Ecosystem Health and Sustainable Agriculture

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Sustainable Agriculture

Editor: Christine Jakobsson

SLU
Swedish University of Agricultural Sciences

Baltic University Press

CSD Uppsala.
Centre for sustainable development

UPPSALA UNIVERSITET

Soil Acidification

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CASE STUDY
Lithuania

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Concept

Soil acidification is described as a process whereby soil becomes acid (pH <7) because acid parent material is present or in regions with high rainfall, where soil leaching occurs (Soil Atlas of Europe, 2005). Soil acidification takes place in both natural and anthropogenic environments. That is precisely why in practice soil acidification is usually also perceived as acidification of limed soils (renewal of acid soil reaction after liming). The evidence for soil acidification is a change in soil acidity expressed as a pH value or by terms ranging from slightly acid for pH values <6.5 to extremely acid for pH values <4.5. Acidification is a slow process. For example, moraine loam Albeluvisols (initial pH in KCl suspension 4.6) in Lithuania after initial liming at 1.0 rate with rapid and slow activity liming materials, acidified to the initial level after 13 and 40 years, respectively. The intensity of soil acidification in the case of rapid activity liming materials is about 0.8 pH units (in KCl suspension) per 10-13 years (Eidukevičienė, 2001; Eidukevičienė et al., 2007). At present, the acidification of cultured (anthropogenic) soils is understood as cation leaching and removal with plant production in a theoretical sense, while practically it is regarded as soil degradation, i.e. the process of deterioration of its chemical, physical and biological properties (Eidukevichiene et al., 2001; Chwil, 2002). Acidification can be accelerated by human activities, e.g. use of fertilisers or deposition of industrial and vehicular pollutants (Soil Atlas of Europe, 2005).

Soil acidification (pH value moves down towards 4) is the opposite process to acidity neutralisation (pH value moves up towards 7). However, soil acidification and acidity neutralisation are different processes that proceed simultaneously, and the degree of intensity of both depends on the buffering capacity of the soil (Eidukevičienė, 1993; Eresko, 2005). This is the explanation for the dependence of both processes on the carbonate content of parent rocks or bedrocks (Eidukevičienė, 1993).

Problem Research and Results

Soil acidification as a process has been studied far less comprehensively than acidity neutralisation because since the mid-1960s it has been not analysed per se but most often only in the context of liming as a result of the chemical activity of liming materials (chemical ameliorator, lime fertilisers that are referred to as agricultural limes). In Europe over the last 150 years, studies of liming as the most efficient and irreplaceable preventive means of soil degradation have been exhaustive and have encompassed the object of liming (soil genesis), the duration of the effect of liming materials and their impact on soil and yield. In the sense of knowledge, the core problem has al-

ways been, and still remains, the lack of systemic analysis. Experimental results have revealed the various effects of liming – agrochemical, agrophysical, biological, agronomic, environmental (Eidukevičienė, 1993; Eidukevichiene et al., 2001), both the widely known positive effects and potentially negative effects (Eidukevichiene et al., 2001). There is evidence to suggest that potentially negative effects of intensive periodical liming lead to soil acidification (Eidukevichiene et al., 2001).

With the conception of the nature-friendly anthropogenic environment gaining in increasing importance since the 1990s and with the present day concepts of the profitable market economy, elucidation of soil acidification processes has become of particular significance.

The concept of a correlation between soil as the object of liming and soil acidification as a process in the 20th century underwent changes because of different approaches to the soil and to the need for liming:

- The scientific approach to an individual soil profile and the resulting concept of differentiated liming depending on the depth to carbonate layer in the soil (Lithuania, 1960s) was formulated.
- Overestimation of the upper soil horizon and the concept of liming depending on the upper horizon properties (Eastern Europe, 1970-1980s) became a feature.
- The scientific spatial approach to soil, the dependence of activity of natural and anthropogenic factors of soil acidification on the carbonate content of parent rocks, the depth of parent rock and bedrock and recognition of the significance of the geological and hydrological state of the soil cover for the profile pH were included (Bulgaria, Denmark, the United Kingdom, Poland, Lithuania, the Netherlands, Russia, Hungary, Germany – 1990s).
- Finally, the revival of the concept of differentiated liming on the properties of soil profile horizons or parent rock (Poland, Lithuania, Russia – 1990s) was validated (Eidukevičienė, 1993; Eidukevičienė et al., 2007).

In Eastern European countries, nowadays the problem of soil acidification is especially urgent. In Lithuania, both for economic reasons and because of the underestimation of scientific knowledge, 15 years ago the soil liming intensity was reduced, and the cessation of liming in 1997 due to lack of financing is already showing its first results in soil acidification (Mažvila et al., 2006). This applies to both heavy and light-textured soils. In Belarus, even a temporary (three-year) reduction of liming by 50-60% evoked soil acidification (Bogdevitch et al., 2005). In Russia, where the volume of liming was drastically reduced after 1990, soil acidification is expected to increase (Ivanov, 2000).

The turn of the century did not manifest any leap of the scientific thoughts; on the contrary, a strengthening of the former ideas was evident (Ivanov, 2000; Eresko, 2005; Mažvila et al., 2006). When interpreting the results of the most recent investigations in terms of present day reality, it has been recognised that under real conditions of farming on light loam moraine soils, only intensive liming gives fast results as it allows rapid optimisation of the acidity/basicity indices (Ivanov, 2000; Eidukevichiene al., 2001).

The state of soil acidity/basicity is related to the chemical composition of parent rocks and therefore even in well managed soils the influence of genetic differences remains preserved (Ivanov, 2000; Mažvila et al., 2006). It has been acknowledged that soil acidification differences in the territory of Lithuania, in the absence of liming, are essentially dependent on the genetic diversity of soil acidity in the profile. Therefore, when considering the renewal of soil liming, the concept of differentiated liming is proposed. The concept prioritises so-called originally acid soil areas that were present before intensive liming (Mažvila et al., 2006). The search for a correlation between the above-mentioned concepts and a practical solution for the problem gave the following results in Lithuania: Spatial differences in soil acidity neutralisation were elucidated and substantiated; the solution of differentiated liming depending on the depth to carbonate was proposed (Eidukevičienė, 1993); spatial differences in soil acidification in the territory of Lithuania were established (Mažvila et al., 2006), and the methods of investigation – GIS statistical analysis (Eidukevičienė et al., 2006; Volungevičius et al., 2006) – were improved and provided a scientific background for developing the theory of soil acidification prognosis. Finally, retrospective systems analysis was performed on acid soil gradation on the national level as well as on soil acidification rates at a local level, i.e. field trials (Eidukevičienė et al.,

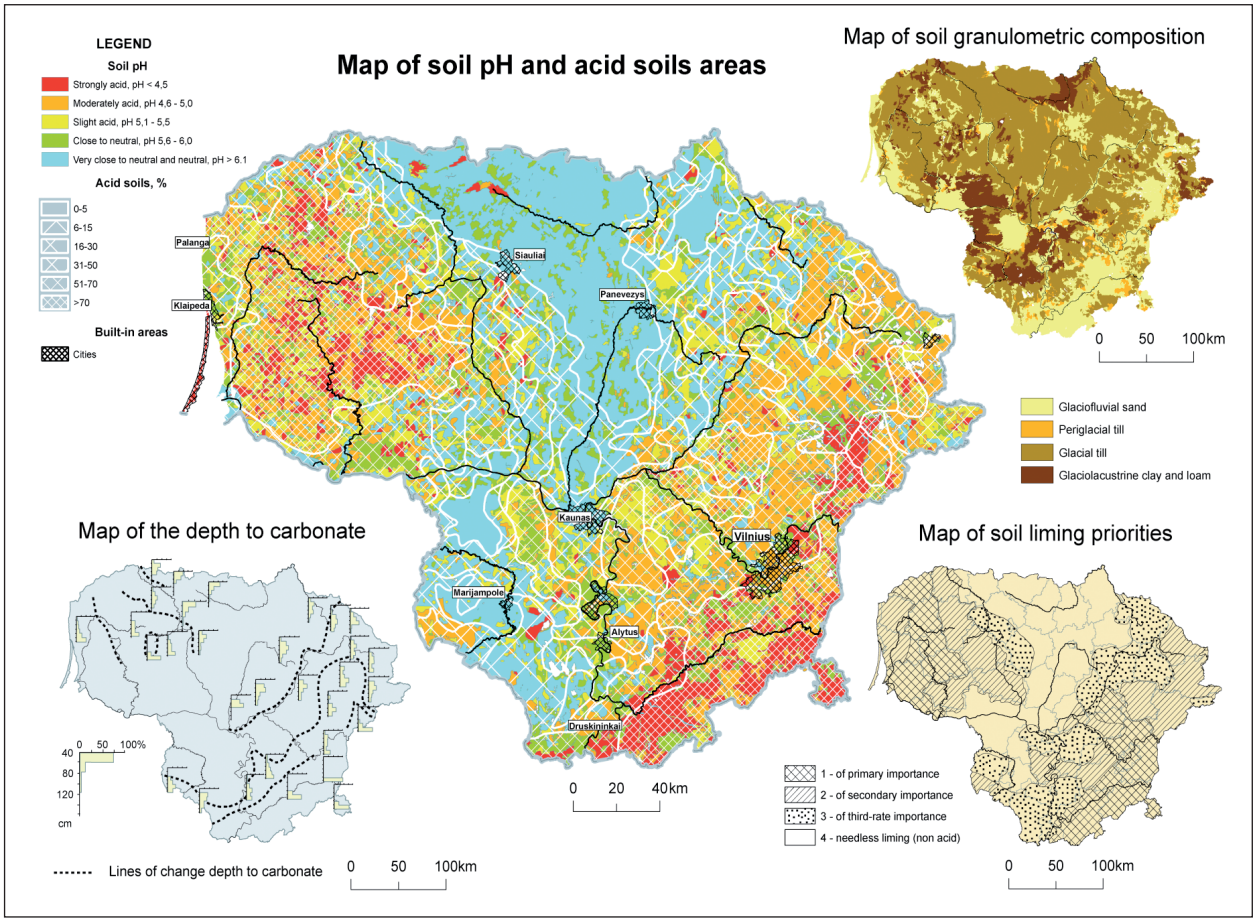

Figure 32.1. National map of acid pH of Lithuania (Eidukevičiene et al., 2010).

2007). This revealed that in moraine loam Albeluvisols, the rate of both neutralisation and acidification processes depends on the initial soil acidity level and on the type of lime materials applied. In both cases, pH changes in the upper soil horizon modify the properties of the whole soil profile as an indivisible natural body resulting from the genesis of the parent rock. The correlation between the spatial structure of pH in the upper soil horizon (0-20 cm) of agricultural lands limed one or two times and the regularities of an increase or decrease in acid soil plots over a period of 40 years is positive proof of the spatial localisation of acid soils and indicative of potentially acid territories. Soil acidification in the whole territory of Lithuania, if no liming is applied, confirms the necessity for regular uninterrupted liming. The case study results of system analysis are presented below for the well-known Baltijos Highlands (Figure 32.1).

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