressions between relative NO_2^- formation or DMPP sorption and selected soil parameters (see Figure 3 and 4) were calculated with SAS version 8.01 (SAS Institute Inc. Cary, NC, USA).

Results and discussion

Ammonium fertiliser without DMPP was degraded within 25 days in both soils, the loamy sand and the silty loam (Figure 1). DMPP retarded the NH_4^+ oxidation in both soils, but the inhibition effect was much stronger for the loamy sand. This soil dependent higher efficiency of DMPP in light textured soils is in agreement with result from Pasda *et al.* (2001). In long term incubation experiments, this performance might be associated

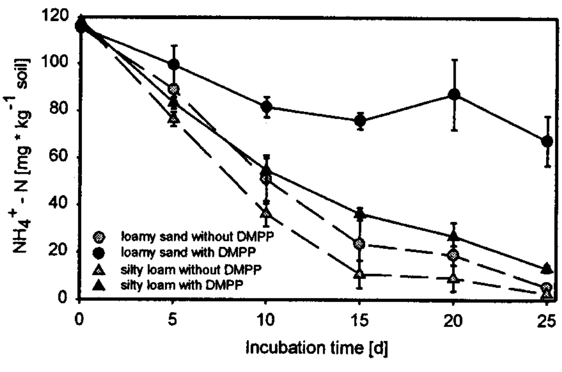

Figure 1. Effect of DMPP on ammonium degradation in two different soils at a soil matric potential of – 50 kPa. Error bars represent standard deviation.

with several interdependent factors, like differences in 1) the activity of the nitrifiers, 2) the degradation of

DMPP, 3) the availability of the nitrification inhibitor to microorganisms.

In agreement with theses results from the long term study, also in short term experiments, where DMPP degradation can be disregarded, the DMPP inhibition effect on the formation of NO_2^- was related to the soil type. The relative NO_2^- formation was more reduced in the *coarse textured soils (Figure 2).*

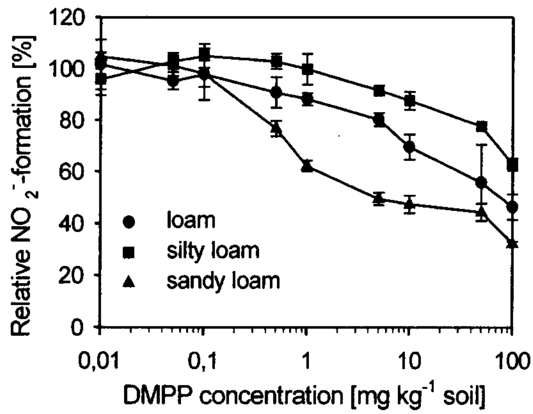

Figure 2. Influence of DMPP in short term incubation experiments on the relative NO_2^- formation. Three examples selected from 22 soils. Error bars represent standard deviation.

Soil texture proved to be a major factor to describe the inhibitory effect of DMPP in short term experiments, but NO_2^- formation was only slightly related to individual soil parameters (Barth *et al.*, 2001). In multiple regression analysis the efficiency of DMPP was best explained by supplementing textural parameters with additional factors, i.e. catalase activity and soil pH value (Barth *et al.* 2001) or catalase activity and potential nitrification, representing the potential activity of the nitrifiers (Figure 3).

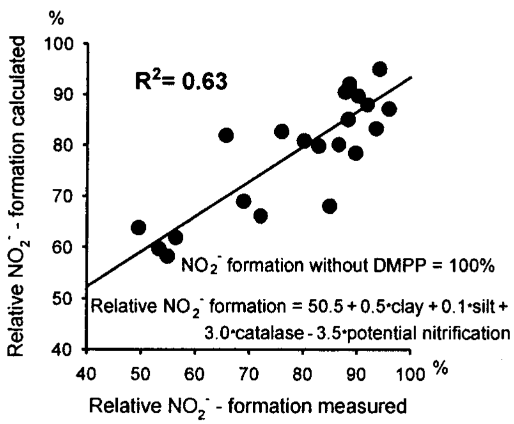

Figure 3. Influence of soil parameters on the relative NO_2^- formation in short term incubation experiments. Measured versus calculated values (DMPP concentration 5 mg kg^{-1} soil). Signifi-cance of the regression coefficient $p < 0.05$.

Soil components might act as binding partners for the adsorption of DMPP to soil surfaces and hence determine the availability of DMPP to microorganisms. Adsorption studies demonstrated, that about 8 to 30 % of the added DMPP were adsorbed to the soil. Regression analysis gave evidence, that 64 % of the DMPP adsorption was described by soil clay and silt content (Figure 4).

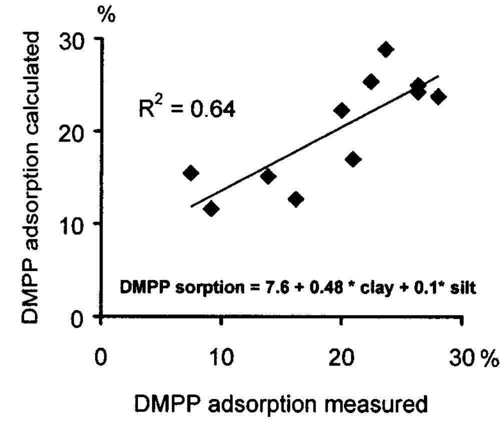

Figure 4. Adsorption of DMPP to soil. Relation to soil clay and silt content. Measured versus calculated values. Significance of the regression coefficient $p < 0.05$.

Adsorption of DMPP to soil surfaces is in agreement with results from Fettweis *et al.* (2001). In this study no DMPP was found in leachates collected from lysimeters.

Conclusions

Soil dependent differences in the efficiency of DMPP are related to soil type and the adsorption of DMPP to inorganic soil surfaces. Hence, textural properties, supplemented by additional factors as soil catalase activity, pH value and nitrifier activity, will play an important role in the prediction of the effect of DMPP on the inhibition of NH_4^+ oxidation. Further research is neccessary to evaluate the role of these parameters for the long term inhibition effect of DMPP.

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References

Barth G, von Tucher S and Schmidhalter U 2001 Biol. Fertil. Soils, (in press).

Fettweis U, Mittelstaedt W, Schimansky Ch and Führ F 2001 Biol. Fertil. Soils, in press.

Linzmeier W, Schmidhalter U and Gutser R 1999 VDLUFA Schriftenreihe 52, 485-488.

Pasda G, Hähndel R and Zerulla W 2001 Biol. Fertil. Soils, (in press).

Weiske A, Benckiser G and Ottow J C G 1999 VDLUFA Schriftenreihe 52, 517-520.