

## SOIL STRUCTURE PROBLEMS IN TULIP CULTURE

P. Boekel  
Institute for Soil Fertility,  
Haren, Groningen, The Netherlands

### Abstract

The production of tulip bulbs is more difficult on silt and clayey soils than on sandy soils, due to the less favourable physical properties of the former. Many silt soils are liable to slaking and puddling, which makes them denser in rainy winters. Under these conditions, many bulbs die off in the winter or growth is retarded in the spring and summer. In addition, the mechanical planting and harvesting sometimes gives difficulties on clayey soils.

The physical properties of these soils were found to be closely related to soil texture, lime status, organic-matter percentage, and drainage. For successful cultivation, these properties must satisfy certain criteria, the most important of which are: (a) the ground-water level in the autumn and winter should be more than 1 m below the soil surface; (b) the organic-matter content should be at least 2 per cent in soils containing 15 to 20 per cent clay, some lime, and some medium-coarse sand. On soils with a higher clay content, a poor lime status, or fine sand, the organic-matter content must be higher.

The physical properties of soil are also affected by tillage. It was found that heavy clay soils must be tilled in early autumn and in such a way that a rather fine seed bed is obtained, whereas silt soil must be tilled as late as possible in order to obtain a rather coarse seed bed.

### Introduction

Over the last 10 to 15 years tulip growing has undergone a marked expansion, which has led to a gradual spread from the dune-sand regions to places with silt or clay soils. However, this spread is not without its problems. Especially after rainy winters, many fields with a slightly silty soil may show considerable slaking and poor emergence (figure 1), and in many other cases emergence is satisfactory but the yield leaves much to be desired. Mechanical planting and lifting present difficulties, especially in regions with a clay soil. For reliable exploitation, these soils obviously must meet definite requirements with regard to structure, requirements which are less critical in sandy soils.

### Essential properties of soil structure

The essential properties are connected with: tilling of the soil and planting of the bulbs; the actual soil structure, which is important for emergence and growth; and mechanical lifting of the bulbs.

Planting has to be carried out in the autumn, usually in October, which means in a period when weather conditions are generally less favourable. Tilling can usually be done in the summer under better circumstances, and usually gives no problems. During the autumn planting the ground is driven on or trodden on, and the bulbs have to be brought into the soil,

but under wet conditions a heavy soil tends to be too sticky. This should be prevented in any case, so soil moisture should be lower than the so-called workability limit (i. e. the lower plastic limit = the moisture content at which the soil still can be crumbled without deformation or smearing). This workability limit can be determined in the laboratory (Boekel, 1959; 1968). Clay and silt soils with a moisture content persistently exceeding this limit in the autumn are consequently less suitable for the cultivation of tulips (figure 2).

To ensure good emergence and growth of the tulips, the actual structure (= spatial arrangement of the soil particles) must meet certain criteria. The metabolism of bulb and roots means that oxygen is consumed and carbon dioxide produced. An adequate exchange of gases with the atmosphere is only possible when a fair number of spaces or passages are present in the soil. The bulb is planted at a depth of 10 cm or more and forms its roots below that level down to a depth of 30 to 40 cm. Consequently, the oxygen will be consumed mainly in the 10 to 40 cm layer, but will have to be supplied through the layer above that. Since the bulb itself also requires a considerable supply of oxygen, this means that the top layer of 10 to 12 cm should be fairly loose and have an air content of at least 12 volume per cent in the winter, and 20 volume per cent in the early summer (Boekel, 1965a; 1966).

It has been shown that for the soil under the bulb a lower air percentage is admissible, viz. 10 volume per cent in the winter and 14 volume per cent in the early summer (Van der Valk and Schooneveld, 1964).

The desired soil condition can usually be obtained by proper tilling but cannot always be maintained in the autumn and winter, either because the soil becomes more compact during planting operations or because slaking occurs. Slaking develops in particular when the moisture content of the soil lies above the slaking limit (= the upper plastic limit = the moisture content at which the soil begins to flow) (Boekel, 1965b). The upper plastic limit can also be determined in the laboratory. Soils having a moisture content in the autumn and winter lying above the upper plastic limit for a considerable length of time are not suitable for the cultivation of tulips.

Mechanical harvesting is only feasible if the soil is friable and clods do not tend to adhere to the bulbs. Under dry conditions the presence of hard clods may cause damage to the bulbs, and under wet conditions the soil cannot be crumbled either. The latter property can be roughly evaluated by determining the lower plastic limit and the moisture content at pF 2. When the moisture content is well over the lower plastic limit, the crumbling properties are unfavourable and the soil is less suitable for the cultivation of tulips, i. e. for mechanical lifting.

For the successful cultivation of tulips, the above requirements should be satisfied as much as possible. This raises the question of which soils do meet them, or if they do not, what measures can be taken to improve the soil. An answer can generally be given to this question, since we know which factors influence the properties just discussed and how great their influence is.

### The influence of certain factors on soil structure

The following factors influence soil structure: the granular composition of the soil, the lime content, the percentage of organic-matter or its supply and the drainage conditions.

Table 1 shows the degree to which these factors exert an influence. The actual structure was graded by visual estimation (on a scale of 1 to 10). For a comparable measure to express the workability, the quotient of the moisture content at the lower plastic limit and at pF 2.0 is also expressed on a scale from 1 to 10. Although comparison of the effect of the factors is difficult owing to the use of divergent units, it may be said that of the factors having relevance in practice, drainage is of the highest importance, followed by the lime status and the organic-matter content. The percentage of particles smaller than 16  $\mu\text{m}$  plays an important role, but this factor usually cannot be modified.

### Suitability of soils for tulip production

On the basis of these data, it is possible to determine which requirements silt and clay soils must satisfy to be suitable for the cultivation of tulips. Figure 3 shows these requirements with respect to the percentage of organic-matter at different percentages of particles smaller than 16  $\mu\text{m}$ , and under different drainage conditions and lime regimes. It is evident that the required organic-matter content is lowest for soil containing 20 to 30 per cent particles smaller than 16  $\mu\text{m}$  and having good drainage and a good lime status. This content must be higher in lighter soils to prevent slaking and also in heavier soils for good workability. The organic-matter content will also have to be higher when drainage is less favourable, but with water levels in the autumn and winter shallower than 50 to 60 cm it is of no avail.

If these requirements are met, the cultivation of tulips on silt and clay soils should be free of difficulty. If these requirements are not met, the culture of tulips can be expected to be less successful unless certain measures can be taken (improved drainage, liming, application of organic-matter). Another condition is that certain rules must be observed regarding tillage and the avoidance of soil compression caused by driving heavy machines over the ground.

### Rules regarding tillage and driving heavy machines over the ground

Experience has taught that the following points must be taken into account:

- a. Tillage and driving should be avoided when soil is very wet, because of smearing and compacting of the soil. The moisture content of the ploughed layer as a whole should be taken into account and not only the top few centimetres.
- b. Heavy clay soils must be tilled in the early autumn and in such a way that a rather fine seed bed is obtained. Silt soils, however, must be tilled as late as possible and a rather coarse seed bed must be created.
- c. Silt soils are often broken up too much by using rotavaters and shaking-harrows, which increases the chance of slaking.
- d. The soil of the planting-bed should obtain a rather loose structure as

deep as the bulbs are planted. Planting of bulbs in dense soil often gives difficulties.

In practice, problems associated with the cultivation of tulips on silt and clay soils can be prevented by proper selection of the fields, which must satisfy the requirements discussed here or be made suitable by the application of the necessary modifications.

#### References

- Boekel, P., 1959. Evaluation of the structure of clay soils by means of soil consistency. Meded. LandbHogeschl. Opzoekstns Gent 24:363-368.
- Boekel, P., 1965a. Teelt van tulpen op slempige percelen. Meded. Dir. Tuinb. 28:381-387.
- Boekel, P., 1965b. Karakterisering van de slempigheid van zavelgronden door bepaling van de consistentie. Landbouwk. Tijdschr., Wageningen 77:306-311.
- Boekel, P., 1966. De luchthuishouding van de grond in verband met de zuurstofvoorziening van de gewassen. Bodem 1966 (herfst/winter):2-9.
- Boekel, P., 1968. Betekenis van het vochtgehalte voor de structuur van de grond. Buffer 14:27-35.
- Valk, G. G. M. van der, en J. A. Schooneveld, 1964. Reactie van tulpen op grondwaterdiepte en profielopbouw. Meded. Dir. Tuinb. 27:631-639.

Table 1 - Influence of several factors on soil structure and workability.

Factor	Increase of factor	Modification of structure (estimated on a scale of 1 to 10)	
		actual soil structure	workability
Organic-matter content	1%	+0.25	+0.70
pH - KCL	1 point	+0.50	+0.50
Particles < 16 $\mu$ m	10%	-0.40	-1.00
Ground-water level	0→50 cm	+0.75	+1.80
Ground-water level	50→100 cm	+0.25	+0.70



Figure 1 - Poor emergence of tulips as a result of serious slaking.

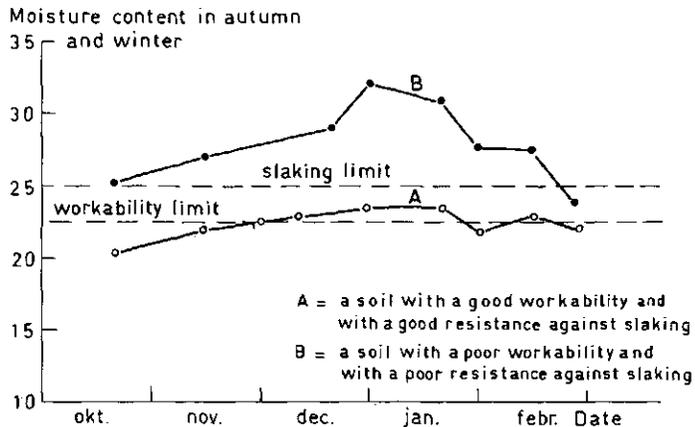


Figure 2 - The course of the moisture content in the autumn and winter in respect of the workability limit and the slaking limit.

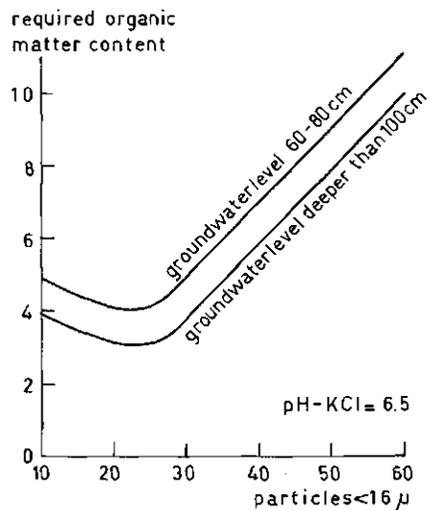
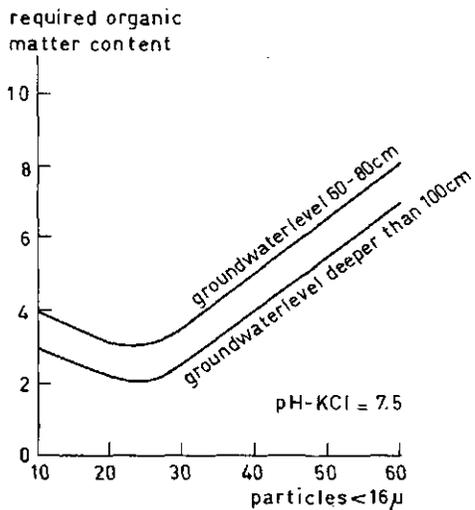


Figure 3 - Required organic-matter content for soils differing in percentage of particles <16  $\mu$ , drainage conditions, and lime status.