

GROWTH AND ROOT DEVELOPMENT OF SPRING WHEAT ON VARIOUS LOAM PROFILES UNDERLAIN BY SAND IN RELATION TO THE FERTILIZATION OF THE SUBSOIL

by

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INTRODUCTION

In preceding experiments with profiles having a clayey top-soil and a sandy subsoil it appeared that the root development of several crops suffered, when the roots in the clay reached the sand. In some cases there was hardly any penetration of the roots into the sand, whereas in other cases we found an abrupt decrease of the roots. From these experiments it was impossible to conclude the real cause of these phenomena. There were some indications that there might be some relation to the soil-water-air conditions in the various profiles, but there was no conclusive proof.

This induced us to carry out the following experiment.

Four concrete tanks were used with a diameter of about 180 cm and a height of 1 metre. These tanks were sunk into ground to a depth of 90 cm. In each of these tanks 18 concrete tubes were placed with an inner diameter of 30 cm and a height of 1 m, which were filled with various profiles. We employed 2 kinds of sand, having an U-value (1) of about 80 and about 40. Moreover differences were introduced into the thickness of the clay layer, the density, the amount of fertilizers and the pH of the underlying sand. The aim of the experiment was to study the influence of these factors on the root development. The soil water level was fixed at 90 cm below soil level. In order to maintain this water level, water was added several times during the experiment. The whole experiment was carried out with duplicates (fig. 1).

In this article we will only deal with the fertilization of the subsoil.

(1) The U-value is a measure for the coarseness of the soil =
surface of 100 grammes soil particles
surface of 100 grammes quartz balls, diameter 1 cm
The lower the figure, the coarser the sand.

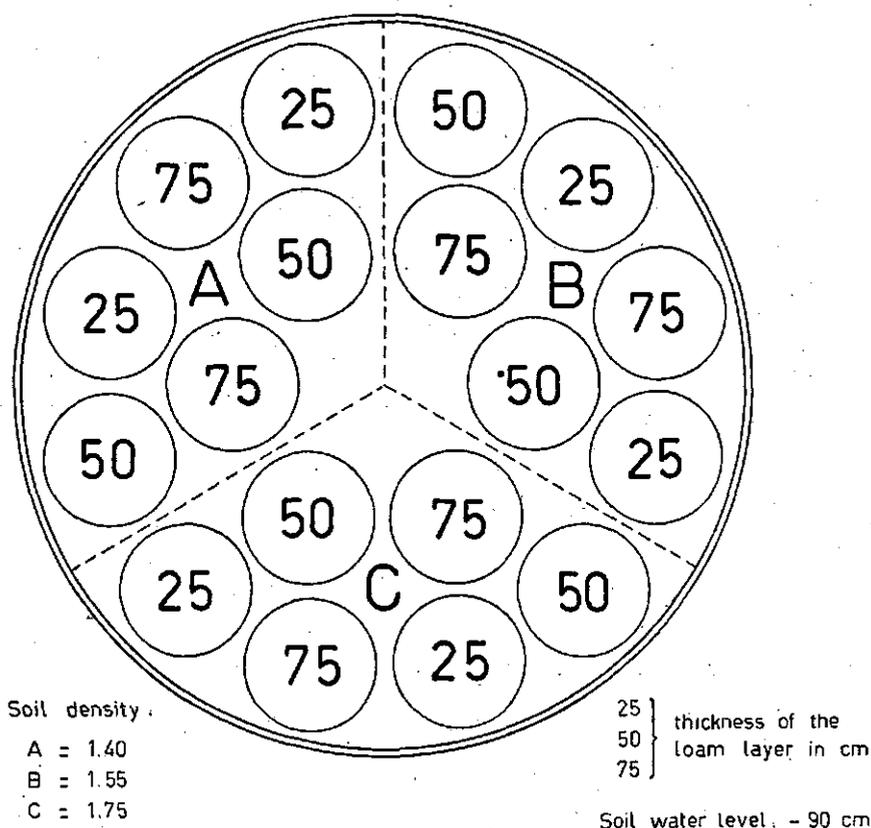


FIG. 1

Lay-out of one tank with concrete tubes.

FILLING OF THE TUBES

This was carried out between 15th and 22nd April 1955, when the tubes had already been placed in the tanks. The tubes in one of the tanks got a subsoil of unfertilized sand, those in the other tank sand which was mixed with:

- 0,1 g N (nitrate of ammonium) per kg moist soil,
- 0,1 " P_2O_5 (super phosphate) per kg moist soil,
- 0,15 " K_2O (sulphate of potassium) per kg moist soil.

The quantity of soil which was necessary was computed beforehand. This was especially important in view of the various densities of the sand. In most cases we succeeded in filling the tubes to the desired height with the determined quantities of soil evenly distributed. Only in a few cases was there a remainder of certain, though negligible, quantities of soil, or there was a shortage.

FERTILIZATION OF THE TOP SOIL

The loam had already been fertilized by the owner of the field from which we obtained it, with a mixture of 400 kg/ha NPK 0-15-30. Shortly before sowing we added some fertilizer, so that ultimately the following amounts were added to the various profiles:

	75 cm loam upon sand		50 cm loam upon sand		25 cm loam upon sand	
	kg/ha	gram per kg soil	kg/ha	gram per kg soil	kg/ha	gram per kg soil
	N	35	0,02	35	0,02	60
P ₂ O ₅	61	0,03	61	0,03	80	0,04
K ₂ O	120	0,06	120	0,06	120	0,06

GROWTH OF THE CROP

The crop chosen was spring wheat. This was sown between 26th and 27th April. The germination of the seed was poor, so that about 20th May a supplementary sowing was carried out with germinated seed. After this the growth was satisfactory. The crop flowered at about the same time as the crop on farms in our district.

During the growth period from 17th June to 26th August the crop was evaluated several times. It appeared that the growth showed differences even at an early stage. There were differences between the tubes as well as between the tanks as a unit. The crop in the tank with the fertilized subsoil showed a better growth and a darker green colour.

The crop was harvested in the beginning of September by cutting the stalks about 2 cm above soil level. There was a clear difference between the tanks. The whole tank with unfertilized subsoil was harvested on 1st September, that with fertilized subsoil on 5th September. This was due to differences in the ripening of the crop.

CONSUMPTION OF WATER DURING THE GROWTH

At the beginning of the experiment the soil water level was fixed at 90 cm below soil level. An excess of water caused by rainfall was automatically removed by a siphon. During periods without rain, water was regularly added to readjust the water level. The total amount of water supplied to the tank with fertilized subsoil amounted to 495 litres, to the tank with unfertilized subsoil 348 litres. Since both tanks received the same amount of rain, it may be concluded that the water consumption of the tank with fertilized subsoil exceeded that of the other by about 150 litres.

YIELD OF THE CROP

After harvesting, the number of ears per tube was counted. The data are summarized in figure 2.

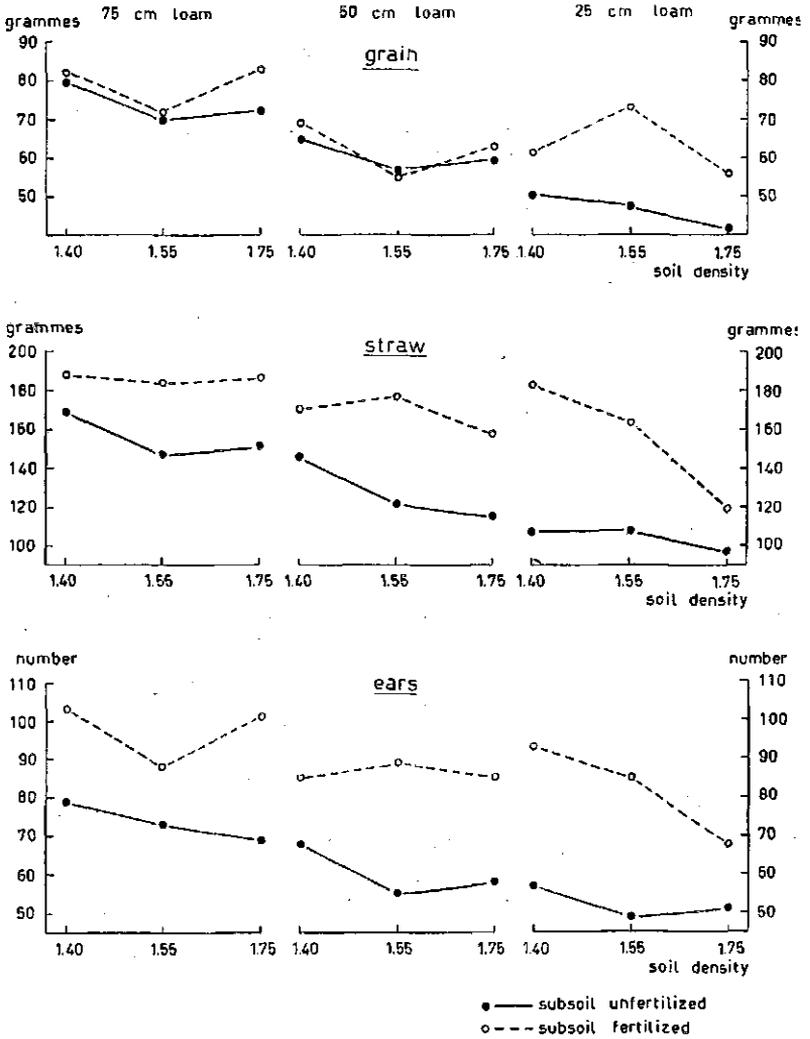


Fig. 2
Average yields per tube.

From figure 2 it is evident that the number of ears on the profiles with fertilized subsoil always exceeded that of the corresponding unfertilized profiles, independent of the density of the sand of the subsoil.

Completely in agreement with this it was found that the straw yields

on the fertilized profiles were always higher than those of the unfertilized ones.

It is remarkable that the differences in grain yield were less evident. It is true that 8 out of 9 profiles with fertilized subsoil yielded more than the analogous unfertilized ones, but these differences amounted only to a few percents. Only in case of the profiles with 25 cm loam the absolute differences were much greater.

It appears from the grain yield that the significance of the subsoil in profiles with 50 or 75 cm loam is much less than with 25 cm 100 m. This is plausible. The absolute numbers of ears and the straw yields were less evident in this respect, but the relative numbers of ears and straw yields were in agreement with the grain yields.

ROOT DEVELOPMENT

The root development was studied by means of sampling in July, during the growth period of the crop, immediately after the harvest and again after about 2 weeks. The sampling was carried out in layers. In this way 6 data were obtained per layer. From these data averages were computed per layer, which are summarized in figure 3.

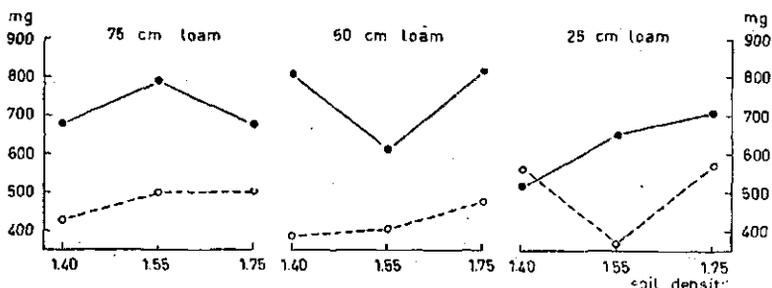


FIG. 3
Average root weights per profile.

This figure shows that the quantities of roots found in unfertilized profiles with 50 or 75 cm loam were always higher than in the analogous fertilized profiles. This was not influenced by the density of the sand in the subsoil. The profiles with 25 cm loam showed a different result. In these profiles the fertilized profile exceeded the unfertilized one, but the difference was only small and probably not significant. It is clear that in general more roots were formed with unfertilized subsoil compared with fertilized subsoil. It may be wondered in which part of the profiles these differences are to be found. This is demonstrated by figures 4 and 5, showing the root quantities found in the loam layers of 25, 50 or 75 cm and in the accessory sand layers of 75, 50 and 25 cm. These graphs show that the root development in the loam layer of all profiles decreased if the subsoil was fertilized. The differences were important in 8 out of 9 profiles. There was only a small difference between the profiles with a loam layer of 25 cm and a sand density of 1,40. It is remarkable that the root

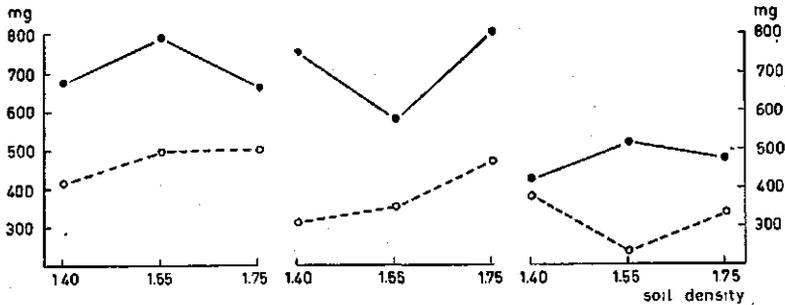


FIG. 4
Average root weights in the topsoil of loam.

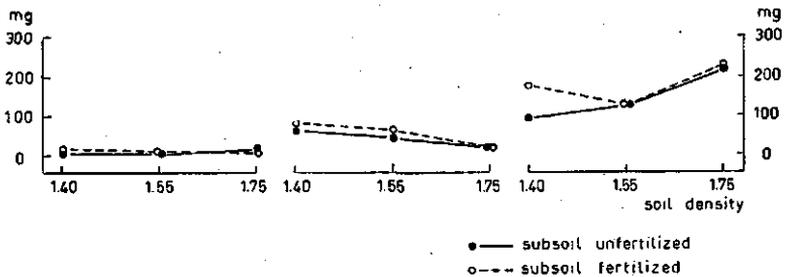


FIG. 5
Average root weights in the subsoil of sand.

development in the sandy subsoil of this profile had reacted positively to the fertilization of this sand. The same tendency, but to a lesser degree, was found with the profiles with 50 and 75 cm loam and the same density of 1,40.

It may be wondered how the differences found in the loam are distributed in this layer. This is shown by figure 6. From this graph it appears that the increase in quantity of roots in the unfertilized profiles compared with the fertilized ones, is found chiefly in the top layer of 30 cm and within this layer in the upper 10 cm. However, in the profiles with the lowest density of the subsoil the increase may be observed in the whole loam layer.

The profiles with 25 cm loam may be divided into two groups, in relation to the density of the subsoil. The profiles with densities of the sand of 1,55 and 1,75 are quite in accordance with the analogous profiles with 75 cm loam, since the difference between unfertilized and fertilized is chiefly found in the toplayer of 10 cm.

The profile with a density of the sand of 1,40 must be considered apart from the others. Contrary to the other profiles in this profile more roots were found in the top layer of 10 cm of the fertilized profile. On the other hand in the lower part of the loam layer more roots were formed in the unfertilized profile. As a result the total amount of roots in the whole loam layer was greatest in the unfertilized profile.

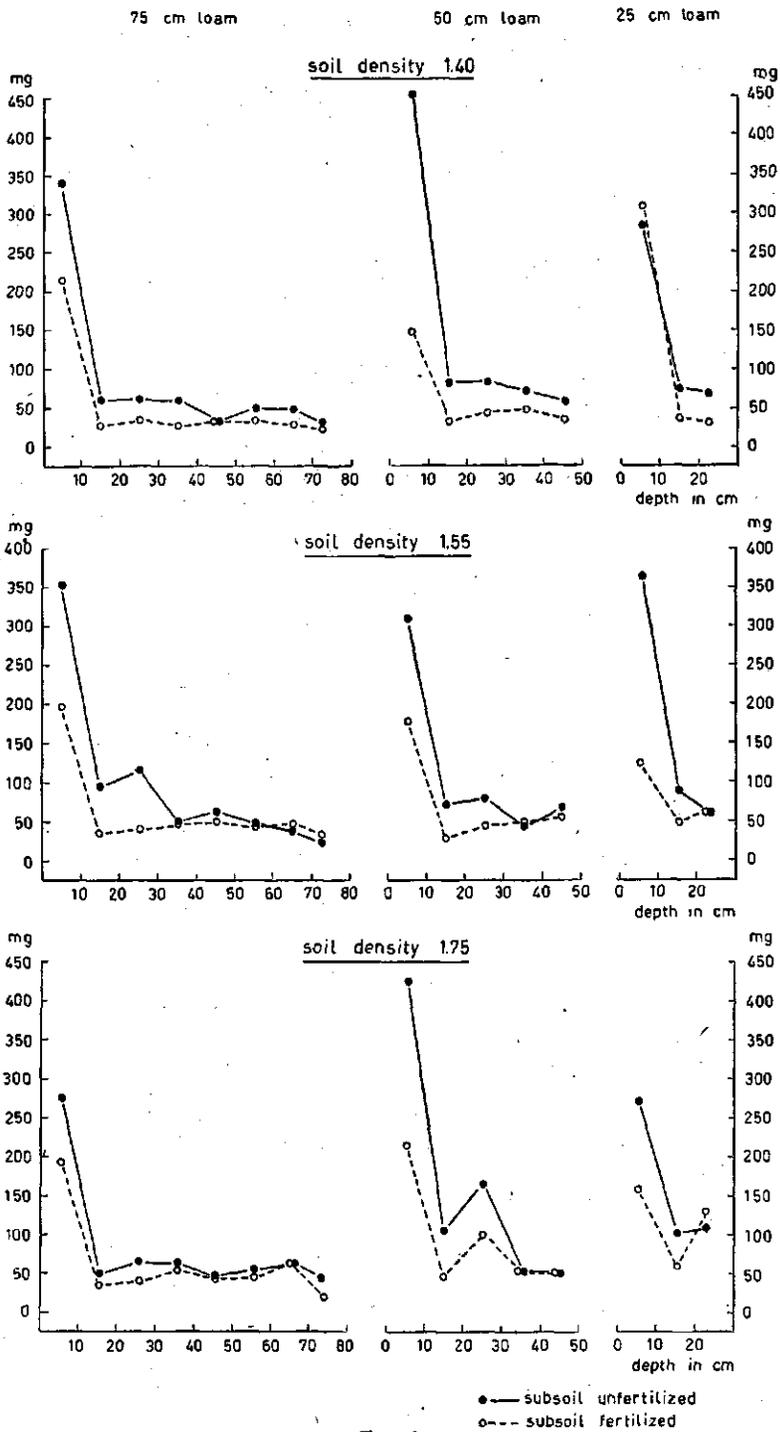


FIG. 6
Average root weights distributed in the topsoil of loam.

The differences, influenced by the fertilization of the subsoil were less evident in the sandy subsoil (fig. 7). At densities of 1,55 and 1,75 it may be concluded that there were no clear differences between fertilized and unfertilized profiles. When the sand had a density of 1,40 a tendency may be assumed for greater quantities of roots in the upper sand layer with fertilized sand. It is worth noting, however, that this tendency decreased with increasing thickness of the loam layer. Moreover, the actual amounts of roots in the sand, especially in the profiles with 50 and 75 cm loam, were very low.

The fact that the quantities of roots in profiles with fertilized subsoil were lower than those of unfertilized profiles, whereas the differences in the amounts of roots in the sandy subsoil was insignificant in most cases shows that the root development in the sand has increased relatively.

The influence of the fertilization of the subsoil at the maximum depth of rooting is shown by figure 7. It appears from this graph that there is a slight indication that the maximum root depth in the profiles with 25 cm loam has increased due to fertilization. In the profiles with thicker loam layers this was not shown.

ZUSAMMENFASSUNG

1. Es wurde der Einfluss der Düngung des sandigen Untergrundes bei Böden mit einer lehmigen Deckschicht auf sandigem Untergrunde auf die Bewurzelung und den Ertrag von Sommerweizen geprüft.

2. Der Versuch wurde ausgeführt mit Profilen in Beton-Röhren, die sich in grossen eingegrabenen Beton-Zisternen befanden. Der Grundwasserstand wurde auf 90 cm unter der Bodenoberfläche fixiert (Fig. 1).

3. Es wurde eine Zunahme der Erträge von Körnern und Stroh und der Anzahl der Aehren per Rohr unter dem Einfluss der Düngung festgestellt. Diese Zunahme war am grössten bei den Profilen mit 25 cm Lehm (Fig. 2). Die Uebereinstimmung zwischen den Erträgen an Korn einerseits und denen an Stroh und der Anzahl der Aehren andererseits war nicht vollständig. Es ist wahrscheinlich, dass dies verursacht worden ist von der ungleichen Reifung der Körner, vornehmlich in den Röhren mit gedüngtem Untergrund.

4. Die Wurzelmenge war, mit bloss einer Ausnahme, in den ungedüngten Profilen stets grösser als in den Gedüngten. Dies wurde verursacht durch ein grösseres Wachstum der Wurzeln in der Lehmschicht (Fig. 3, 4, 5). Dieses Resultat bedeutet also, dass höhere Erträge erzielt wurden mit geringeren Wurzelmengen.

5. Die grössere Wurzelmenge im Lehm der ungedüngten Profile wurde vornehmlich in der obersten Schicht von 10 cm und in geringerem Masse auch noch bis zur Tiefe von 30 cm festgestellt (Fig. 6).

6. In den gedüngten Profilen war die relative Wurzelmenge im Untergrundsand grösser als in den ungedüngten.

7. Die maximale Wurzeltiefe hat wahrscheinlich unter dem Einfluss der Untergründdüngung nur in den Profilen mit 25 cm Lehm zugenommen.

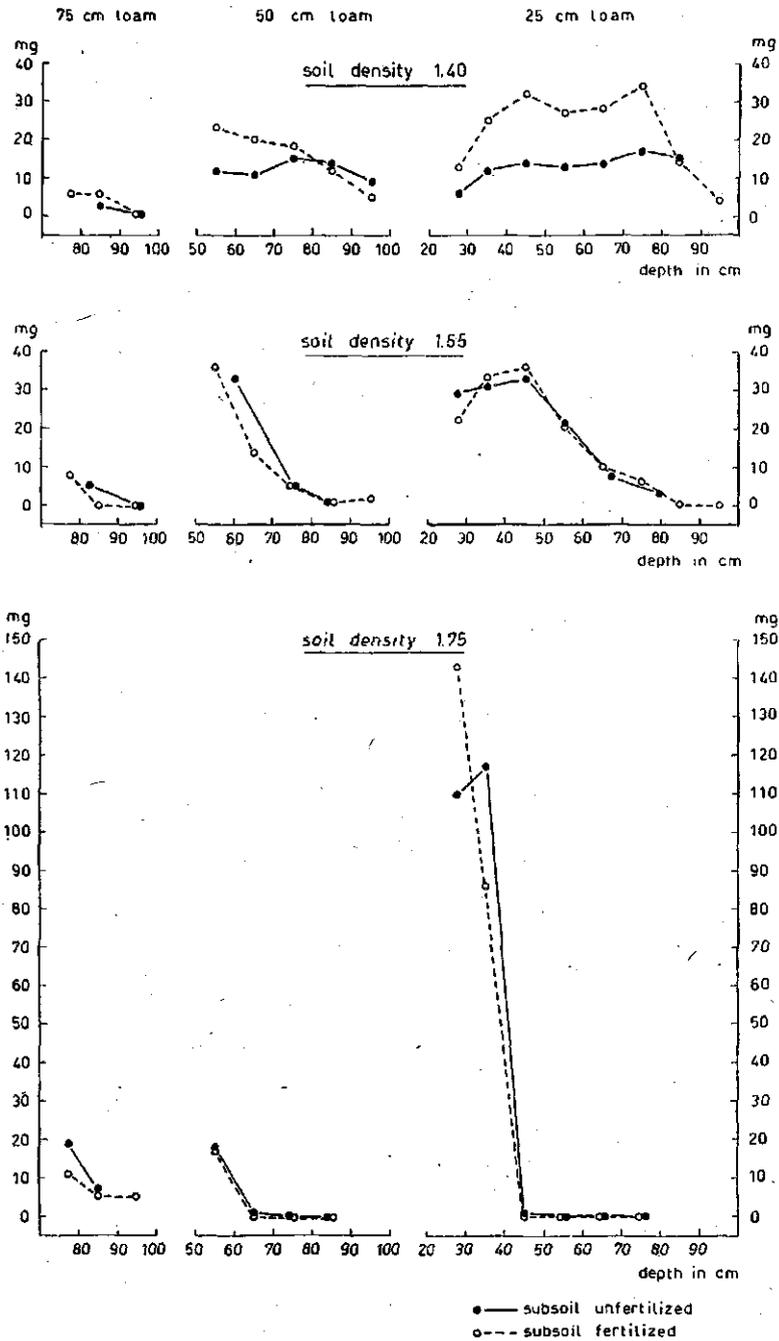


FIG. 7
Average root weights distributed in the subsoil of sand.

8. Nur in den Profilen, worin der Sand eine Packung hatte von 1,40 verursachte die Untergründdüngung eine Zunahme der Wurzeln im Sande (Fig. 7).

RÉSUMÉ

1. Une étude a été faite de l'effet de la fertilisation du sous-sol sablonneux de différents profils ayant une couche arable limoneuse, sur le développement des racines et le rendement d'une culture de froment de printemps.

2. L'expérience a été conduite avec des profils dans les tubes en béton et placés dans un silo de béton enfoncé dans le sol. Le niveau phréatique fut maintenu à 90 cm sous la surface du sol (fig. 1).

3. La fertilisation du sous-sol a provoqué un accroissement des rendements en graines et paille ainsi que du nombre des épis par tube. Cet accroissement fut le plus important sur les profils avec une couche arable de limons de 25 cm d'épaisseur (fig. 2). Il n'y eût pas une concordance complète entre les rendements en graines et ceux en paille ou le nombre d'épis. Il est probable que ceci a été déterminé par le fait que les graines sur les profils fertilisées ne sont pas arrivées à maturité complète.

4. Sauf une exception la quantité totale de racines était la plus élevée sur les profils non fertilisées. Ceci a été causée par une augmentation du système racinaire dans les couches limoneuses (fig. 3, 4, 5). Des rendements supérieurs furent donc obtenus avec un système racinaire moins développé.

5. La quantité de racines la plus élevée dans les couches limoneuses des profils non fertilisées, se localisa dans les premiers 10 cm et à un degré moins prononcé jusqu'à une profondeur de 30 cm (fig. 6).

6. Dans les profils fertilisées la quantité relative de racines dans le sous-sol était plus élevée que dans les profils non fertilisés.

7. La profondeur d'accroissement des racines maximum n'a probablement augmenté que sur les profils avec 25 cm de limons et un sous-sol fertilisé.

8. C'est seulement dans les profils, où le sable avait une densité de 1,40; que la fertilisation de ce sable a donné lieu à un accroissement de la quantité de racines dans ce sable.

