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– reconciling productivity and environmental protection

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Soil phosphorus status in Baltic countries and its sustainable management

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Introduction

According the principles of conservation agriculture the food and feed production on arable lands could be in good concordance with local pedoecological conditions. Actually is essential to reach an acceptable to society compromise between intensification of agricultural productivity and sustaining a good status of environment. The arrangement of environmentally sound cycling of phosphorus (P) in arable soils is possible on the base of knowledge on elements actual status in soil, on P amounts needed for forming annual yield of crop, on theoretical principles of plant nutrition and element equilibrated ratios, and of know-how on monitoring and testing of soil P status (Djodjic et al., 2005).

In the current study the results of national agro-chemical soil survey for three Baltic States over last five decades are summarized. Changes in plant available soil P supply is discussed in context of agronomic and environmental aspects.

Materials and methods

The dominating arable soils in Baltic countries are Albeluvisols, Luvisols, Cambisols and Gleysols. In reduced extent are presented as well Arenosols and Podzols. Only the share of Histosols is in some extent greater (9%) in Estonia. The texture of >70% of arable soils may be classified as loam, sandy loam and loamy sand; share of sands and clays is accordingly in limits 12-15% and 3-6%.
The mean annual air temperature is +4.4–6.6°C, increasing very little from Estonia to Lithuania. The annual precipitations are in limits 520–900 mm, from which 50–70% is evaporated. The vegetation period lasts from 165 to 200 days, being 5-10 days longer in Lithuania in comparison with Estonia.

In Latvia and Estonia the plant available P content in soil was determined by double lactate (DL) extraction method, but in Lithuania by ammonium acetate lactate (AL) method. Since 2004 in Estonia the Mehlich-3 method is used in national soil monitoring.

**Results**

In 1960s to 1980s the P status in agricultural soils improved significantly in all Baltic States (Figure 1). The application of both mineral and organic fertilisers peaked in the 1980s. Intensive fertilization and related P surplus in that period has decreased the share of soils with P deficiency approximately 2–3-fold in Estonia and in Latvia. Since 1990s the use of P fertilizers decreased drastically and soil P balances turned to negative (Csatho et al., 2007). Therefore the deterioration of soil P status in last decade could be presumed but results of national soil agro-chemical survey show even minor (Estonia, Latvia) or remarkable (Lithuania) decline in P deficiency. In Estonia the last agro-chemical soil testing (in 2002–2006) was carried out in areas with higher soil fertility and covered 38% from area analysed 1980s. The sharp decrease of arable land area (mainly on account of low fertility soils) and the alteration of P determination methods has been complicated estimation of actual changes in soil P supply. In Latvia last national agro-chemical investigation (in 2002–2006) was performed for 2,687 farms. The investigation sample included more intensive commercial farms with relatively fertile soils and better management practices. Area surveyed (184,602 ha) was only 7.5% from state total agricultural land area. In Lithuania latest results of changes in plant available P were observed within 1994–2005 (473,337 ha area in former farms located in 34 administrative districts). The data was compared to the results obtained during the previous research activities and the agro-monitoring carried out 5 years later on the same 75 plots (approximately 200 ha size). Results showed that in various soil regions and sites variation of available P is very high and tendencies of changes compare to previous observations is hardly comparable.
According to the latest national soil agro-chemical testing in Baltic States is the share of arable soils with very low plant available soil P content the largest in Latvia (Table 1). Soils with high P content form significantly larger share in Lithuania and in Estonia compared to Latvia.

Table 1. Distribution of arable soils (in % of total tested area) depending on the content of plant available phosphorus.

<table>
<thead>
<tr>
<th>Content degree</th>
<th>Lithuania¹</th>
<th>Latvia</th>
<th>Estonia²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>7</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>Low</td>
<td>27</td>
<td>25</td>
<td>21</td>
</tr>
<tr>
<td>Medium</td>
<td>28</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>High</td>
<td>38</td>
<td>17</td>
<td>29</td>
</tr>
<tr>
<td>Very high</td>
<td>-</td>
<td>9</td>
<td>8</td>
</tr>
</tbody>
</table>

1) in Lithuania P supply level high and very high is combined
2) in Estonia - agricultural land

In Estonia the soils are divided into five groups according the content of plant available P: (1) very low – 150%; (2) low – 130%; (3) medium – 100%; (4) high – 50% and (5) very high content -10%. Percentage at content degree characterizes amount of P removed with yield and should be returned to the soil. In the case very high content of P the possibilities for eutrofication of environment should be expected.
In Latvia fertilizer recommendations usually are based on reference tables which consider yield goal, soil texture and organic matter amount and soil P status. These tables were developed on the base of field experiments but their verification and relevance for current crops’ varieties and cultivation practice is actual. The average quantities, expressed as P$_2$O$_5$, kg/ha: cereals 40–45; rape – 50–80; potatoes and maize – 100; grasses – 30–50 and vegetables – 60–120.

As alternative to mineral fertilisers mainly farmyard manure and composts are largely used. The using of bone meal is prohibited in Estonia and Latvia as product dangerous product for environment.

**Discussion**

P surplus can cause environmental threat but nutrient mining causes agronomic and economic problems. Nutrient surpluses are often found in areas with high livestock density. Livestock density per agricultural land is in Baltic States 2.6–4.6-fold lower compared to average of EU15 countries. Averaged over the EU15 countries is the use of both mineral and manure P fertilizers fourfold as high as in the Baltic countries (Phosphorus. Topsoil, 2008). To minimize P pollution load from agriculture the crop P requirements should be met as precisely as possible.

Large-scale national agro-chemical soil testing in 1960s to 1980s has provided reliable overview of changes in soil fertility in Baltic States. Reforms and remarkable decrease in soil testing since 1990s has complicated detecting of actual changes in soil P supply at national level. The problematic comparability of the latest testing occasion with previous shows that conclusions about soil P status at state level may be insufficient without additional criteria (fertilizer use intensity, nutrient balances etc). For more precise interpretation of results of national soil testing temporal analysis must be further made at field scale.

Excessive soil P content enhances the risk of increased agricultural P loads to surface waters. Therefore is crucial to have a reliable spatial data (from field to national scale) about soils P status. There is important to know the distribution of soil P supply categories. Despite the significant proportion of P-deficient soils in all Baltic States the precise information about location of P-rich soils forms basis for environmentally sound fertilization.
In all Baltic States the organic farming increases year by year. Unfortunately the organic farming is more popular in regions with naturally low soil fertility. In organic farms the soil monitoring is necessary as the soil P status may become critical by depletion. Negative P balances in Estonia are evident especially for grasslands and while more than 80% of the organically farmed area is under grasslands. The issue of long-term sustainability of low-input farming practices should be given more prominence.

**Conclusions**
- Phosphorus surplus in arable soils of Baltic countries rests in average under 10% of their area. These areas must be indicated and declined to environmentally sustainable management.
- Phosphorus deficiency (as certain kind of soil degradation) in arable soils of Baltic countries varies in limits from 27 to 38%. On these areas the means for mitigation of soil scarcity and optimization of soil P status are needed.
- Development of site-specific soil P status testing methods and implementation of continuous soil agrochemical status monitoring for balanced phosphorus management should be developed with joint Scandinavian-Baltic research projects.

**References**