THE INFLUENCE ON SOIL STRUCTURE OF THE "NATURAL ORGANIC MANURING" BY ROOTS AND STUBBLES OF CROPS

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About fifteen years ago most soil scientists were of opinion that the humus, the final organic residue of the decaying organic matter in the soil, is due to the principal binding force between the particles of a sandy soil. Of late years the work of GEL'TSER (2), BROWNING and MILAM (1), Mc HENRY and RUSSELL (8), Mc CALLA (7), MARTIN (5, 6), GEOGHEGAN and BRIAN (3) and others shows that certain polysaccharides, formed during the transformation of organic matter in the soil by microbiological activity, as well as the bacteria and fungi themselves play an important part in the formation of soil structure as cementing substances. These substances, however, are not stable, but undergo a further transformation by microbiological influences. In this way there is after adding fresh or partly decayed organic material to the soil a building up and at the same time a decomposition of the cementing substances. It is plausible that these substances cement the particles of light soils and thus strengthen the weak binding forces in these soils. On the other hand the cementing substances can form a separating layer between the particles of a clay soil (4) and in this way replace the strong clay-clay binding force by the weaker cohesion of the substances mentioned. Now it will be plausible that by the increase and decrease of the cementing substances after manuring with organic material the soil structure will first ameliorate and then get poorer as is described by several authors (6, 7, 8) and is shown in a diagram (fig. 1). After a certain time OG, dependent on the quantity of organic manure and its stage of decay, the structure will be back (in E) on the same level as before manuring. In the next space of time (after G) the organic matter that is left in the soil and can hardly be attacked, will be decomposed very slowly and owing to this there is some deterioration of soil structure (EF, nearly parallel to AC).

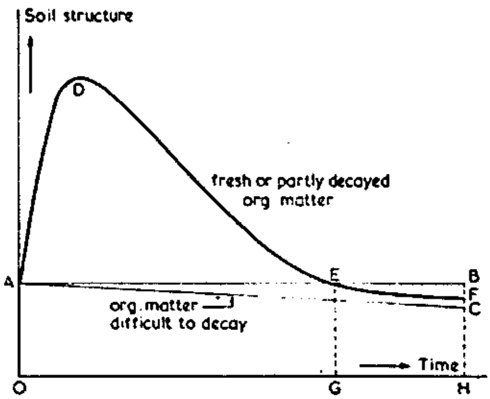

Fig. 1. Diagram of soil structure in course of time after manuring (at time O) with fresh or partly decayed organic material.

By repeating the manuring before the structure has arrived at state E it must be possible to keep the soil structure on a higher level. The fact that there must be a possibility to ameliorate soil structure without the necessity to increase the humus percentage, a favourable circumstance for practical agriculture, is illustrated by fig. 2 in a statistical way. The great vertical variation in the diagram shows the possibility of a whole range of different structures at each humus percentage. As is shown by the drawn lines in fig. 2, indicating the lower limit of this range in relation to the humus percentage, obviously the poorest structure which is possible at a certain humus percentage is better according as this humus percentage is greater.

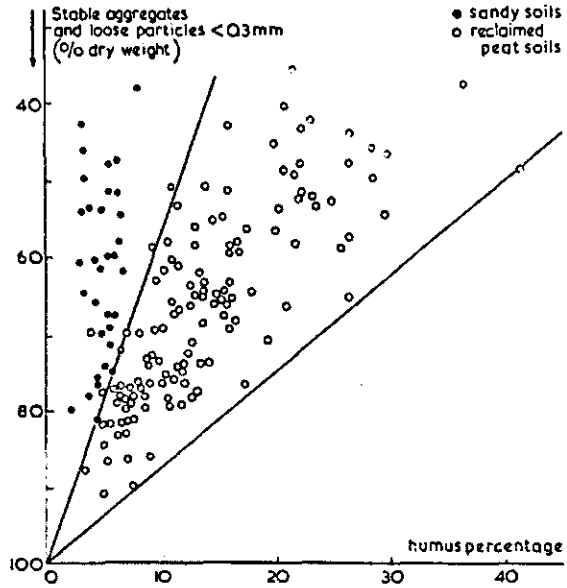

Fig. 2. Soil structure (the smaller the quantity of stable aggregates and loose particles in the fraction < 0.3 mm, obtained by a wet-sieving analysis (9), the better the structure) plotted against humus percentage of 37 parcels with a sandy soil and 133 parcels with a reclaimed peat soil in the neighbourhood of Groningen. Arable land. Layer: 0—15 cm. An excellent soil structure must have a fraction < 0.3 mm of about 25 %.

It is worthy of note that the line of the sandy soils is the highest. This means that the humus of the sandy soils is a better cementing substance than that of the reclaimed peat soils. A diagram of the same kind as fig. 2 was obtained from the wetsieving analysis of a great number of clay soils.

As is shown by fig. 1 it is necessary for raising the structure level as well as for stabilizing a level that an organic manuring is repeated periodically. A natural form of such a manuring is given by the roots and stubbles, remaining on arable land after harvest and by the roots and other parts of plants dying during the period of growth of the crops on grassland as well as on arable land. Since the initial state of decay of all organic matter brought into the soil in this way is nearly the same, the influence on soil structure is in the main dependent on the quantity of the organic material and on the frequency with which it comes into the soil. On arable land this frequency is about once a year. If the "natural organic manuring" is not sufficient to make the time OG (fig. 1) as long as or longer than a year the structure level will sink. Therefore it is to be expected that all factors influencing the quantity of roots will affect soil structure. Some examples will justify these ideas.

The quantity of "natural organic manure" left in the soil by potatoes and beets is much smaller (something like a tenth) as the mass of roots and stubbles of cereals. Therefore a rotation with a great frequency of potatoes and beets has an unfavourable influence on soil structure, as is shown by fig.'s 3 and 4. Rotations with — never —, — every two years —,

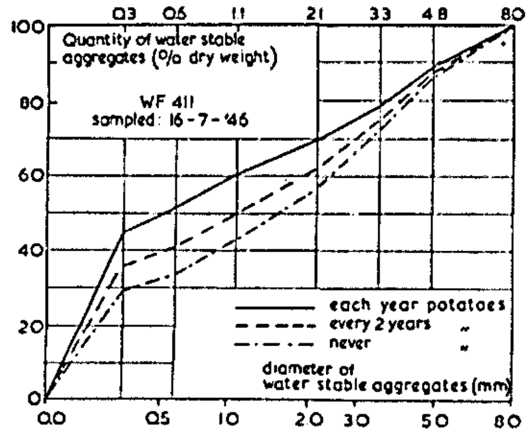

Fig. 3. Influence on soil structure of the frequency of potatoes in a rotation on a sandy clay soil. Cumulative diagrams.

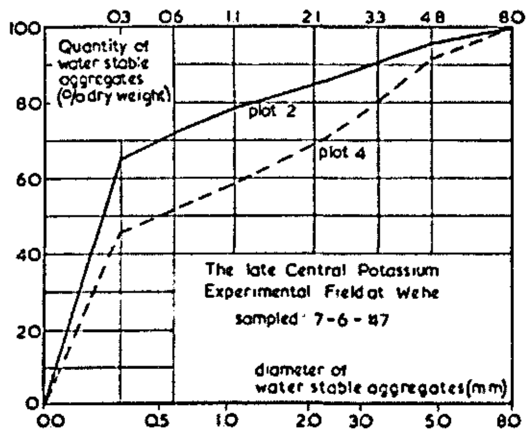

Fig. 4. Influence of two rotations with different frequencies of potatoes and beets on the structure of a sandy clay soil. Rotation during the years 1942—'47 on plot 4 clover, seed beets, wheat, beans, barley, wheat, respectively, and on plot 2 wheat, sugar beets, canary grass, seed beets, potatoes, wheat, respectively. Cumulative diagrams.

and — each year — potatoes give on one and the same parcel of a sandy clay soil fractions of stable aggregates and loose particles < 0.3 mm (obtained by a wet-sieving analysis (9)) of respectively 29, 36 and 45 % (fig. 3). This means: the more frequently potatoes are grown, the poorer the soil structure. On an other sandy clay soil a rotation with once in six years beets (fig. 4, plot 4) gives a much better soil structure than a rotation with three times beets or potatoes in the same period (fig. 4, plot 2).

The depth of the water table, too, may influence the soil structure in the upper 15 or 20 cm. This is shown by table 1 in the case of an experimental field on a heavy clay soil. Plots with different ground-water levels are made on this field side by side. In table 1 the structure is reflected by the values of the fraction 3.3—8.0 mm of stable aggregates.

TABLE 1. Fraction 3.3—8.0 mm of stable aggregates (% dry weight; wet-sieving analysis) in the layer 0—15 cm of a heavy clay soil at different ground-water levels (Pr 657)

ground-water level (cm below surface)	40	60	90	120	150
sampling in May 1947	52	38	29	32	34
sampling in Dec. '47 and '48 (mean)	28	20	24	23	26

The greater this fraction, the poorer the structure. It appears from the table that the best structure is obtained with a water-table at 60 to 90 cm below surface and that at higher and lower ground-water levels the structure deteriorates. In general this change in soil structure runs parallel with the changes in the quantity of roots in the layer under examination. It seems, however, that with a water table at 40 cm below surface unfavourable circumstances for the decay of organic material in the soil play a part in the formation of the poor structure.

Besides those mentioned we found influences on soil structure of some parasitical plant diseases, of the acidity of the soil and of manuring with fertilizers on poor soils, examples of which cannot be given within the extent of this paper. It will be evident, however, that in general all factors affecting the growing of crops and especially the development of the root-system will influence the soil structure sooner or later. This hinders the study of the importance of structure for soil fertility, for it is difficult to separate the influence of structure on the crop from the influence of the crop on soil structure. On the other hand it shows, since structure will certainly have an influence on crops and it therefore acts like a kind of amplifier for changes in fertility, that it is important to make all other factors of fertility as favourable as possible.

Finally it is worth mentioning that from a combination and an extrapolation of results obtained by Mc CALLA (7) and by MARTIN and CRAGGS (6) it appears that in the Netherlands the quantity of roots and stubbles of cereals is sufficient to keep up a structure level, but that potato and beet-crops need a supplementary organic manuring. We are at present testing this quantitatively.

SUMMARY

It is pointed out that for stabilizing or raising the structure level on arable land a periodical organic manuring is necessary and that in the Netherlands the "natural organic manuring" by roots and stubbles of cereals fills this want to a high degree. In this way all factors affecting the development of the root-system (crop rotation, ground-water level, plant diseases, soil acidity, manuring with fertilizers) will influence soil structure. Some examples illustrate this.

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