# Map of the Susceptibility of Soils to Acidification in Hungary

G. VÁRALLYAY, M. RÉDLY, A. MURÁNYI and J. SZABÓ

Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences, Budapest

The basis for sustainable land use is adequate information on the soils, including soil properties, their territorial distribution and susceptibility to various degradation processes (SZABOLCS & VÁRALLYAY, 1978; VÁRALLYAY, 1987; VÁRALLYAY et al., 1979, 1980, 1985).

One example is presented of information of this type from a series available in our institute (VÁRALLYAY, 1992).

The soil reaction status in Hungary is, in general, favourable for agricultural production but regular nation-wide soil survey data have proved that a significant increase in soil acidification can be detected on large territories of the country (BARANYAI et al., 1987; BUZÁS et al., 1986; SZABÓ, 1989). This is caused by both natural factors and human activities (acid deposition, incorrect fertilization, etc.) (MÉSZÁROS, 1984; PUSZTAI, 1979). For this reason the qualitative and quantitative characterization of the susceptibility of soils to acidification was necessary (MURÁNYI, 1987; MURÁNYI & RÉDLY, 1987).

## Material and Methods

In our work, soil acidification was defined as a decrease in the acid neutralizing capacity, which may result in a pH decrease (MURÁNYI, 1987). Soil acidity and soil acidification depend on the acid load, i.e. the quantity, concentration and chemical composition of various substances getting into the soil from different sources, as well as the buffer capacity of the soil which is determined by numerous soil properties.

Representative soil sample collection was used for the study and analysis of the relationship between buffer capacity and different soil properties. The different acid loads in Hungary are estimated (Table 1).

The category system used in the 1:100 000 scale map of soil factors determining the agro-ecological potential of Hungary (VÁRALLYAY et al., 1979, 1980) (Table 2) served as basic information for the elaboration of soil categories from the point of view of their susceptibility to acidification.

*Table 1*
**Acid loads in Hungary**

| Source of acid loads | Dosage* | Estimated average of acid loads, kmol $H_3O$/ha/year | $CaCO_3$ necessary for neutralization, kg/ha |
|---|---|---|---|
| $NH_4NO_3$ fertilizer | 118 kg N/ha | 5.1 | 252 |
| Urea fertilizer | 118 kg N/ha | 5.8 | 286 |
| Superphosphate fertilizer | 78 kg $P_2O_5$/ha | 0.5 | 24 |
| Acid rain | 573 mm | 0.2 | 9 |
| Total (dry+wet) acid deposition of compounds containing S and N | | max. 2.0 (stress) | 90 |

* The average dosage of fertilizers for arable land, gardens, orchards and vineyards in Hungary in 1985

## Results

Hungarian soils were classified into six groups according to their susceptibility to acidification:

(1) Strongly acidic soils. These soils have an originally low pH and low base saturation. Their further acidification is restricted under the influence of acid loads. For their chemical amelioration, high ("ameliorative") lime doses are necessary. These soils cover 13% of the total area of Hungary.

(2) Highly susceptible soils due to their low buffer capacity. This group includes slightly acidic soils formed on various parent materials (except loess), having high amounts of coarse fragments and light texture (sand, sandy loam), low organic matter content and/or less than 70 cm thick soil solum. In these soils the permanent control of pH and/or carbonate status is very important. Their rapid acidification can be prevented (neutralized) by low rate lime application. These soils cover 14% of the total area of Hungary.

(3) Susceptible soils due to their medium buffer capacity. The soils belonging to this group are slightly acidic soils with sandy loam texture, low organic matter content, and less than 70 cm depth, but formed on calcareous loess parent material; or soils with sandy loam texture but higher organic matter content and deep solum; or medium-textured soils (loam) with lower organic mat-

*Table 2*

**Soil factors determining the agro-ecological potential in Hungary (VÁRALLYAY et al., 1979, 1980)**

| No. | 3. - 8. Numbers of the 8-digit code-system | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2. Parent material | 4. Soil reaction and carbonate status | 5. Soil texture | 6. Soil water management categories | | | | 7. Organic matter content, t/ha | 8. Depth of the soil, cm |
| | | | | Infiltration rate (IR) | Hydraulic conductivity (K) | Field capacity (FC) | Water retention (WR) | | |
| 1. | Glacial and alluvial deposits | Strongly acidic | Sand | Very high | Very high | Low | Very poor | < 50 | < 20 |
| 2. | Loess, loess-like deposits | Moderately acidic | Sandy loam | High | High | Medium | Poor | 50 - 100 | 20 - 40 |
| 3. | Tertiary or older deposits | Calcareous from the surface | Loam | Good | Good | Good | Good | 100 - 200 | 40 - 70 |
| 4. | "Nyirok" | Salt-affected, non-calcareous from the surface | Clay loam | Moderate | Moderate | High | Good | 200 - 300 | 70 - 100 |
| 5. | Limestone dolomite | Salt-affected, calcareous from the surface | Clay | Moderate | Poor | High | High | 300 - 400 | > 100 |
| 6. | Sandstone | | Organic | Low | Very low | | High | > 400 | |
| | | | | Unfavourable water management | | | | | |
| 7. | Shale, phyllite | | Coarse fragments or solid rock | Very low | Extremely low | | Very high | | |
| | | | | Extremely unfavourable water management | | | | | |
| 8. | Granite, porphyrite | | | Good | Good | Very high | Very high | | |
| 9. | Andesite, rhyolite, basalt | | | Extreme moisture regime due to shallow depth | | | | | |

*Table 3*

**Classification of Hungarian soils according to their susceptibility to acidification**

| Categories | Soil characteristics | | | | | Acreage as a % of the total area of Hungary |
|---|---|---|---|---|---|---|
| | Parent material | pH and carbonate status | Texture | Organic matter, t/ha | Depth of solum, cm | |
| 1. Strongly acidic soils | - | strongly acidic | - | - | - | 13 |
| 2. Highly susceptible soils due to their low buffer capacity | - | slightly acidic | sand | - | - | 14 |
| | | | coarse fragments | | | |
| | anything except loess | slightly acidic | sandy loam | < 200 | < 70 | |
| 3. Susceptible soils due to their medium buffer capacity | loess | slightly acidic | sandy loam | < 200 | < 70 | 5 |
| | - | slightly acidic | sandy loam | > 200 | > 70 | |
| | | | loam | < 200 | < 70 | |
| 4. Moderately susceptible soils due to their high buffer capacity | - | slightly acidic | loam | > 200 | > 70 | 23 |
| | | | clay loam | - | - | |
| | | | clay | | | |
| | | | organic | | | |
| 5. Slightly susceptible soils | - | salt affected soils non-calcareous from the surface | - | - | - | 4 |
| 6. Non-susceptible soils | - | calcareous from the surface | - | - | - | 41 |

ter content and shallower solum. These soils cover 5% of the total area of Hungary.

(4) Moderately susceptible soils due to their high buffer capacity. This group includes slightly acidic soils with medium texture, high organic matter content and deep solum; or soils with heavy texture (clay, clay loam). Non-calcareous organic soils were also classified in this group. The pH of these soils decreases slowly under the influence of acid loads, but their acidity can be neutralized only by high-rate liming. These soils cover 23% of the total area of Hungary.

(5) Slightly susceptible soils (4%). This group consists of salt affected soils, non-calcareous from the surface, but the pH is always alkaline in the illuvial B-horizon of these solonetz soils.

(6) Non-susceptible soils, which are calcareous from the surface (41%). There is no considerable change in their reaction (pH) until the complete neutralization (dissolution, mobilization) of their carbonate content takes place.

The category matrix of the system is given in Table 3.

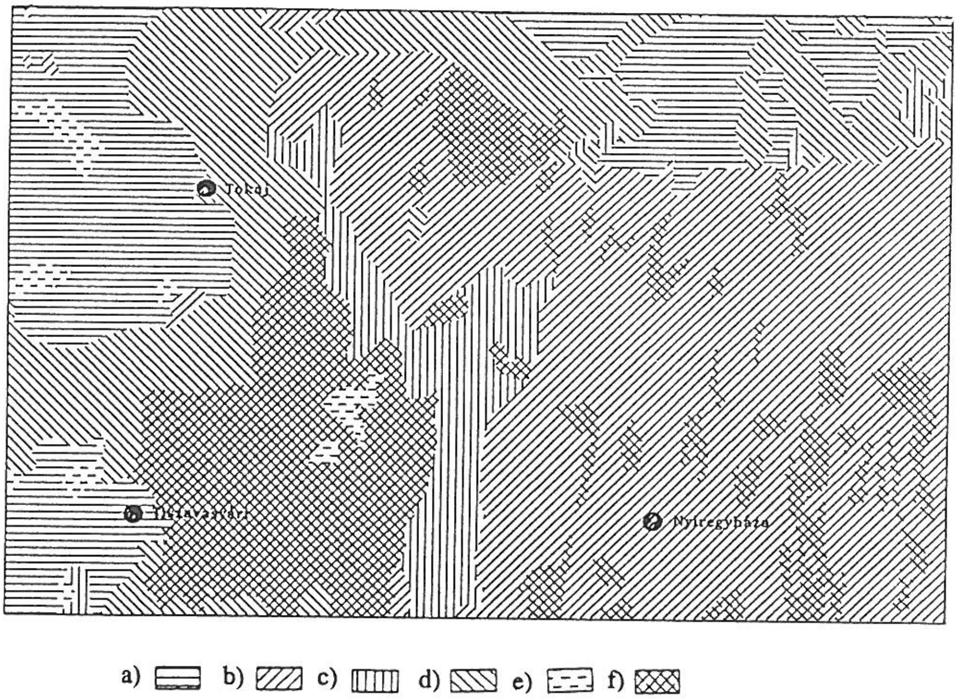


*Fig. 1*

Map of susceptibility of soils to acidification in 1:100,000 scale.
a) Strongly acidic soils; b) Soils highly susceptible to acidification;
c) Soils susceptible to acidification; d) Soils moderately susceptible to acidification;
e) Soils slightly susceptible to acidification; f) Soils non-susceptible to acidification


*Fig. 2.*

Map of the susceptibility of soils to acidification in Hungary. 1. Strongly acidic soils. 2. Highly susceptible soils due to their low buffer capacity (slightly acidic soils with light texture and low organic matter content). 3. Susceptible soils due to their medium buffer capacity (slightly acidic soils with medium texture and organic matter content). 4. Moderately susceptible soils due to their high buffer capacity (slightly acidic soils with heavy texture and/or high organic matter content). 5. Slightly susceptible soils (salt affected soils non-calcareous from the surface). 6. Non-susceptible soils (calcareous from the surface)

The territorial data, the distribution of different susceptibility categories for any type of region (e.g. agro-ecological or administrative) and the soil types were summarized. They are included in the attribute data base file of the AGRO-TOPO information system compiled on a regional scale (SZABÓ, 1992).

The example presented for the 1:100,000 scale maps of the susceptibility categories (Fig. 1) and the schematical version of the 1:1,000,000 scale generalized map (Fig. 2) for the whole country were prepared using the above information system.

## Conclusion

With the use of the computer-based information system the territorial distribution of soils with different susceptibility to acidification can be simply determined, including a specification of the reasons for this acidification.

The maps and their territorial data can be used for the national and regional planning of the amelioration of acid soils as well as for the prevention of soil acidification.

## References

BARANYAI F., FEKETE A. & KOVÁCS I., 1987. A magyarországi tápanyagvizsgálatok eredményei. [Results of the nutrient status analyses of Hungarian soils]. Mezőgazdasági Kiadó. Budapest.

BUZÁS I-NÉ, CSERNÁTONY CS-NÉ & HERCZEG A., 1986. A magyarországi talajok pH csökkenése. [Decrease in soil pH in Hungary]. Agrokémia és Talajtan. **35.** 63-71.

MÉSZÁROS E., 1984. Savas esők Magyarországon. [Atmospheric acid depositions in Hungary]. Magyar Tudomány. **29.** 529-536.

MURÁNYI, A., 1987. Soil acidification and the soil properties. Zeszyty Problemowe-Postepow Nauk Rolniczych. Z. **344.** 123-126.

MURÁNYI, A. & RÉDLY, M., 1987. The susceptibility of Hungarian soils to acidification. Zeszyty Problemowe Postepow Nauk Rolniczych. Z. **344.** 111-121.

PUSZTAI A., 1979. Az intenzív kemizáció hatása a talajok reakcióállapotára és más tulajdonságaira. [The effect of intensive chemization on the pH status and other properties of the soil] 108-129. Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences. Budapest.

SZABÓ, J., 1992. AGRO-TOPO, Hungarian Agroecological System in a scale 1:100 000. Proc. Workshop on Satellite Datahandling and GIS technologies in the Alps-Adria Region. 26-31.

SZABÓ, P., 1989. Changes of soil reaction and fertility in Hungary. In: Ecological Impact of Acidification. Proc. Joint Symp. "Environmental Threats fo Forest and Other Natural Ecosystems". Oulu, 1-4 Nov., 1988. 95-102. Budapest.

SZABOLCS I. & VÁRALLYAY GY., 1978. A talajok termékenységét gátló tényezők Magyarországon. [Limiting factors of soil fertility in Hungary] Agrokémia és Talajtan. **34.** 243-248.

VÁRALLYAY, GY., 1987. Soil degradation processes and their control in Hungary. Zeszyty Problemowe Postepow Nauk Rolniczych. Z. **344.** 17-44.

VÁRALLYAY, GY., 1992. Soil data base for sustainable land use - Hungarian case study. Proc. Int. Symp. on Soil Resilience and Sustainable Land Use, Budapest, 28 September - 2 October, 1992.

VÁRALLYAY GY. et al., 1979. Magyarország termőhelyi adottságait meghatározó talajtani tényezők 1:100 000 arányú térképe. I. [Map of soil factors determining the agro-ecological potential of Hungary, 1:100 000. I.] Agrokémia és Talajtan. **28.** 353-384.

VÁRALLYAY GY. et al., 1980. Magyarország termőhelyi adottságait meghatározó talajtani tényezők 1:100 000 arányú térképe. II. [Map of soil factors determining the agro-ecological potential of Hungary, 1:100 000. II.] Agrokémia és Talajtan. **29.** 35-76.

VÁRALLYAY, GY. et al., 1985. Soil factors determining the agro-ecological potential of Hungary. Agrokémia és Talajtan. **34.** Suppl. 90-94.