INTERACTION BETWEEN LIMING AND NITROGEN FERTILIZATION ON SEMI-NATURAL GRASSLAND

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Abstract: The experiment monitors the changes of exchangeable soil reaction (pH) and yields of the semi-natural grassland after using dolomitic limestone and urea (with and without inhibitors). The field experiment was founded on the area of 480 m^2 in Bohemian-Moravian Highlands. These variants were followed: not limed - control (C), not limed + urea (NL + U), not limed + urea with urease inhibitor (NL + UI), not limed + urea with nitrification inhibitor (NL + NI). Likewise there were differentiated variants of nitrogen fertilization, where the liming was done: limed (L), limed + urea (L+ U), limed + urea with urease inhibitor (L+ UI), limed + urea with nitrification inhibitor (L + NI). Liming was done by dolomitic limestone at a dose of 1.8 t · ha^{-1}. The urea fertilizers were applied at a dose of 100 kg · ha^{-1}. After the first mowing in June 2014, the data from one year of the experiment were evaluated. The results showed that the interaction between liming and nitrogen fertilization was not statistically significant, maybe average values of pH observed that liming clearly increased the pH values of the soil (L, L+U, L+UI, L+NI). The effect of dolomitic limestone and nitrogen fertilizers was not statistically significant, even in case of the yield of dry forage. It is however clear that all variants with liming had lower yield even than the control variant (C).

Key Words: grassland, lime, soil reaction, fertilizer, inhibitor

INTRODUCTION

Soil pH is an important characteristic which influence processes as: nutrient availability, microbiology activity (Kulhánek et al. 2013), supports the formation of humus and can also increase yields (Vaněk, Penk 1991).

Grasslands as well as arable land were not limed since 1989 mainly because of changes in agriculture after the fall of the communist regime. Nowadays, the grasslands in the Czech Republic have soil pH average value of 5.5. The worst value of pH is in Olomouc region and Vysočina region (Klement et al. 2013).

Quantity of calcium in soils is influenced by a lot of effects such as leaching, taking by plants (Černý et al. 2013), industrial emissions, air pollution and use of physiologically acidic fertilizers (Vaněk, Penk 1991). Leaching of calcium is an important cause of acidification of soils. Leaching is closely related with a rainfall. It was founded that in the Czech Republic by an annual rainfall of up to 500 mm are the annual losses of calcium 10 kg · ha^{-1}, whereas by a rainfall above 700 mm are the losses up to 50 kg · ha^{-1} per year.

In the place of the experiment, the average annual rainfall is 758.4 mm. This can be the reason of low pH values at the Kameničky experimental area. Higher leaching of calcium is typical for an extensive cultivation (Černý et al. 2013). The optimal value of pH is in the range from 5.0 to 5.6 for semi-natural grasslands. If soil pH drops below 5.0, liming should be performed (Hrabě, Buchgraber 2004).

Most commonly used mineral fertilizers increased consumption of lime. Amide form of nitrogen in the urea is converted to ammonium form, and it is further converted to nitric acid-acting form (Kulhánek et al. 2013).

MATERIAL AND METHODS

Characterization of growing locality, experimental design

The semi-natural grassland is placed near village Kameničky (49 ° 43'30.0 "N, 15 ° 58'38.2" E); (Pardubice region, Czech Republic). Experiment is 650 m a. s. l., inclination 3 SW, with loamy soil, soil reaction is 4.4. Area of the experiment had an area of 480 m^2.

It is a field study. The whole area was split in two parts. Dolomitic limestone and nitrogen fertilizers were used on one part. The other part was not limed, only different variants of nitrogen fertilizers were used. Dolomitic limestone was delivered at a dose of 1.8 t · ha^{-1}. These two parts were organized as blocks to plots with an area of 15 m^2 (1.5 * 10 m). The plots were separated according to a type of nitrogen fertilization. Three types of fertilizers were used: urea, urea with urease inhibitor (Urea Stabil) and urea with nitrification inhibitor (Alson 46). Complete variants were: control (C), not limed + urea (NL + U), not limed + urea with urease inhibitor (NL + UI), not limed + urea with nitrification inhibitor (N + NI), limed (L), limed + urea (L+ U), limed + urea with urease inhibitor (L+ UI), limed + urea with nitrification inhibitor (L + NI). Each variant had four replications. Nitrogen fertilizers were applied in one dose of 100 kg · ha^{-1} in the spring.

Cuts and analyses

The first cut was done on June 24th, 2014. Mower MF-70 was used for the first cut, width of cutter bar 1.2 m, height of stubble was 0.07 m. The biomass from every plot was raked and weighted, than it was recalculate to yield of dry forage. For statistical evaluation of interaction between nitrogen fertilizers and liming on the yields of dry forage of semi-natural grassland was used statistical analysis Anova in software Statistica with Tukey post-hoc test. The data from the first cut were used for the analysis.

Soil samples were also taken. Exchangeable soil reaction was monitored. The procedure was as follows: 10 grams of fine earth soil were suffused by 50 ml 0.01 M solution of $CaCl_2$, suspension was extracted on a mechanical shaker for 60 minutes, the suspension stayed in rest for one hour, then the value of pH was measured in the suspension by pH-meter. Statistical analysis Anova in the software Statistica with Tukey post-hoc test was used for statistical evaluation of interaction between nitrogen fertilizers and liming on the changes of exchangeable soil reaction (pH) of semi-natural grassland.

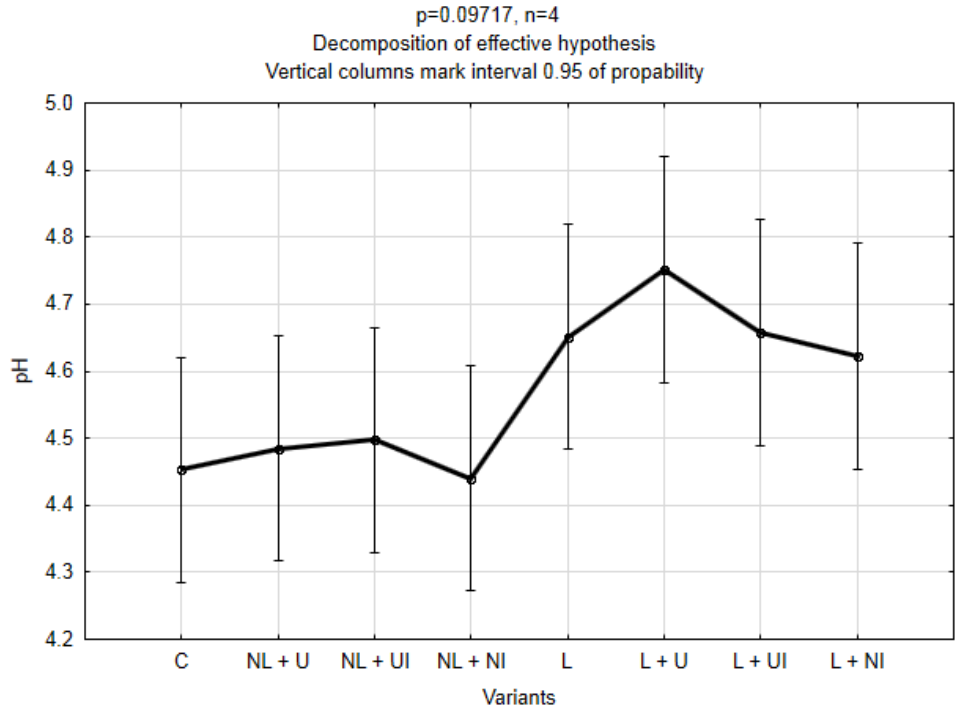
RESULTS AND DISCUSSION

Soils at Bohemian-Moravian Highlands are from 67 % acidic (Klement et al. 2014). The area of the experiment had pH 4.4. The low value of soil pH can be caused by high average annual rainfall. The seepage water flushes out the alkaline substances (Kulhánek et al. 2013).

The results show that liming and nitrogen fertilization was not statistically significant (see Figure 1). But it is clear that liming increased the pH values of the soil (L, L+U, L+UI, L+NI). Best combination for higher pH was liming with classic urea (L + U). The pH was lowest within variants with nitrification inhibitor (NL + NI and L + NI).

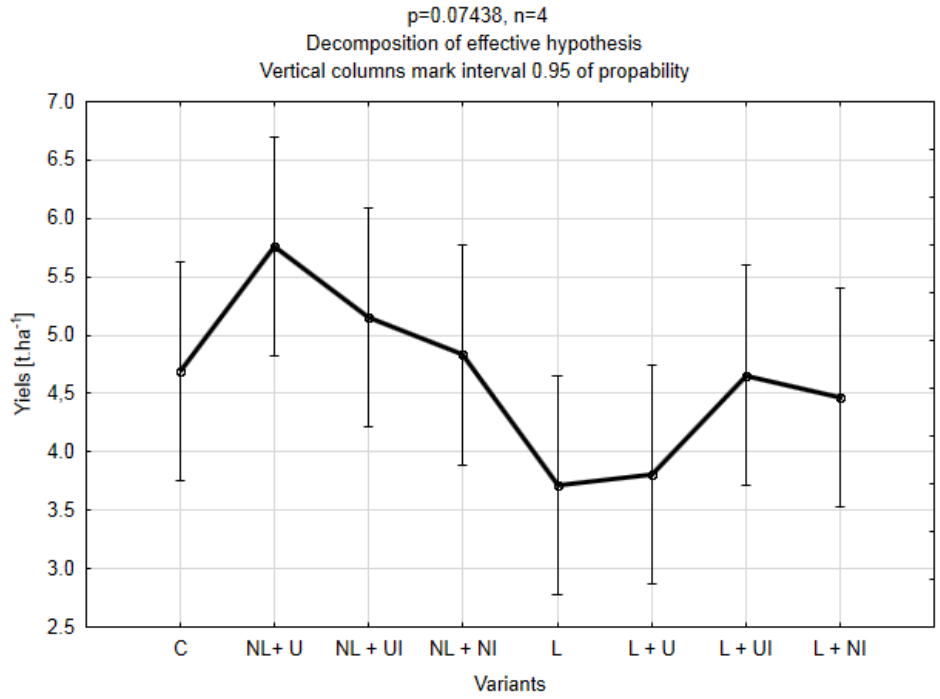
The interaction of dolomitic limestone and nitrogen fertilizers was not statistically significant in case of the yield of dry forage (see Figure 2). Variant with urea had the highest yield (NL + U). All variants with liming had lower yield than the control variant (C). According to Kulhánek et al. 2013, liming can cause temporary increase of yields, but in this case it was not demonstrable. He also commented that it is important to supply mineral or organic fertilizer with liming too. Using calcium and fertilizers together obviously leads to higher yields, because they support microbial activity which causes rapid decomposition of organic matter and then a release of nutrients (Kulhánek et al. 2013). Dolomitic limestone should increase biomass production (Trakal et al. 2011). This theory was not confirmed by our results. Variant L had lower yield than C.

Figure 1 The change of soil reaction after liming and nitrogen fertilization, Kameničky, 2014



Legend: control (C), not limed + urea (NL + U), not limed + urea with urease inhibitor (NL + UI), not limed + urea with nitrification inhibitor (N + NI), limed (L), limed + urea (L+ U), limed + urea with urease inhibitor (L+ UI), limed + urea with nitrification inhibitor (L + NI).

Figure 2 Yields of dry forage after liming and nitrogen fertilization, Kameničky, 2014



Legend: control (C), not limed + urea (NL + U), not limed + urea with urease inhibitor (NL + UI), not limed + urea with nitrification inhibitor (N + NI), limed (L), limed + urea (L+ U), limed + urea with urease inhibitor (L+ UI), limed + urea with nitrification inhibitor (L + NI).

CONCLUSION

The results show that the interaction of dolomitic limestone and urea fertilizers on the soil reaction and yield of dry forage is not statistically significant. The use of dolomitic limestone (L, L + U, L + UI, L + NI) obviously led to higher values of pH but lower yields - even lower than control. Contrary variants with only fertilization (NL + U, NL + UI, NL + NI) had low pH values but higher yields of dry forage. It is important to monitor the changes of soil pH within following years because of the long-term effect of liming. It is also important to monitor the effect of nutrients on yield of dry biomass of semi-natural grasslands.

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