Soil Structure in Relation to Beet Growth

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A Problem in Plant Improvement

There was a time in the Netherlands when many people did not give much attention to the soil and soil problems other than from point of view of fertilization and plant rotation. They more or less considered the soil only as a medium from which the root takes water and nutrient substances. We have learned now that there are many other factors in the soil which influence plant growth. A number of these factors may be grouped together as "soil structure." A discussion of soil structure should include its influence on sugar beet growth and development, but at this time I will limit it to experiences with sugar beets which may be useful for consideration by breeders.

Our work of the last years has shown us that the development of the beet is influenced strongly by soil structure and that the roots of the sugar beet react to variations in soil structure which we do not see with the naked eye and which we cannot at present measure with our instruments.

There is, however, a tendency in certain quarters that I should like to mention as I consider it as being dangerous from an agricultural point of view. Some of our soil structure enthusiasts arc inclined to overrate the influence of soil structure and even go as far as to tell us that if soil structure were better there would be no plant diseases, no insect pests at all. If such theories were to prevail, along with the overexploited humus theory, the farmer would be inclined to neglect necessary agricultural and hygienic measures—a course that could only lead to serious disappointments.

Among the problems for the Dutch beet grower excessive tare, caused by sprangled or fangy roots, is a major one. Under our usual soil and climatic conditions during the harvest period loss of yield and excessive tare constitute limiting factors affecting efforts to mechanize the sugar beet harvest.

As our Institute has variety trials all over the beet districts of the Netherlands it is easily understood that we also turn our attention to the problem of forked, misshapen sugar beet roots. Striking differences in root size and shape were found for the same series of varieties when grown on different soil types as, on basis of our earlier observations, we expected would be the case.

But going more closely into details we found that on a field with good structure there was not much difference in root development between the varieties. Each conformed well to the shape characteristic for the variety and developed practically no side roots or fangs. On soil of poor structural condition, however, some varieties grew nicely shaped roots but others gave only stunted roots with many fangs.

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We first attributed these differences to the fact that in one case the breeder probably had paid more attention to the root shape than in the other case. As this factor was of general interest for our Dutch beetgrowers we discussed this problem with two of our most important Dutch sugar-beet breeders without coming to a conclusion as we found that each paid much attention to the shape of the root in his breeding work. Then we visited the breeding stations and found that one was located on a very fine soil (a young silt of maritime origin with a high percentage of $CaCO^3$ and sufficient organic matter) where the soil structure was excellent, whereas the other was located mainly on clay soil with a poor structure.

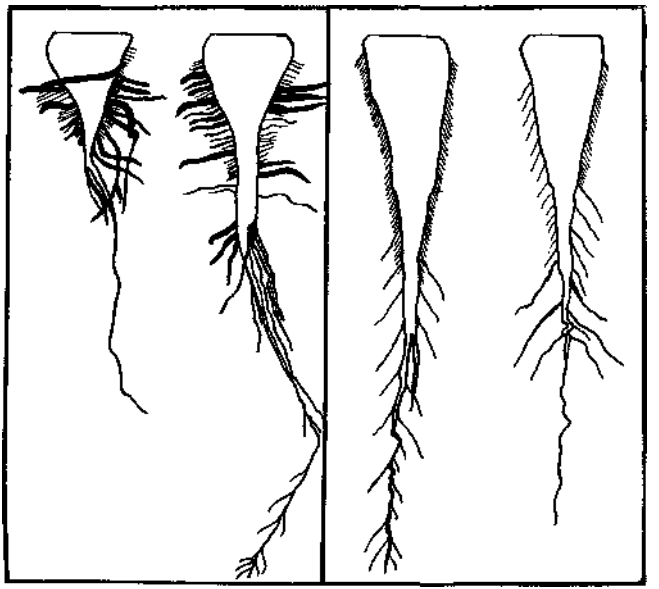

Figure 1. Two varieties of sugar beet as grown on a clay soil of poor structure (left half of this figure). Left: Seed from a breeding station located on soil of good structure. Right: Seed from a breeding station located on soil of poor structure. On soils of good structure both varieties react as at the right side of this drawing.

When we saw progenies of various mother beets tested on the soil with poor structure we came to the conclusion that here the plants were undergoing a very severe test with respect to root shape. On the other station, however, with its better soil the variation between progenies with regard to the development of fangy roots was only very small. When these beets were sown on a soil type with a poorer structure there was an unexpected development of sprangled roots. In contrast to this the beets from the station with poor soil structure developed good roots on practically every type of soil.

In the summer of 1949 we did more intensive work on the influence of soil structure on the shape of the root and on the growth of beets in general. We collected a great quantity of drawings and photographs and many interesting relations of soil structure to the development of beet roots could be discussed, but as most of these relations are agronomic rather than genetic I will only mention here that this work, which is still being continued, has fully corroborated our idea that the success of breeding for root shape is conditioned by the structure of the soil where the breeding work is done. Under the conditions prevailing in the Netherlands it will be necessary to test new strains and hybrids extensively on a soil with poor structure if disappointments with otherwise promising new varieties are to be avoided. Since fangy roots are a limiting factor preventing the Dutch farmer from making much advance in mechanizing his beet harvest this problem will continue to be of great importance.

There are also other points in which soil structure interferes with the work of the breeder. For instance, bolting under the climatic conditions of the Netherlands is mostly induced through a spell of cold weather during the period when the seed is germinating in the soil. Variations in soil structure have their influence on the bolting. Soils of poor structure retard germination and this prolonged period of sprouting tends to increase the period of exposure to cold. Readings of soil temperature at the depth where the seed is planted often show a few degrees centigrade difference between good and poor structure.

In many years we have practically no bolters, but in 1949 conditions were favorable for bolting and we saw striking differences in bolting not only between varieties but also in the distribution of bolters throughout a field. The same was seen in trial fields laid out by breeders to test their strains for resistance to bolting.

It is our idea that, because of soil heterogenecity, the exposure to cold in the field tests in our country is not sufficiently uniform for the breeders to make trustworthy selections for resistance to bolting based on their field trials.

We find also that there is much variation in emergence of seed of various varieties, even if the tests in the laboratory show the same vitality. Our work on this subject is not yet finished but we have indications that

even in the seedling stage there are important differences in plant reaction not only to temperature but also to soil structure. This point has interested us very much because rapidity of emergence and first growth have far reaching significance. Twenty-five years of research work have proved clearly that in the Netherlands at the end of June, i.e., eight to ten weeks after emergence, we are able to predict whether we will have an average, a low or a high root yield. Therefore, the rapidity of growth in the period till the end of June is more or less decisive for the final beet yield.

If we want to have varieties for early drilling on soils of proper structure which will emerge rapidly and give an early sturdy growth we will have to pay more attention to this part of the problem and include it in our breeding objectives.

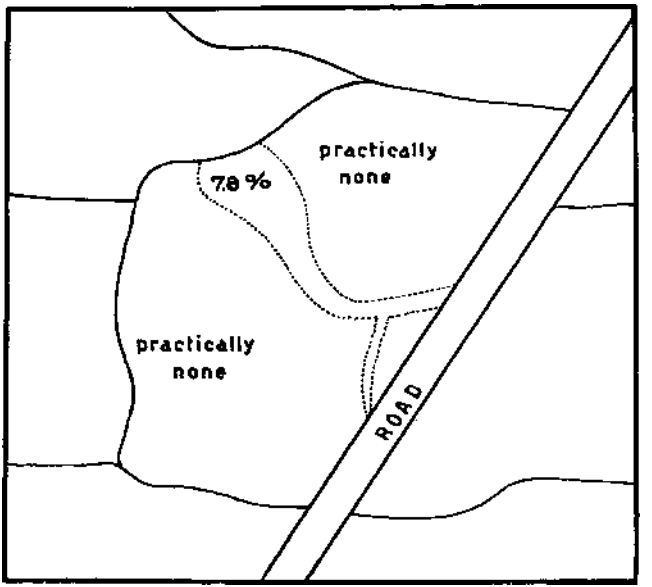

Figure 2. Diagram to illustrate influence of soil structure on bolting. The whole field was prepared and planted at the same date with the same variety. Between the dotted lines the soil was of poorer structure. Bolting here reached 7.8%, with practically none elsewhere in the field.

Summary

A number of factors in the soil influencing plant growth may be grouped together as "soil structure." In this paper the discussion has been restricted to information useful for sugar beet breeders.

1. Under the conditions prevailing in the Netherlands the success of breeding for rootshape is conditioned by the structure of the soil where the breeding work is done.

2. Field tests for bolting resistance under our conditions are not sufficiently trustworthy due to the influence of soil heterogenecity on bolting.

3. In breeding varieties for early drilling more attention will have to be paid to soil structure in relation to emergence and early growth.