Research Work and Development for Protecting and Increasing the Fertility of the Soil by Complex Amelioration

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One of the fundamental conditions for the quantitative and qualitative development of primary biomass production and for the utilization of the potential created in the biological basis of plant production is the protection of soil fertility and the moderation or, where possible, elimination of factors which limit fertility. In this respect amelioration operations are extremely important in Hungary, since poor chemical, physical, biological and water management properties and hydrological and relief features restrict soil fertility on almost two thirds of the area suitable for agricultural cultivation /Table 1/.

In order to improve or eliminate these unfavourable growing site conditions, systematic amelioration was commenced after the second world war, together with scientific research and development based on the results achieved in the course of long years of research in this field.

Both theoretical and practical results prove that complex amelioration is one of the most efficient forms of agricultural investment, the costs of which are the most reliably returned.

The continual reduction in the fertility and size of the agricultural land area, combined with the increase in the volume of supplementary costs, which leads to a drop in efficiency, makes it vital to lay greater emphasis on amelioration.

The regional programming, planning and execution of modern amelioration, satisfying the needs of rational soil utilization, and the maintenance or improvement in the level of investment efficiency will only be possible if there is an adequate standard of scientific grounding, involving an expansion in research and development in this field and an adjustment of the research programmes to match the complexity of amelioration.

Major aims of the amelioration research programme

The Karcag Institute is charged with the development of various components in regional, flatland complex amelioration, concentrated on the Tisza Valley and the Trans-Tisza Region, with the improvement in soil utilization techniques for maintaining and increasing the efficiency of amelioration, and with the elaboration of new techniques.

Table 1

Extent of areas requiring amelioration

Areas flooded by inland waters		
averaged over 20 years		130 000 ha
minimum		60 000 ha
maximum		600 000 ha
Valley bottoms and hill bases covered with stagnant water		200 000 ha
Areas affected by erosion		2 263 000 ha
of which at present	823 000 ha is strongly	
	890 000 ha is moderately	
and	550 000 ha is weakly eroded	
Salt affected areas		960 000 ha
of which	560 000 ha could be ameliorated	
and only	234 000 ha has been ameliorated so far	
Secondary alkalization		400 000 ha
Drift sand /mobile sand/		253 000 ha
Acidic areas requiring liming		2 219 000 ha

Within this framework the most important tasks are perfection

- of methods for improving the chemical and physical properties of acidic /forest, alluvial, meadow and skeletal/ soils and those poor in Ca,
- of methods for the permanent improvement of the chemical, physical and water management properties of solonetz-type alkali soils and those which are salty in the deeper layers,
- in the planning parameters and methods for soil moisture regulation within the field /introduction of moisture into the soil, efficient storage in the soil, removal of surplus moisture, moisture supplementation,
- economic analysis of ameliorative techniques and methods, and the elaboration of a system of conditions and economic efficiency indices for their application,
- of soil utilization and agrotechnical methods designed to achieve a high level of amelioration efficiency and to ensure soil conservation with special regard to the cultivation of exceptionally dense, compacted soils.

The special soil scientific and hydrological conditions of the Hungarian Plain, its geomorphology and the basin-like geological structure have a decisive influence on amelioration and on the research and development necessarily associated with this work. A new, extremely important, but also difficult task facing complex amelioration is the elaboration of efficient moisture regulating systems for the mostly hydromorphic soils, which contain large quantities of organic and inorganic colloids, have unfavourable water, air and heat management and are periodically or constantly subjected to the effect of water. The relevant ameliorative and agrotechnical methods must be coordinated and systematically applied.

The soil moisture regulation called for within the framework of amelioration is very complex and closely connected to almost every element in the amelioration, so it requires very great circumspect and careful planning. At the same time, very little scientific or practical information is

available on how moisture regulating methods can be applied, and with what success, on the soils of the Trans-Tisza Region, which contain a large proportion of sedimentary material, have extremely low water absorption capacity and permeability, are compacted, airless and salt affected over large areas, and salty in the deeper layers.

Until recently the efficiency of chemical and mechanical soil reclamation and its effect in increasing soil fertility had only been studied under non-regulated soil moisture conditions, and neither analytical research nor practical work had been carried out on a combination of soil amelioration and soil moisture regulation. The results of research conducted over the last 10 years prove that water regulation, particularly soil moisture regulation within the field, is a basic condition for the reliable utilization of these soils as arable land, for the achievement of their potential fertility and for the efficiency of chemical and mechanical soil reclamation.

The rest of this paper will be devoted to certain thoughts provoked by this research.

Moisture regulation of heavy soils within the field

Research results prove that when selecting the form of amelioration and the individual ameliorative elements it is extremely important to coordinate soil moisture regulation, soil reclamation and soil conservation. Chemical and mechanical soil amelioration alone, without soil moisture regulation, can be applied reliably and efficiently on areas where the effectiveness is not limited, or only to a slight extent, by extreme hydrological conditions. There is a long tradition of chemical and mechanical reclamation of soils requiring amelioration in Hungary. Nevertheless, sufficient attention has been paid to the appearance, prevention and elimination of harmful surpluses of water, which may appear on the surface of the soil or within the soil profile from time to time, often for long periods. This is also a problem because over considerable areas of the Hungarian Plain the soils are in close connection with very salty groundwater. Regardless of whether this situation arises due to natural causes /e.g. unfavourable drainage conditions, rain and groundwater flow/ or as the result of human intervention /e.g. establishment of reservoirs, drains and irrigation facilities/, it always involves the danger of an expansion of salinization and/or alkalization processes. On such areas ameliorative soil moisture regulation must therefore ensure the prevention of such processes and the arresting or reversal of present processes. This is particularly important, since salinization and/or alkalization can take place on any type of soil, even on those which recently are not affected by salt accumulation, such as alluvial, meadow and chernozem soils. An expansion of the process may thus endanger highly fertile soils. It follows from this that, from the point of view of amelioration, special attention must be paid to the large areas of mostly hydromorphic soils which are subjected to the effect of water and which are potentially endangered by salinization and/or alkalization as well as having limited fertility due to the lack of regulation of soil moisture conditions.

The research results achieved so far indicate that for heavy soils in the Trans-Tisza Region which are subjected to the effect of groundwater either periodically or permanently, an average groundwater level of around 1 m can be considered feasible, effective and satisfactory using the soil moisture regulation technologies currently applied. At the same time, knowledge is inadequate on the effect of soil moisture regulation to various

depths on the mobility, salt balance, water, air and heat management of soil-borne materials and on soil formation processes, and little is known about their interconnections and about the laws governing them. For this reason, within the framework of the field research a lysimetric research base was established, consisting of 2 m deep soil monoliths of original structure and large volume. It is hoped that the new information obtained in this way will contribute to:

- the determination of the dynamics and extent of chemical and physical changes taking place as the result of various types of water regulation in soils which contain large quantities of organic and inorganic colloids and are salty in the deeper layers, and the determination of the factors which have the strongest influence on the mass of plant products produced,
- the improvement and refinement of soil physical and agrochemical parameters required for the planning and application of soil moisture regulation,
- the scientific grounding of the more efficient soil moisture regulation methods now being elaborated, and the determination of development trends and programmes.

The research results indicate that ameliorative soil moisture regulation can only be regarded as complete if it ensures a satisfactory degree of looseness in the upper layer /at least 50-60 cm/ of soil and an adequate ratio /at least 80:20/ of capillary space /for water storage/ to gravitational space /for water conductivity and gas exchange/. It follows from this that an ameliorative standard of deep loosening, carried out at a sufficient depth and with satisfactory loosening efficiency, is an essential component in the moisture regulation of heavy soils and in the successful application of hydromeliorative engineering operations /e.g. soil drainage systems/.

On the basis of the effect of ameliorative deep loosening on soil moisture regulation and of its inevitable connection with other ameliorative operations, Hungarian soils can be divided into two major groups:

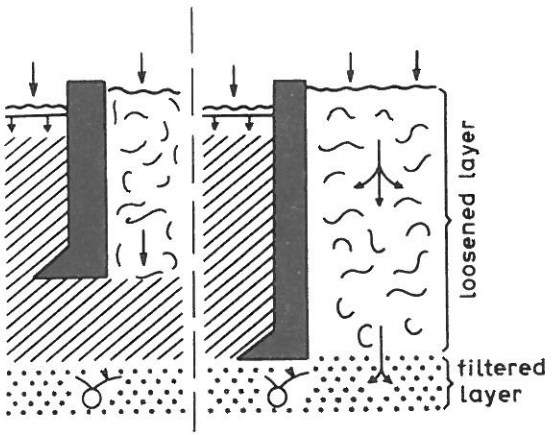
- In the profiles of soils in the first group, the compacted genetic level/s/ or layer/s/ is/are located at such a depth that the whole thickness can be loosened using the deep looseners available, i.e. the deep loosener is able to reach the base rock or layer with better water conductivity.
- In the profiles of soils in the second group, the compacted genetic level/s/ or layer/s/ with low water permeability extend/s/ to such a depth that base rock with good or better water conductivity cannot be reached even by deep loosening of ameliorative standard.

The present research results unambiguously confirm the concepts and assumptions based on the results of foreign research, implying that on the heavy soils of Hungary moisture regulation carried out by means of soil drainage systems is most successful if the technology allows the creation and maintenance of a connection between the deep loosener and the drain filter /Fig. 1/. The optimum depth for drainage is determined by the depth of soil loosening, which is necessarily associated with the operation and should be of an ameliorative standard, and by the thickness of the filter layer above the soil drain. The thickness of the soil layer above the drain, which is free of the effect of groundwater and represents the main, reliable growing space for the cultivated crops, should preferably be at least 60-70 cm. On heavy soils the depth of soil drainage can only be increased if there is a parallel increase in the thickness of the drain filter layer or in the depth of soil loosening.

The examples presented here confirm the need for further research on the efficient application of this costly type of amelioration and for a deeper knowledge of the laws governing the relevant processes, without which the method cannot be applied reliably over wider areas.

If soil loosening and drain filtering are unsatisfactory as regards depth and quality there is a strong likelihood of:

- surface water formation
- the continuation of unfavourable porosity conditions /low water permeability and air capacity, unfavourable heat management/
- in short, totally inefficient drain functioning



In general, the regularly cultivated 0-30 cm layer must be expected to be rapidly re-compacted, with the siltation and choking of the soil surface

If soil loosening is carried out to the depth of the filter layer, the following will be ensured in the profile above the soil drain:

- mobility of moisture in soil
- creation of a more favourable porosity state, which will be maintained for a longer period

Fig. 1

Possibilities of improving the moisture regulation of excessively heavy soils and unfavourable water, air and heat management properties in the case of soil draining

Summary

A brief report is given of research carried out at our Research Institute on the development of complex amelioration for heavy lowland soils, with special regard to the results achieved and the problems encountered in work on ameliorative soil moisture regulation.

The results prove:

- that soil draining carried out at an average depth of 0.90-1.00 m with drain filtering, combined with deep loosening to an adequate depth and quality, can be successfully applied even on salt affected soils or on those with an excessively high clay content;
- that the substantial, consistent yield-increasing effect and the agrotechnical advantages are worthy of consideration in the development of complex amelioration and as a means of making the soil of wide areas, now only suitable for extensive cultivation, successfully utilizable as arable land;
- that, on the basis of the effect of deep loosening on soil moisture regulation and its inevitable connection with individual ameliorative operations, Hungarian soils can be divided into two major groups, depending on whether deep loosening is able to reach soil layers with better water conductivity.