

633:
632.8.03:

581.432: 634.417

II.4. ROOT PRODUCTION BY AGRICULTURAL CROPS ON
ARABLE LAND AND ON GRASSLAND AS A SOURCE OF
ORGANIC MATTER IN THE SOIL

M. A. J. GOEDEWAAGEN and J. J. SCHURMAN

Agricultural Exp. Station and Institute for Soil Research T.N.O.
GRONINGEN, Netherlands

It is a well-known fact that an application of organic matter to the soil may increase its fertility by improving the soil structure as has been shown by Dr P. K. PEERLKAMP in his paper in Vol. I of these *Transactions* (p. 50).

The most common sources of organic matter are farmyard manure, compost and a number of crop plants cultivated for green manuring. Besides, several other crops add considerable amounts of organic matter to the soil by means of the crop residues consisting of roots and stubbles. In judging the amount of organic manure a particular kind of soil needs, the quantity of organic matter supplied by roots and stubbles of crop plants must be taken into consideration.

In this paper some information is given of the technique used for the determination of the weight of roots and stubbles and of some data obtained in this way.

There is a great disparity, however, between the amounts of roots and stubbles, found by different investigators.

This variation is mainly due

- (a) to the kind of the crop and the environmental conditions (more especially the soil conditions) during the growth of the crop;
- (b) to the method of soil sampling and of separating the roots from the soil.

At the Agricultural Exp. Station at Groningen the root weights of a number of crops on arable land and on grassland were determined by sampling the soil to a great depth in layers of generally 4 inches and by separating the roots from the soil in the samples by means of a stream of water. Because of the great variation of the root mass in the same field special attention was paid to the method of sampling. In order to ensure reliable results the roots were cleaned carefully and adequate sieves were used for collecting the roots quantitatively. Then the roots were dried and weighed in an air-dry condition. To determine the maximum root production the greater part of the crops were sampled at harvest time. Cereals and some other crops showing a decrease of the root weight after reaching the flowering stage were sampled at an earlier time. Weed free fields were chosen for this purpose, as the removal of weed roots from the root samples takes much time. For the same reason no root weights were determined on soils, in which undecayed roots of former crops were present. On peaty soils the amount of roots could not be determined because of the impossibility of separating the roots from the undecayed organic substances by washing.

The greater part of our root studies was carried out on grassland, as in the literature only a small number of data on the root production of grass crops is available. As to the root weight of crops on arable land, however, our data are incomplete and insufficient for realizing the average root production of the principal crops.

For this reason we have completed the results of our investigations on arable land with corresponding data available in the literature since



1860. Most authors sampled only the surface soil and isolated the roots by washing away the soil and by collecting them on a sieve. In general, however, no further description of the technique applied has been given in their papers, so that the reliability of the results could not be ascertained.

Therefore the usefulness of the results, obtained by different authors, has been appreciated in another way. The weights of roots and stubbles of three graincrops in the surface layer, obtained by different authors since 1860, were plotted against the year, in which the root weight had been determined. From this graph, to which the more recent data of GERICKE (1943—46) and ours (1936—48) were added, it appeared

(1) that the weight of roots and stubbles showed on the whole a decreasing deviation from 1860 up to the present time, apparently as a result of a gradually improved technique during this period.

(2) the root and stubble production of any crop could be determined approximately by averaging the data over the whole period.

In this way the root production in the surface layer was calculated for a number of crops. Although these values must be considered as the result of a rough approximation, the following conclusions seemed to be plausible.

1. *Cereals* produce a rather high amount of roots and stubbles in the top soil. Wintercereals yield a higher amount than springcereals do, probably because of the longer growth period of the former. There seems to be a great difference in root yield between different grain crops. Of the cereals, sown in the spring, oats give as a rule the greatest amount of roots. Among the wintercereals rye seems to give the highest root yield. The average amount of roots and stubbles of the graincrops in the surface soil amounted to about 2,200 lb. per acre with a minimum of 1,400 lb. for spring barley and a maximum of 3,100 lb. per acre for rye.

2. of the dicotyledonous plants *colza* (*Brassica Napus*) and *caraway* gave a good root yield. The same applies for *perennial leguminous crops*, the root weight of which increases with increasing age of the plants. The root production of clovers, especially of lucerne (alfalfa), may exceed that of the cereals to a considerable extent. With lucerne an average weight of roots and stubbles of nearly 5,500 lb. per acre has been found.

3. On the other hand the *annual leguminous crops* and other *annual green-manuring* plants seem to have a much lower root yield, i.e. approximately an average of 800 lb. per acre. The same holds good for root and tuber crops, such as beets and potatoes, the average root weight of the latter being nearly $\frac{1}{7}$ of the mean amount of roots and stubbles, produced by the grain crops.

Although the major part (according to our determinations nearly 75 %) of the root system of arable crops is concentrated in the surface soil (0—8 inch), the deeper roots are important since they are the only means by which the amount of organic matter in the subsoil can be increased. Moreover, these roots (more especially those of deep rooting crops such as lucerne) may play a part in ameliorating the structure and the permeability of the subsoil. With eleven crops an average root weight of nearly 400 lb. per acre was found in the subsoil between one and four feet below the soil surface.

As to the root weight on *grassland* only few data are available in the literature. Therefore at the Agricultural Exp. Station at Groningen the root yield has been determined of a number of grass fields of different age both on sandy and on clayey soils.

In general on grassland much higher root yields were ascertained than have been found with crops on arable land. Of 15 fields of old grassland the average root weight was found to be about 6,500 lb. per acre to a depth of 8 inches, this amount being 87 % of the whole root mass. On other fields still higher yields (up to more than 10,000 lb. per acre) were obtained in the upper 8 inches of the soil. The amount of roots varies to a considerable extent from field to field and from year to year. On young grassland the amount of roots is also high though generally lower than on older land. Moreover, the root system on young grassland is less concentrated in the top soil.

In all seasons the root system on grassland consists of living roots and of dead roots, the latter of which have more or less seriously been damaged by soil bacteria. The total amount of roots, which increases in the early spring up to May, decreases after that month more or less gradually and reaches its minimum in the next winter. The rise of the root weight in the spring is due to the formation of new, adventitious roots, whereas later in the season the root formation decreases and is overcompensated by the decay of the dead roots, which have developed beforehand.

Obviously the annual root production on grassland cannot be determined by means of the root weight in such a simple way as it is possible with annual crops. From the values of the seasonal variation of the root weight on grassland, however, some evidence could be obtained, that the average amount of roots, produced by grass crops on mineral soils every year amounts to approximately 5,000 lb. per acre.

From data in the literature (more especially from those of GERICKE) and from our own experience it is apparent that the root production both on grassland and on arable land may to a certain extent be increased by improving the fertility of the soil. This means that application of artificial fertilizers may cause rather an increase than a decrease of the amount of organic matter in the soil.

The paper will be illustrated by the projection of tables and graphs during the lecture.

LITERATURE

- GERICKE, S. Die Bedeutung der Ernterückstände für den Humushaushalt des Bodens. *Bodenk. u. Pflanzenern.* **35** (80), 1945, 229 und **37** (82), 1946, 46.
- GOEDEWAAGEN, M. A. J. De methoden, die aan het Landbouwproefstation en Bodemkundig Instituut T.N.O. te Groningen bij het wortelonderzoek op bouw- en grasland in gebruik zijn. *Landb. proefstation Groningen* 1948.
- PEERLKAMP, P. K. The influence on soil structure of the „natural organic manuring“ by roots and stubbles. *Trans. Fourth Int. Congr. Soil Science, Volume I*, 50. *Amsterdam* 1950.