Soil Factors Determining the Agro-Ecological Potential of Hungary

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The main aim of agriculture and forestry is the production of yields in good quality and maximum quantity to satisfy the needs of the increasing population, without any harmful side-effects of production, e.g. without any unfavourable antropogenic changes in the well balanced equilibrium state of the biosphere. /These unfavourable changes, if permitted to occur, are almost irreversible in many cases, and if their correction is possible at all, it can be very expensive and not economical./

There are three main possibilities of this:

- the territorial extension of agricultural land /extensive agricultural development/;
- the increase of crop yields per territorial unit through the maintenance and increase of soil fertility, the establishment of optimum soil ecological environment, approximation of the permanently adequate moisture and nutrient supply of plants /intensive agricultural development/;
- the rational planning of development /industrial and urban development, transport, recreation, etc./ which result in the decrease of agricultural area; prevention of further territorial extension, increase of worsening of undesirable soil processes, or at least their localization or moderation.

The possibilities of the increase of agricultural production and, especially, of crop yields are mainly determined - besides climatic, relief, and hydrological factors - by soil conditions, both directly and indirectly, because soil properties considerably influence /or may influence/, sometimes even determine the ecological effects of the hydrological conditions and, to a certain extent, the consequences of some meteorological factors, as well.

Soils represent a considerable part of the natural resources of Hungary, consequently their rational utilization has particular importance in our national economy. Soils are "conditionally renewable" natural resources. The possibilities, conditions, rate and efficiency of this "renewal" are primarily determined by the rate of solar energy transformation through the plants' photosynthetic activity. If the ecological factors are properly controlled /e.g. by creating optimum ecological environment for crops and guaranteeing their continuous and adequate water and nutrient supply/ this potential can be realized in high crop yields, and at the same time, in the maintenance and increase of soil fertility /VÁRALLYAY et al., 1979/.

The evaluation of land-site characteristics, the assessment of the agro-ecological potential, the rational use of natural resources, the increase of the production of agriculture and forestry, the planning and realization of intensive agricultural development, the maintenance, conservation and/or increase of soil fertility can be achieved successfully only if we are in possession of more detailed, comprehensive, exact and quantitative information on soils.

A multi-disciplinary programme was initiated at the Annual Meeting of the Hungarian Academy of Sciences in 1978 for the "Assessment and evaluation of the agro-ecological potential of Hungary" /LÁNG et al., 1983/. The two main objects of the programme were:

a/ Prognosis for unit area yields /t/ha/ and total yields /tons/ of the main agricultural crops at the end of this century as a function of the existing ecological conditions and the forecasted level /in the case of various input levels/ of agricultural production, respectively.

b/ Determination of the theoretical, potential and actual possibilities for the more efficient utilization of the agro-ecological potential in the near and far future.

Map of soil factors determining the agro-ecological potential of Hungary

Within the scope of this programme, a map was prepared by the authors on the scale of 1:100 000, showing the soil factors determining the agro-ecological potential of the country /VÁRALLYAY et al., 1979, 1980a/.

For the preparation of the map all the available physico-geographical and soil information were used /descriptions, data, maps, aerial photographs, etc./ /STEFANOVITS, 1968; STEFANOVITS and SZÜCS, 1961; SZABOLCS and VÁRALLYAY, 1977/.

The following soil factors were indicated on the map by using an eight-digit code system:

1st and 2nd digits:	Soil types and subtypes /31 units/;
3rd digit:	Parent material /9 categories/;
4th digit:	Soil reaction and carbonate status /5 categories/;
5th digit:	Soil texture /7 categories/;
6th digit:	Soil water management properties /9 categories/;
7th digit:	Organic matter content /6 categories/;
8th digit:	Depth of the soil /5 categories/.

The map was prepared at the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences, on 50x50 cm, digital cartographical sheets on 1:100 000 scale. The work was completed in 1979. Another series of the map /with the same content/ were prepared for the 19 counties /administrative regions/ of Hungary. The minimum area contoured on the map was 1 cm^2 /= 1 km^2 = 100 hectare/. The contours and serial numbers of the 35 agro-ecological regions of Hungary were also indicated on the map.

The tematical maps of the 7 soil factors /indicated on the 1:100 000 scale map/ were prepared separately, on 1:500 000 scale/ /VÁRALLYAY et al., 1980a/.

Territorial data of the map

The area of each plot indicated on the map /altogether about 6,000/ was determined. On the basis of the computer-stored plot-list /including

the serial number, geographical coordinates, code-number and the area of each plot/ any soil variants /with determined soil properties/ can be easily selected and territorially determined. Knowing the optimum soil requirements of the various crops, the areas ecologically best for their cultivation can be delineated; soils with limited fertility due to various factors can be indicated; and, on this basis, the necessity of various measures /soil amelioration, agricultural water management, agrotechnics/ can be determined and the proper methods /technologies/ can be elaborated.

The territorial data of the map were tabulated. In the tables the absolute /hectare/ and relative /percental/ extension of the various soil types /subtypes/ were given per counties and agro-ecological regions. The distribution of the different soil types /subtypes/ according to the other 6 soil factors /indicated on the map by code-numbers/ were tabulated, as well. Finally 5 integrated tables were constructed, showing

- the distribution of the various soil types /subtypes/ per administrative units /19/ and agro-ecological regions /35/;
- the distribution of soils according to their properties indicated on the map per administrative units and agro-ecological regions;
- the distribution of the 31 Hungarian soil /sub-/ types according to their properties indicated on the map.

Possibilities of the practical application of the map

The accuracy of the 1:100 000 scale map is high. It was prepared on the basis of detailed soil investigations /detailed field survey and laboratory analyses, large-scale soil maps, long-term observations, etc./, consequently, it can be used as an exact and comprehensive cartographical information basis for further small-scale and large-scale soil mapping systems, e.g.:

- various tematical maps showing more or less exact and quantitative data on different soil properties /e.g. $CaCO_3$-status; pH; acidity, salinity-alkalinity; limiting factors of soil fertility, macro-, meso- and micronutrient status; soil as energy resource and energy transformator, etc./;
- synthesis maps /based on the above summarized tematical maps/ indicating recommendations for soil and land evaluation; agricultural regionalization /agro-ecological grouping/; amelioration, agricultural water management, irrigation, drainage, soil reclamation and improvement; soil conservation, water and wind erosion control; soil cultivation, optimum use of fertilizers, etc./.

The map provides direct and indirect information on the various soil properties important from the point of view of agricultural production and agricultural water management, and on this basis it is possible

- to evaluate the land site characteristics, and to estimate the agro-ecological potential of the given area;
- to determine the limiting factors of the ecological potential, its efficient utilization, land capability, actual and potential soil fertility, to evaluate their causes, influencing factors and consequences, and to reveal the theoretical, real and economic possibilities of their elimination, moderation and/or prevention /SZABOLCS and VÁRALLYAY, 1977, 1980; VÁRALLYAY, 1980/;
- to characterize the soil moisture regime, and to estimate the quantity of water which runs off and/or directly evaporates from the soil surface, filtrates into the soil, percolates through the soil profile and feeds the groundwater; can be stored within the soil and is available for the plants;

- to determine the limitations of the continuously adequate water supply of plants and the possibilities of their regulation;
- to evaluate the soil factors of the plant nutrient regime, which is a precondition of the establishment of a rationally optimum system of fertilization.

The map and its territorial data give copious soil information for the elaboration, planning and realization of various measures aiming at the creation of optimum soil ecological environment, the maintenance and increase of soil fertility /agricultural water management; rational use of natural precipitation, irrigation, drainage; soil amelioration and improvement; water and wind erosion control; agrotechnics, etc./. This way it represents a reliable soil scientific basis for the various national and regional agricultural development programmes, water management plans, soil amelioration projects, etc., as well as for the determination of optimum land use and cropping pattern, for the development of ecologically rational agricultural specialization /regionalization/ and for "biological landscape planning" /territorial development with minimum unfavourable changes in the well-balanced equilibrium state of the biosphere, deteriorations in the natural environment/.

The map can also provide valuable assistance in:
- the rational use of natural resources;
- studies on the mass and energy transport and transformation processes /description and characterization of their general trends; analysis of the influencing factors, their mechanisms/ with the aim of controlling and regulating the existing processes, preventing unfavourable changes, maintaining and increasing soil fertility;
- soil and land evaluation;
- environmental studies and control /prognosis of probable soil changes in the biosphere, and the elaboration of efficient measures for the prevention, elimination or moderation of unfavourable phenomena/;
- the activities of related sciences /geology, geomorphology, geography, hydrology, hydrogeology, biology, etc./ and various branches of the national economy.

Soil data bank - soil information system

The complete information material /indicated on the map and summarized in the tables/ serves as an exact, comprehensive basis for an up-to-date soil data bank, a computerized national soil information system, which is being developed by the authors, and is in the final stages of elaboration. In this system both digital and graphical inputs are possible and the characteristics of each distinguished plot /soil properties, e.g. code-numbers indicated on the map; slope characteristics; land use parameters; etc./ are stored with their contours. The input of contours can be done either directly, with the application of a semi-automated digitizer; or by using the "raster" /elementar point/ procedure, built up from 2x2 or 3x3 mm mosaic-squares. Besides the automatic determination of the area of each plot, the output of our data and contour bank can be the graphical or digital display of any stored data, and automated mapping of soil properties on any convenient scale. The simple and quick recall can be for instance: soil information on a given point or territorial /geographical, farming or administrative/ unit in digital or graphical form; digital or graphical information on any data, or data-combination groupped according to a given aspect; automated or semi-automated digital soil mapping for various purposes /e.g. se-

lection of optimum land use and cropping pattern according to land site characteristics; necessity and forecasted efficiency of various ameliorative measures, control of soil moisture regime, etc./. The soil information system provides a proper framework for the continuous enlargement of the data collection; for correlation analyses; for the further interpretation of the stored information with up-to-date data-processing, etc. /VÁRALLYAY et al., 1980a/.

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