Impact of organic fertilising on soil microbial biomass in acid soil

Mateja MURŠEC¹, Remi CHAUSSOD²

¹ University of Maribor, Faculty of Agriculture and Life Sciences, Pivola 10, Hoče, Slovenia
(e-mail: mateja.mursec@uni-mb.si)
² INRA – Université de Bourgogne, UMR Microbiologie des Sols et de l’Environnement, 17 rue Sully, B.P. 86510, 21065 Dijon, France

Abstract
A two-years field experiment in organic apple orchard in NE Slovenia was carried out, studying the effects of organic fertiliser and liming on soil microbial biomass (MB) in acid soil (pH=4.7). Four treatments were included: organic fertilising without liming (OF), organic fertilising with liming (OFL), liming without organic fertilising (L) and control (C). The effect of OF on MB was mitigated by soil pH due to increasing soil acidity. L initially increased MB, while as a long time effect, it slightly decreased MB. The interaction of OFL was not clear, but in long term this is probably the best solution because it had positive consequences on soil pH, while preserving fair levels of MB.

Key words: organic fertiliser, liming, acid soil, soil pH, microbial biomass

Introduction
Maintenance of soil organic matter is important for the long-term productivity of agroecosystems. Soil application of organic amendments is a management strategy to counteract the progressive loss of organic matter (Marinari et al., 2000; Tejada et al., 2008). The addition of organic amendments may improve soil physico-chemical, biochemical and microbiological properties involved in biogeochemical cycles and thus positively influences plant productivity parameters. The organic amendments are a source of slow-releasing nutrients and available energy for soil microorganisms (Gómez et al., 2006). In organic production, the use of inorganic nitrogen fertilisers is not allowed, so plant nutrition with nitrogen often represents the main limiting factor. To improve nitrogen nutrition in organic plant production, it is important to focus on microbes, which enable the release of available nitrogen forms in soil. Application of organic fertilizers is linked to soil organic carbon and nitrogen pools, which consequently change microbial parameters and plant nutrition via mineralization processes. In organic farming, the main goal with different agricultural techniques is to enhance microbial activity, thus improving element recycling and soil fertility. As microorganisms respond very quickly to changes in land management (Entry et al., 2008), microbial biomass can be used as one of potential quality indicators in orchard soils. This research was devoted to study the effects of organic product (fertiliser) and liming on soil quality with the goal to enhance soil microbial biomass towards better plant nutrition.

Materials and methods
Study site
The experimental organic orchard was settled at the University Agricultural Centre Pohorski dvor in Pivola near Maribor (NE Slovenia). The climate was moderately continental with mean rainfall in the growing period (May-September) of 522 mm in 2004 and 744 mm in 2005; and mean air temperature of 15.5˚C in 2004 and 15.9˚C in 2006. The soil type was ‘Dystric Cambisol’ (FAO, 1998), developed on schist. Soil pH was 4.7 (in KCl), the soil texture was silty loam. The experiment was performed in four treatments as randomized block design, including two factors (organic fertiliser and liming). The included treatments were: organic.
fertilising without liming (OF), organic fertilising with liming (OFL), liming without organic fertilising (L) and control (C). Experimental site was made of five parallel tree rows, each of them contains 240 trees of ‘Topaz’ apple (Malus Domestica Borkh.) cultivar. The surface of the experimental plot was about 1600 m².

**Organic fertiliser and lime applications**

Different organic fertilisers were applied every spring (in April) from 2004 to 2005, according to nutritional requirements of apple trees (60 kg N ha⁻¹ year⁻¹). Compo Guano was chosen as a reference fertiliser in the study of soil microbes, assumed to be the most efficient organic fertiliser due to the highest percentage of total (12.3 %) and mineral (ammonium - 3.7%) nitrogen and the highest soluble organic matter content (97.4 %), comparing to the other products.

Lime material was 98 % natural grinded (120 μm) limestone (CaCO₃) with 1.5 % MgCO₃, 0.02 % FeO₃ and 0.05 % Al₂O₃. The lime requirement was calculated by an old internal system, based on potential (in 0.1 M KCl solution) and hydrolytic (in 0.5 M Ca-acetate) soil acidity. During our study, liming was performed twice a year, in the spring and in autumn, three weeks before organic fertilizers application. Lime was mechanically incorporated within the first 10 cm of the soil.

**Analytical methods**

Soil sampling was done till 15 cm depth. Soil pH was measured in KCl solution with electrometric method, according to ISO 10390. Soil microbial biomass was determined by using CHCl₃ fumigation-extraction method (Vance *et al*., 1987), modified by Chaussod *et al.* (1988).

**Statistical analysis**

The data were statistically analysed as a two factor (organic fertiliser and liming) trial in three blocks. Statistical procedures were carried out with the software package Statgraphics Centurion XV (Statgraphic®, 2005). The means were separated by the Duncan test, considering a significance level \( p<0.05 \).

**Results and discussion**

Soil pH was measured during both seasons of the experiment. Temporal distribution of this parameter is represented in Fig.1. During two seasons, treatments including liming (L and OFL) significantly increased soil pH comparing treatments without liming (OF and C). The strongest effect on soil pH increase was observed in the treatment L (lime without Compo Guano). Similar pH distribution was observed in the treatment OFL, but the values were slightly lower. The immediate reaction between soil and lime lead to an immediate increase in pH of the soil water due to partial dissolution of carbonates (Ola, 1978). However, the completion of the reaction is slow and their effect may show up in days, months, or years (Ola, 1978). Benefits of compost amendments to soil also include pH stabilization (Stamatiadis *et al*., 1999) and this could explain slightly lower soil pH in OFL. In the treatments without liming, Compo Guano additionally attributed to lower soil pH, what was confirmed by Ritchie & Dolling (1985).

From Fig. 2a, b, c & d it can be seen that MB increased during the experiment, following the addition of fertiliser or lime. At the beginning of the experiment (May and Sept. 2004), MB was not significantly affected by treatments yet, while a slight increase of BM in L and OF was noticed in September 2004. In May 2005, liming had a positive effect on MB. MB was significantly higher in OFL comparing OF; while comparing C and L, higher MB was noticed in case of liming (L), but this difference was not statistically proved. L showed significantly higher MB as OF, what was linked with liming effect on soil pH. MB values were the highest in OFL treatment, where soil pH rose due to liming and pool of organic carbon was enriched with additional Compo Guano. In September 2005, a slight decrease of MB in case of liming was probably linked with less organic matter input, which represent the main source of microbial food. The highest MB values in OFL in September 2005 confirmed previous statement from May 2005.

Liming alone had a positive short-term effect on MB, but there is a question about what happens in the long term (decline of BM in Sept. 04). Anderson (1998) found that the microbial activity measured as basal respiration was higher after liming as compared to the control, and Kreutzer (1995) noticed that the organic pool of the organic surface layer and upper mineral soil decreased (root biomass not included) after long lime application. Considering previous observations it can be presumed that stimulation of soil BM through liming results in more intensive microbial activity, which will gradually leads to MB decrease.
Figure 1. Temporal distribution of soil pH (0-15 cm).

Figure 2a, b, c & d: Temporal distribution of soil microbial biomass (0-15 cm).
Impact of organic fertilising on soil microbial biomass in acid soil

Conclusion

Liming alone initially increased MB, but without additional organic fertiliser it could decrease MB as a long time effect. Organic fertilising in acid soils without liming must be avoided. The interaction of Compo Guano and lime together is presumably the best solution for the long term because it had positive consequences on soil pH and fair levels of MB. For higher microbial density and activity (especially in organic farming), soil pH should be improved in the first place, and further it is important to maintain good level of soil organic matter with application of organic fertilisers.

References


