OVERDRUK UIT MEDEDELINGEN VAN DE LANDBOUWHOGESCHOOL EN DE OPZOEKINGSSTATIONS VAN DE STAAT TE GENT. 1959. DEEL XXIV. N° 1
„INTERNATIONAL SYMPOSIUM ON SOIL STRUCTURE, GHENT, MAY 28-31, 1958."

SOME REMARKS ON THE INFLUENCE OF SOIL STRUCTURE ON PLANT GROWTH

P. Boekel

Instituut voor Bodemvruchtbaarheid, Groningen
Nederland

1. Introduction

In the course of several years, the effect of soil structure on plant growth has been studied by many scientists, but generally the results have not been uniform. Sometimes they have found a favourable influence of an improvement of soil structure on plant growth and yield, but in other cases, however, they found an unfavourable influence.

Some years ago a study of the relationship of soil structure to plant growth would have been difficult, for it was not possible to obtain different structures in an easy way without changing the other fertility factors of a given soil.

Plot experiments were carried out in which all the important factors were measured and the yield determined. Then, by means of a numerical or graphical and statistical method, the influences of all these factors, including soil structure, on plant growth or crop yield were calculated. This method however takes much time, is very expensive and usually gives only the result for one year and for one crop. It is clear that in this way a general view of the agricultural significance of soil structure is not obtained.

The possibilities were increased by the discovery of soil conditioners. Although these agents are of little significance to practical agriculture because of their expense, it is clear that they are able to improve the structure of clay soils greatly without changing other fertility factors.

2. The experimental field with the application of soil conditioners

We had in 1953 the opportunity to lay out a soil structure experimental field on which we could study among other things the influence of soil structure on plant growth. The soil was a sandy clay with a good structure except that during a heavy rain the soil surface was dispersed easily and formed afterwards a hard crust. This experimental field has been giving very interesting

results up until now. In the first year barley was cropped and although the differences in soil structure were not yet so very great, we obtained a significant greater yield on the fields with improved soil structure.

In the second year sugar beet were grown and the fourth year potatoes. In both years we obtained the lowest yield on the plots with the improved structure. However, half way through the growing season we found the greatest height of the potato-crop on the plots with the improved structure. This is shown in fig. 1.

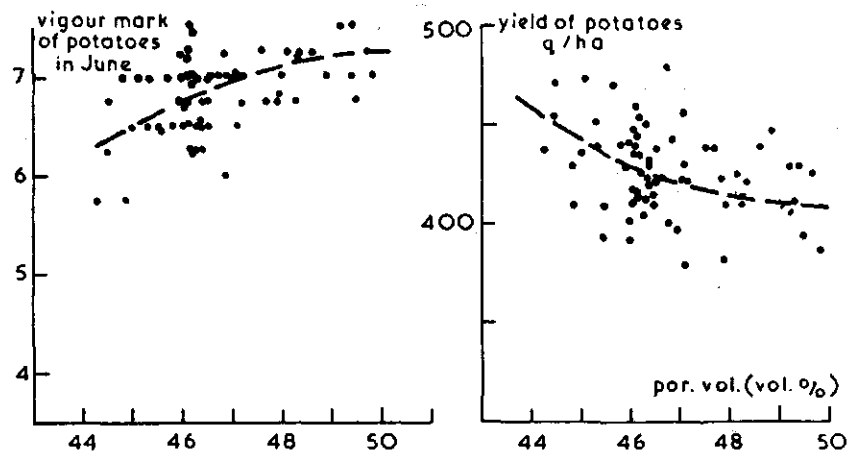

Fig. 1

Influence of soil structure on the growth of potatoes

Thus soil structure produced a favourable influence on the growth of the overground parts of the crop which particularly occurred during the first half of the growing season, and an unfavourable influence on the growth of the underground parts, which occurred later. It is unlikely that the air and water content played a part here as the moisture content and pF were approximately constant during the growing season. We think it may be possible that improvement of soil structure increases the availability of nitrogen and perhaps other nutrients. The plant can take up in a short time a lot of nitrogen and can show an early good growth. In the second half of the growing when principally the tubers are formed, nearly all the easily available nitrogen has been used up and the yield of the tubers do not justify expectations.

This course depends naturally on the weather (dry or wet) during the growing season and whether the crop has a long or short growing period.

In the third year (1955) peas were grown and the results with this crop were also interesting. Half way through the growing season the height of the crop was greatest on the plots with

improved soil structure, where the yields, however, were not highest (fig. 2).

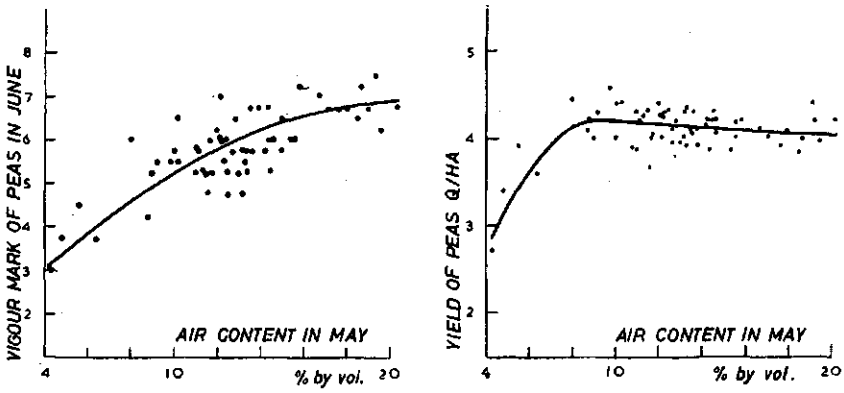

Fig. 2
Influence of soil structure on growth of peas

This must have been caused in some other way than in the second and fourth year for the sugar beet and the potatoes, as peas do not require nitrogen. During the first half of the growing season the conditions were rather wet and the moisture content of the soil was always equal to that at field capacity. Under these circumstances on the plots with poor soil structures the air content (less than 15 % by volume) was too low to give a good growth. On the good structured plots however the air content (about 20 % by volume) was sufficient.

During the second half of the growing season, the weather was very dry and the soil dried until the wilting point was reached. It is clear that now the moisture content was the limiting factor and not the air content. It is probable that the water content was highest on the plots with a poor structure as the smaller crop used less water. Thus the growth in this period was the best on the plots with a poor soil structure.

Therefore on the plots with a good structure the good growth in the first period was nullified by the bad growth in the second one.

The conclusion is that on this sandy clay soil it is not advisable to loosen the soil too much, unless it is possible to control the nitrogen and water available to the plants in a better way.

3. The experimental field with the application of lime

Many years ago another experimental field was laid out on a heavy clay soil. Several dressings of lime were applied with the result that the pH increased and the soil structure was improved. In every year the highest yield was obtained on the limed plots as is shown in fig. 3.

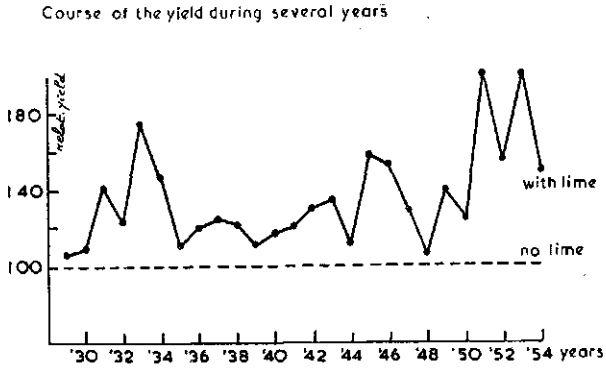

Fig. 3

Influence of liming on crop yield

At first it was impossible to find out which factor — pH or soil structure — was most important since there was close relationship between them. But with the aid of soil conditioners the influences of both factors could be separated and it was found that the soil structure was the most important one on this clay soil. This means that the results shown in fig. 3 are mainly due to soil structure. Therefore soil structure is a very important factor for plant growth on this heavy clay soil and it is believed that the air content plays an important part. On the unlimed plots the air content was very low (2-4 % by volume).

One year however (1956) forms an exception, which shows how carefully a conclusion must be drawn from the results of one year.

In 1956 peas were cropped and at first a favourable influence of liming was seen on the growth and on the height of the crop. On harvesting the crop however, we found an unfavourable influence of soil structure on the yield of the peas. This was caused by heavy rainfall in the late summer when the crop was struck down and decayed partly, causing most damage where the crop was best.

The conclusion here is that the improvement of soil structure on a heavy clay soil which is in a bad physical condition, will give almost every year an increased yield.

SAMENVATTING

Enkele opmerkingen betreffende de invloed van de bodemstructuur op de plantengroei

Gedurende verschillende jaren werd op twee proefvelden de invloed van de bodemstructuur op de plantengroei nagegaan.

Op het ene, een zandige kleigrond, werd de invloed van grondverbeteraars (soil conditioners) op bodemstructuur en plantengroei onderzocht, terwijl voor het tweede de aandacht ging naar de invloed van bekalking op een zware kleigrond.

Daar gedurende het onderzoek grote verschillen in structuur optraden, terwijl alle andere bodemeigenschappen constant bleven, konden wij de invloed van de bodemstructuur op de plantengroei nagaan.

In de zandige kleigrond scheen het resultaat af te hangen van de klimatologische omstandigheden en waarschijnlijk ook van de aard van het gewas.

Zo hebben we in vochtige omstandigheden een gunstige invloed van de structuur op de groei van erwten waargenomen, dit gedurende de eerste helft van de groeiperiode; maar de droge omstandigheden gedurende de tweede helft van de groeiperiode hebben later bijna gans deze gunstige invloed te niet gedaan.

Dit is uit te leggen door de verandering in water- en luchthuishouding.

Een ander jaar werd een ongunstige invloed van de structuur op de opbrengst van aardappelen waargenomen. De ontwikkeling van het bladergestel was nochtans het best op goede structuur. Dit resultaat kan uitgelegd worden door een betere beschikbaarheid van stikstof in de gronden met goede structuur t.o.v. die met slechte structuur.

Telkenjare werden op de percelen met zware kleigronden de beste opbrengsten bekomen op de gedeelten met goede structuur. Dit is te verklaren door een betere luchthuishouding.

RESUME

Quelques remarques concernant l'influence de la structure du sol sur la croissance des plantes

L'influence de la structure sur la croissance a été étudiée pendant plusieurs années sur deux champs d'expérimentation. Sur l'un d'eux, une terre sablo-argileuse, l'influence de stabilisateurs sur la structure et la végétation a été suivie de près. L'autre champ a été aménagé sur une terre argileuse lourde dans le but d'y étudier l'influence du chaulage.

Des différences importantes dans l'état de la structure ont été réalisées dans les deux cas, sans toutefois changer les autres conditions du sol. Ceci nous a permis d'étudier l'influence mentionnée dans le titre.

Sur la terre sablo-argileuse, le résultat semblait dépendre des conditions climatériques et probablement aussi du genre de culture. Ainsi, nous avons constaté, au cours de la première moitié de la croissance et dans des conditions humides, une influence favorable de la structure sur la croissance des pois, mais les conditions sèches de l'autre moitié de la période de croissance ont presque complètement annulé cette influence. Cet effet doit s'expliquer par un changement de l'économie en eau et en air.

Au cours d'une autre année nous avons trouvé une influence défavorable de la structure sur la récolte de pommes de terre, alors que le développement du feuillage était meilleur sur les terres à bonne structure, ce qui peut s'expliquer par les différences dans l'assimilation de l'azote sur les sols à bonne et à mauvaise structures.

Chaque année, les meilleures récoltes ont été obtenues sur les parties à bonne structure de la parcelle argileuse lourde. Ce fait s'explique par une meilleure économie en air.

ZUSAMMENFASSUNG

Einige Bemerkungen zu dem Einfluss der Bodenstruktur auf das Pflanzenwachstum

Während verschiedener Jahre wurde auf zwei Versuchsfeldern der Einfluss der Bodenstruktur auf das Pflanzenwachstum studiert. Auf einem Feld mit einem sandigen Tonboden wurde der Einfluss von Bodenverbesserungsmitteln, auf dem anderen Feld mit einem schweren Tonboden der Einfluss der Kalkung untersucht.

In beiden Fällen wurden wichtige Änderungen im Strukturzustand festgestellt; da aber die anderen Wachstumsfaktoren ungeändert blieben, wurde so eine günstige Gelegenheit zur Untersuchung des Einflusses der Bodenstruktur geschaffen. Im sandigen Tonboden scheint das Ergebnis durch die klimatischen Umstände und wahrscheinlich auch durch die Art der Frucht bedingt zu sein. So haben wir während der ersten Hälfte der Vegetationsperiode und unter feuchten Umstände einen günstigen Einfluss der Struktur auf das Wachstum von Erbsen feststellen können; dieser Effekt war durch die trockneren Umstände der zweiten Vegetationsphase praktisch völlig verschwunden. Dieser Einfluss muss durch die Unterschiede in dem Luft- und Wasserhaushalt zu erklären sein.

In einem anderen Jahr wurde ein ungünstiger Einfluss der Bodenstruktur auf die Kartoffelernte festgestellt, obwohl die Entwicklung des Laubes auf den Feldern mit guter Struktur besser war. Dieses kann durch die Unterschiede in der Stickstoffaufnahme auf guter und schlechter Struktur erklärt werden.

Auf dem schweren Tonboden wurden jedes Jahr die höchsten Erträge auf den Teilen mit guter Struktur erzielt, wass durch eine Verbesserung des Lufthaushaltes hervorgerufen wurde.