EFFECT OF TRAFFIC INTENSITY ON SOIL STRUCTURE AND ROOT DEVELOPMENT IN A FIELD EXPERIMENT ON A SANDY CLAY LOAM SOIL IN THE NETHERLANDS

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Mr. Chairman, dear colleagues,

I would like to inform you about some results of cooperative research on a large-scale field experiment with different traffic intensities. In this experiment, during 1984-1989, the effects on soil structure and crop development of different field traffic systems were were compared.

The experimental field consisted of 4 blocks (A-D) of 100 x 212 m, each of which carried one crop of a typical four-year, intensive crop rotation, consisting of potatoes - winter wheat undersown with rye grass - sugar beet - onions. Each block was split into 4 plots of 50 x 100 m, on which around the year all field traffic was performed with normal "high"-pressure tyres (Treatment H) or with special "low"-pressure tyres (Treatment L). On each block, 2 narrow strips (6 x 100 m), positioned beteen the large plots, were allocated to the zero-traffic or bed system (Treatment Z). Soil tillage and all other cultural treatments were the same for all three field traffic systems.

The soil was a typical heterogeneous, calcareous sandy clay loam soil. In the topsoil of carefully selected sampling sites, $CaCO_3$ contents ranged from 3.4 to 9.0 % (w/w), organic matter contents from 1.6 to 2.6 % (w/w), and clay contents varied from 12.6 to 32.7 % (w/w). Roughly, light soils were found in the bottom left-hand corner of the field and heavy soils in the top right-hand corner. This, of course, complicated comparison between treatments considerably.

The working group which performed the research, investigated the causative chain:

traffic intensity -> soil structure -> root development -> crop yield ?

Before dealing with the actual data, it may be necessary to explain chain and the question mark.

The traditional concept that a better root development will directly contribute to a higher crop yield, has been rejected. We now view the root system as a mediator between the supply of water and nutrients on the one hand and crop growth on the other hand. In a bad soil structure, poor root development can be largely compensated for by increased chemical soil fertility and improved water supply. Therefore, it may be expected that soil compaction will affect nutrient use efficiency rather than crop yield.

The effect of traffic intensity on soil structure obviously depends on soil texture, soil water content, the tillage system used, and on biological activity in the soil. Relevant aspects of soil structure which may be influenced by traffic intensity are: soil bulk density, aggregate size, water retention and porosity. Aspects of the root system which may be modified by soil structure include: penetration of soil layers and depth of root development, root distribution pattern within each soil layer – as influenced by aggregate size and penetrability – , root-soil contact and root survival – as influenced by periods of aeration stress after heavy rainfall. In this lecture I will inform you only about some of these aspects.

Soil structure was characterized by total pore space, and the water and air contents at a matric water potential of –10 kPa. Only the results for the 12-17-cm depth will be shown, because this layer was tilled each year in all treatments and also because the strongest compaction ususally is found at this depth, i.e. in the middle of the tilled layer.

Average results show that pore space was similar for H and L treatments and clearly smaller than on the untrafficked Z treatment, especially on medium-textured and heavy soil.

Water content at –10 kPa was similar for L and Z treatments and slightly higher on the H treatment, which probably is related to a higher proportion of fine pores.

As a result, air content at –10 kPa was smaller on H plots than on L plots. On Z plots, much higher air contents were found than on H and L plots, especially on medium-textured and heavy soil.

Penetration resistance was measured only in the last year of the experiment, concurrent with the core sampling in early summer, with the Bush recording penetrometer. At 5 cm depth, penetration resistance on H and L plots was similar. However, at 15 and 25 cm depth, penetration resistance was clearly larger on H plots. At all three depths, penetration resistance was much smaller on Z plots than on H and L plots.

Of the four aspects of root development, only two were studied. Root maps were made by marking on a plastic sheet all root intersections observed on the vertical wall of a profile pit. The root maps were analysed for the root distribution pattern and the distribution of root length density with depth was determined.

From the pattern we determined the frequency distribution of distances from randomly chosen points on the map to the nearest-neighbour root. This frequency distribution differs for clustered, random and regular root distributions. Based on the actual distribution, inferences can be made on the uptake efficiency of the root system. Generally, in the Z treatment a tendency to a less clustered, more regular root distribution was found.

Root distribution with depth was similar for H and L treatments. In spring wheat and sugar beet, the zero-traffic system led to a higher root length density in the topsoil. For onions, root distribution in the topsoil was similar for all treatments. However, in the subsoil, a higher root length density was found on Z plots.

Conclusions

Pore space and air content at -10 kPa were higher on Z plots than on H and L plots, which had similar pore spaces and air contents. Water content at -10 kPa was similar for L and Z plots; on H plots higher water contents were found than L and z plots.

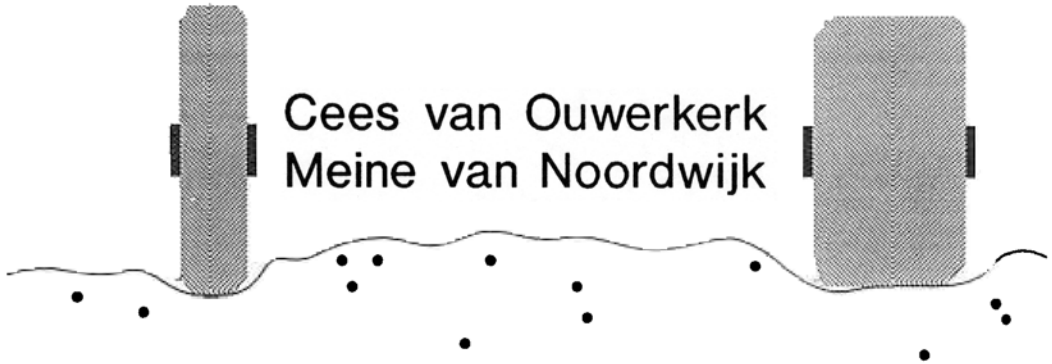
Penetration resistance was lowest on Z plots and highest on H plots

On L and H plots a similar, clustered root distribution was found On Z plots the root distribution was more regular.

In sugar beet, but especially in spring wheat, Z plots had more roots in the topsoil than H and L plots. In onions, Z plots had more roots in the subsoil than H and L plots.

Haren Gn, 27 June 1991

Effects of traffic intensity on soil structure and root development on a sandy clay loam soil



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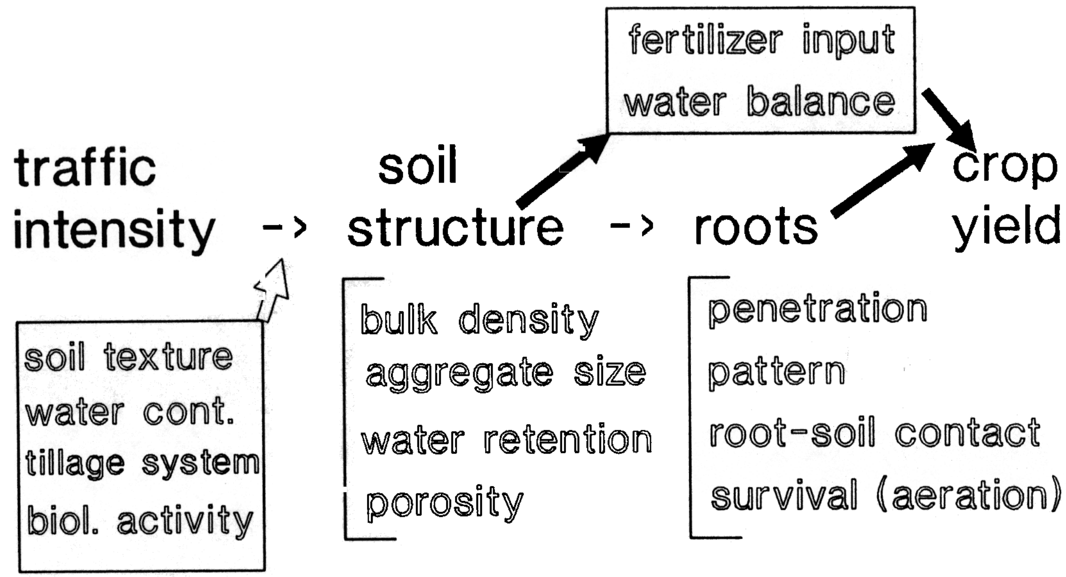
fertilizer input
water balance
traffic intensity
->
soil structure
->
roots
crop yield
soil texture
water cont.
tillage system
biol. activity
bulk density
aggregate size
water retention
porosity
penetration
pattern
root-soil contact
survival (aeration)

Pore space (%, v/v)

12-17 cm depth

Soil	H	L	Z
Light-medium	47.2	47.6	49.4
Medium	46.2		49.5
Heavy		49.4	52.4

Wate conten % w/w a 10 kPa
2 7 cm dep h

So..	H.	L	Z
Ligh medium	5 4	4.8	
Medium	7 4		6
Heavy		3 0	0

Air content (%, v/v) at -10 kPa
12-17 cm depth

Soil	H	L	Z
Light-medium	11.8	13.4	16.0
Medium	7.4	-	14.4
Heavy	-	6.8	11.8