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POSSIBILITIES FOR IMPROVEMENT OF STRUCTURE OF FINE-TEXTURED SOILS

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ABSTRACT

Many clayey and loamy soils have a soil structure that leaves much to be desired. On light silty and loamy soils slaking and capping in autumn and winter often cause difficulties with winter crops, while heavy clay soils are difficult to till and to cultivate. These unfavourable properties may result in a poor actual soil structure that is insufficient for good plant growth, in spite of the fact that more labour must be expended on them.

The workability in spring is another important aspect of soil structure.

Late seedbed preparation and late sowing often mean low yields. To get good results the physical properties mentioned must be good. There are several possibilities for an acceptable situation. Soil conditioners can be used, but for general agriculture and horticulture they are much too expensive. So more practical measures must be taken.

Much can be achieved with a change in clay content or soil profile, an improvement in humus content and lime status, and better drainage. Also a carefully selected tillage system adapted to the soil in question may reduce the difficulties with soil structure in some cases.

To be able to indicate the most significant measures, the influence of the different factors on the physical parameters of soil structure must be known. Some results of our studies on that subject will be given.

INTRODUCTION

Many clays and loams have a structure that leaves much to be desired. On soils with a poor structure usually lower yields are obtained and more time and work are spent than on soils with a good structure. This means that the economic return from these "problem soils" is less than from soils in good condition. Then the question arises how these soils can be brought into a more desirable condition as quickly and cheaply as possible. Before answering this question the meaning of "soil structure" must be duelled briefly.

MEANING OF SOIL STRUCTURE

The notion "soil structure" is complex. Several aspects can be distinguished. The most important on fine textural soils are :

1) Capping of the soil surface or slaking of the entire top layer in autumn and winter, often resulting in insufficient areation, which gives problems with winter crops as winter wheat and tulips. Such difficulties especially occur in light silty and loamy soils.

2) Trafficability or the possibility for driving on the soil. Modern agriculture uses a lot of heavy machines. To make this possible soils must have sufficient resistance against mechanical forces.

3) The workability of soils. A soil that crumbles rather easily, for example during soil tillage and seebed preparation, has a great advantage. For cropping potatoes and tulips that are harvested mechanically also a good workability is needed. Especially on heavy clay soils the workability often is so bad that the possibilities for use are limited.

4) The suitability for seedbed preparation in spring. The time at which the seedbed can be prepared and the crop can be sown is very important. For most crops early sowing gives higher yields.

5) The actual soil structure, that is the spatial arrangement of the soil particles. This determines the soil aeration and therefore is important for plant growth and yield.

POSSIBILITIES FOR IMPROVEMENT

In our modern time with a high degree of mechanisation it is necessary that the structure meets the requirements mentioned. There are several possibilities to get an acceptable situation, namely by changing the texture of the soil, by adding organic matter, by raising the lime content and by improving the drainage. A carefully selected tillage system adapted to the soil in question also may reduce the difficulties with soil structure. And there is of course the possibility of adding chemical products generally called soil conditioners. What management is the best one on clayey soils in agriculture ? In other words, what management gives the best result with the lowest costs and is economically justified ?

The experience during many years of research on soil structure and soil conditions is that some of the so-called soil conditioners have a remarkable effect on soil structure, but are much too expensive for use in agriculture and even in horticulture. Therefore, they give no solution for the problems mentioned. That means that the farmer or the marketgardener has to try to bring his soil in the desired condition in another, somewhat cheaper way. And there are satisfactory possibilities for most soils. To find the most suitable management for the control of soil structure, the influence of the different factors as clay content, organic matter, lime and drainage on the physical aspects must be known. The study of these factors was an important part of our work and in the following some results will be shown.

INFLUENCE OF SOME FACTORS ON SOIL STRUCTURE ASPECTS

1) The slaking of silty and loamy soils is strongly affected by organic matter content and lime condition (Figure 1). The slaking values are the results of a visual rating in spring. A value is given on a scale from 1-10, where a poor condition of the top layer as a result of serious slaking is given a low mark (Figure 2).
There is a favourable influence of both factors and there exists an interaction, which means that the influence of the one factor depends on the level of the other factor. The dotted lines gives the critical

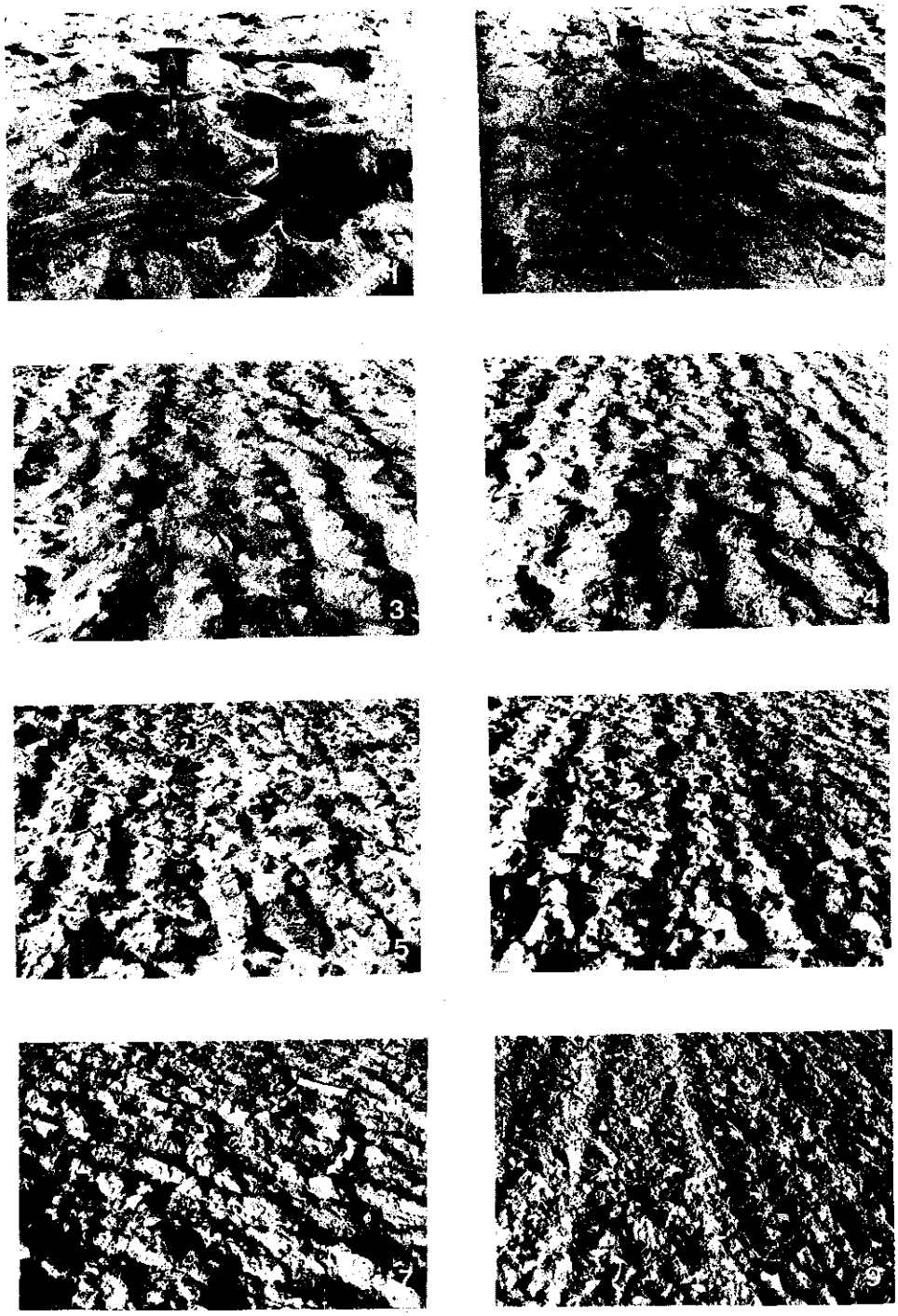

Fig. 2 : Visual rating of slaking of the topsoil.

value, that is the condition needed to prevent damage. From this figure we can decide upon the organic-matter content and the lime conditions that is required.

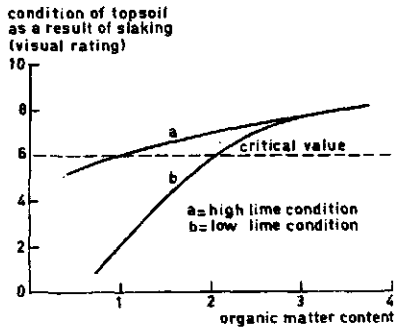

Fig. 1 : Influence of organic matter and lime condition on slaking.

2) The workability, closely related to the cohesion of the soil, is strongly affected by clay content and lime condition, as is shown in figure 3. Here a strong cohesion means a poor workability. It is evident that a high clay content, especially in combination with a low lime condition, causes a poor workability. Here the dotted line gives the critical value of the cohesion. A higher value means an unfavourable one. From this figure it may be concluded that on heavy clay soils it is not possible to realise a good workability by liming only.

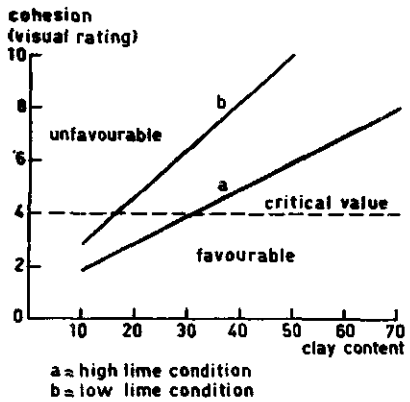

Fig. 3 : Influence of clay content and lime condition on cohesion.

3) The time at which seed-bed preparation can start, depends rather strongly on the level of the groundwater in spring. For a silty clay with different water-levels it has been calculated at what time seed-bed preparation could be started in the spring (Figure 4). That was done for a period of twenty years. It is evident that the mean starting point on soils with a deep water level (100 cm) is about three weeks earlier than on soils with a shallow water level (40 cm). In some years the difference is more than 5 weeks.

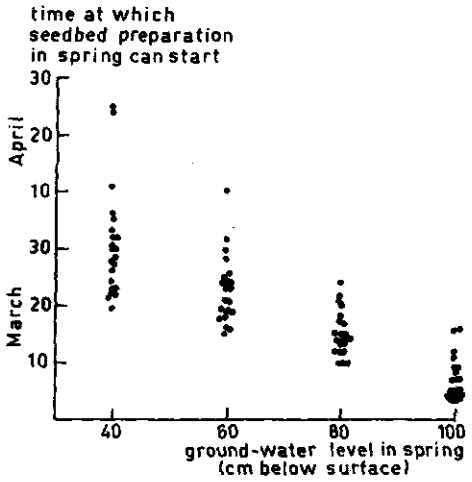

Fig. 4 : Influence of ground-water level on workability in spring.

4) The actual soil structure is affected by lime condition in combination with clay content. On heavy clay soils the actual soil structure is more improved by liming than on sandy clay soil (Figure 5).

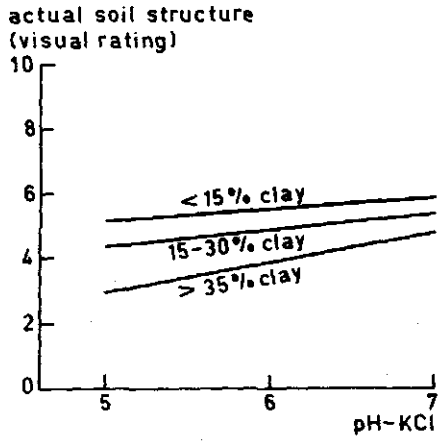

Fig. 5 : Influence of lime condition and clay content on actual soil structure.

THE DESIRED SITUATION

In the preceeding sections some examples are given of the influence of several factors on some aspects of soil structure. The available data are, however, much more comprehensive than so far have been shown, and therefore we were capable of establishing the required soil composition and drainage to obtain a perfect physical condition. The result is given in figure 6.

In this figure is given the organic-matter content, needed to get a situation without detrimental slaking and with a good workability and a good actual structure on soils with a different clay content, lime condition and drainage.

An important conclusion is that on well-drained calcareous soils with about 15 % clay, a rather low organic-matter content will suffice. That means that these soils anyhow have a good soil structure if drainage and lime condition are good. And those factors can easily be manipulated.

Heavy clay soils give more difficulties because a good drainage and a high lime condition are not enough to get a good workability. Therefore they need also a high organic-matter content (5 - 6 %). And that cannot easily be realised in agriculture.

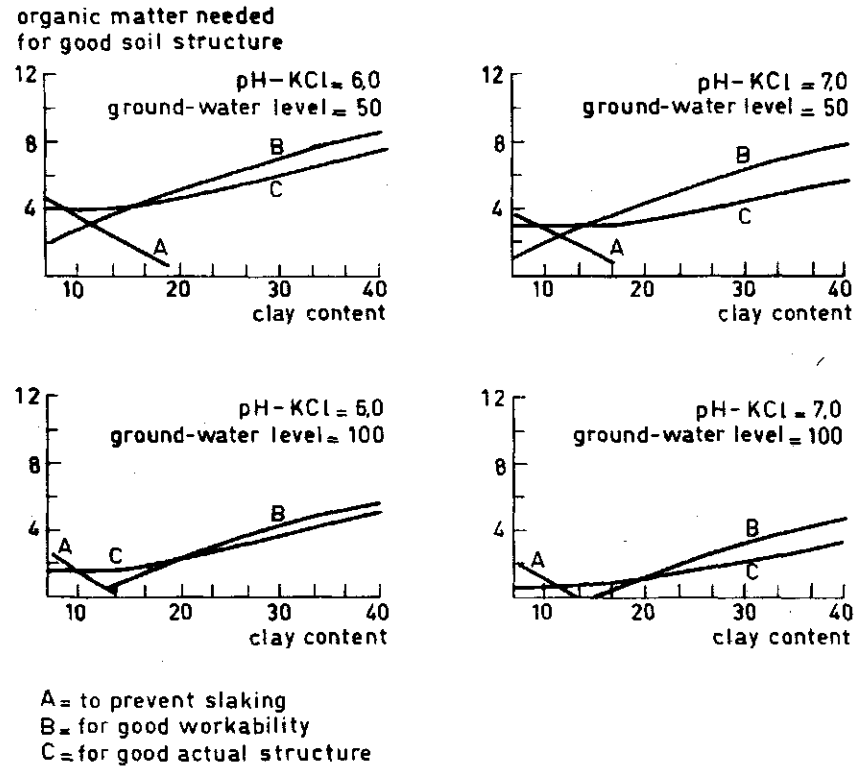

Fig. 6 : Required organic-matter content for soils differing in % of particles < 16 µm, drainage conditions, and lime condition