Särtryck ur Grundförbättring 1966: 1

The Characterization of Soil Structure Changes Produced by Tillage Operations

By H. KUIPERS,[1] C. VAN OUWERKERK,[2] and G. J. POESSE[3]

1. Introduction

Tillage operations and crop yield are two variables of a so complicated nature, and the chain of causes and effects between them is composed of so many links, that it is not surprising that at least three quarters of a century tillage research revealed only a few relationships. Only where one dominant growth factor was consistently influenced by tillage practices, research was immediately successful.

Weather and soil conditions in the Netherlands are so variable that neither the result of tillage operations, nor the reaction of crops on soil structure are identical in different years. Therefore, at the new start of tillage research about ten years ago, it was decided to study the effect of tillage operations on soil structure and the relation between soil structure and crop yield separately.

This simple and logical division appeared to be very useful. It showed immediately that the more classical soil structure determinations might be more or less suited to investigate a relation with crop growth, but certainly not to characterize the technological effect of a tillage operation. Therefore, special soil structure determinations should be developed, which will have to relate three fields of interests: 1) the tillage operation; 2) the more classical soil structure determinations for the study of crop reactions; 3) aspects of soil structure that are related to crop and field management, e.g. avoiding clods in potato ridges in order to facilitate a fully mechanized harvest (Kuipers 1963).

2. Concept of Homogeneity

Although there are many different tillage operations, which may require different measuring techniques, it will generally be possible to

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[1] Tillage Laboratory, State Agric. Univ. Wageningen.
[2] Inst. of Soil Fertility, Groningen.
[3] Inst. of Agric. Eng. and Rationalization, Wageningen.

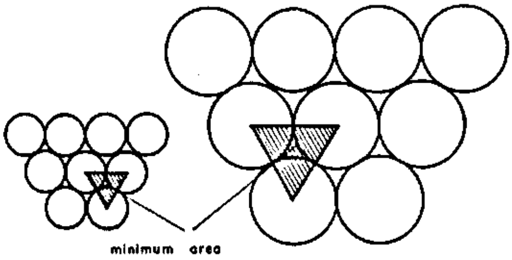

Fig. 1. Schematic drawing of minimum representative area for spherical aggregates of different size.

describe the technological effect of tillage operations as a change in bulk density, homogeneity and soil strength.

Especially the concept of homogeneity requires some further explanation. Its importance can be illustrated by the elucidating image Hawkins and Brown used in the conference on the objectives of soil tillage, held in the Netherlands in 1962: "Ploughing is like cleaning the blackboard": a field with deep ruts, mottled with muddy pools is transferred into the fascinating picture of parallel straight furrows of a mathematical order. Apparently a transfer from a heterogeneous to a homogeneous situation. However, the poor soil physicist who wants to make a routine pore space determination with his 100 ml cylinders, will be less enthousiastic. He is faced with the problem where to take his samples: in the furrows, on top or in the buried mud? Perhaps the easiest place is the best: he may sample only the big holes between the furrows and return home with his empty cylinders to think about the problem: how to measure pore space under these conditions. Certainly he will discover that the characterization of soil homogeneity is the real problem.

In theory the solution is not too difficult. We could simply define homogeneity as the smallest volume or area that is a good representative of the whole. That is, if we take core samples of increasing volume and plot the variability of replicates against the volume of these core samples, we'll certainly find that with increasing volume variability decreases, no matter which aspect of soil structure is involved.

It is interesting to note, that the application of this method to aggregate fractions shows immediately that aggregate size plays an important role in homogeneity (Fig. 1). The finer the aggregates, the smaller the minimum volume, that still gives e.g. the correct mean pore space; therefore, as the aggregates are finer soil structure will be called more homogeneous. In theory we might choose the volume at

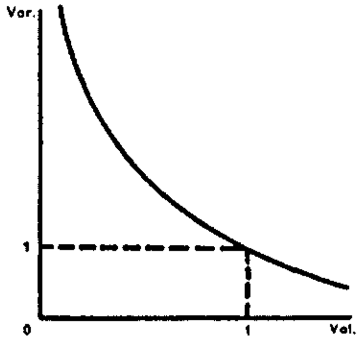

Fig. 2. Schematic drawing of relation between variability–sample volume.

which the variability becomes zero as a characteristic of homogeneity. Then it does not matter how we measure this variability. In practice however, this will be too difficult, because the curve in the sample-volume variability graph is not likely to cut the zero variability axis at a steep angle (Fig. 2). A less general but more practical possibility is to use the volume at which the variability has a certain fixed value. This will be easiest if the variable shows a normal distribution, which we can easily characterize by a standard deviation. Skew distributions can often be normalized by introducing a logarithm, which compresses the high value-side of our scale, or elongates the side of the low values. How strong this effect will be, depends on the absolute value of the variable, so we can regulate this effect by adding or substracting a constant. This means, however, that we'll have to introduce this constant as a new parameter for characterization and we should indeed consider whether this is necessary or not.

In a few cases we might find distributions with more than one peak. In theory it is possible to split them up into a set of single peaked distributions. In practice, however, it will be better to avoid this complication.

A more serious second difficulty in practice is, that our system of increasing volumes would make it necessary to use different sampling techniques for large and small volumes in many cases, and at any rate we would have to take far more samples than we can afford.

Therefore, we generally have to reduce our programme to one volume and to use the variability at this size as an indication of homogeneity. Unfortunately this is a less universal method, because the volume of the samples is a more or less arbitrarily chosen quantity.

The third and probably the most serious complication in practice is that samples should be taken not only at random, but also from one population. Therefore, we must know the spatial boundaries of the population. In a vertical direction these boundaries can often be found on visual examination as the soil normally shows a distinct pattern of different structured layers. It is self-evident that core samples of different layers should not be mixed up. This also holds for patterns in the horizontal plane, e.g. if there are a few ruts in a field, we cannot mix up samples from the ruts with samples from the undisturbed soil in between. If we increase the number of the ruts, we'll finally reach a situation, whereby it is practically impossible to describe the pattern. In that case we generally suppose to be allowed again to take our samples at random all over the field.

Whether a difference in soil structure should be attributed to a pattern or to a variability in a part of a pattern, depends on the size of the samples we are investigating. E.g. if we characterize clod distribution after ploughing a clod of a few liters may be included in the normal variability of clod sizes, but a soil micro-morphologist may distinguish a structural pattern in a small part of this clod and characterize the variability of a structural characteristic in each part of that pattern.

Of course the situation where we have to characterize the structural pattern before we can characterize each part of this pattern is the most complicated. Therefore we should always consider whether this is really necessary. It will be far more convenient, if we can do without description of the pattern. In practice we often restrict ourselves to the description of one or two parts of a structural pattern.

3. Characterization Methods in Use in the Netherlands

A. *Determinations at Ploughing*

a) Before ploughing the standard deviation of pore space is used as one of the characteristics of the initial structural conditions. From a sugar beet field in the North East Polder core samples of 200 ml were taken from a depth between 7 and 12 cm just before and just after harvest. The mean value of pore space was resp. 46.9 and 47.0 vol.%, however the standard deviation was resp. 1.3 and 2.2 vol.%. This decrease in homogeneity indicates that the soil was partly compacted by the traffic and partly loosened by pulling out the sugarbeets. So there was a marked change in soil structure, not indicated by the average pore space, but very clearly by the standard deviation, i.e. by the structural homogeneity.

b) Immediately after ploughing pore space of the soil can be calculated from pore space before ploughing and ploughing depth by measuring the increase in height of the soil surface. Comparable to the variability of pore space before ploughing the variation of the height of the soil surface is now used as an index (Kuipers 1957). Here we touch the problem whether it is necessary to describe the structural pattern made by the plough or not. This of course depends on the purpose of our determinations. If we want to study the different shapes of the furrow produced by different ploughs, the structural pattern will be most important, but if we just want to characterize the surface roughness of the field, because we suppose this may be important for the changes in soil structure during winter or for seedbed preparation, this necessity is not obvious.

As indicated, it is important whether the figures, characterizing the height of the surface have a normal distribution or not. In the Netherlands we normally use 400 height figures, measured in 20 groups scattered over the field, each group composed of 20 figures measured with 10 cm spacing on a straight line perpendicular to the direction of the furrows. These 400 figures generally show a normal distribution. Burwell *et al.* (1963) report skew distributions which had to be normalized by introducing a logarithm. They concentrated 400 figures on a 1×1 m^2 surface, exactly as is done in the far more detailed studies of Andersson and Håkansson (1963).

The relation between the volume, or in this case the area of samples, and variability, as discussed in the introduction, might be approximated by calculating the mean value of a set of different height figures. The variability of this mean value is known, because the standard error of an average is inversely proportional to the square root of the number of items involved. On a rough surface we would have to combine more observations in order to get a certain standard error of the mean value than on a flat surface. However, on a flat surface we can decrease the distance between the needles without disturbing the independence of the observations. How small this distance can be chosen requires a further analysis. Continuously written profiles will be of great help in this matter. In the Netherlands soil surface roughness is defined as $R = 100 \log s$, s being the standard deviation in cm calculated from 400 figures at 10 cm spacing. R ranges from 0 to about 100. This means that if the standard deviation of the height is 1 cm or less, roughness is called zero.

The logarithm is introduced in order to get an equally reliable result over the entire range. To get the same reliability for high and low roughness values, we will have to read far more figures on the rough surface. This is compensated by introducing a logarithm which compresses the roughness scale on the side of the high values (Kuipers

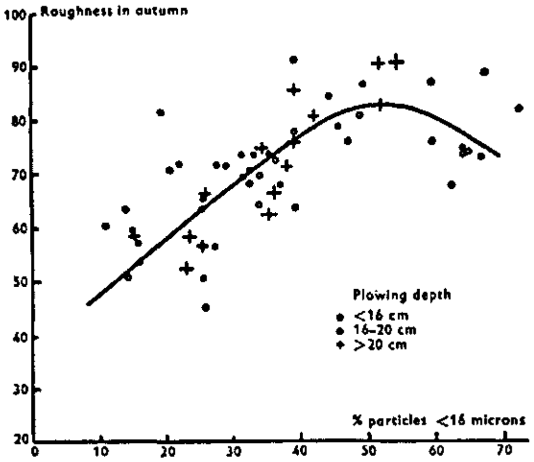

Fig. 3. Relation between clay content of soil and roughness after ploughing in autumn for different ploughing depths in 1955 and 1956.

1957). A few examples will demonstrate how the roughness number *R* is used. On a series of farmer's fields soil surface roughness was determined immediately after ploughing (Fig. 3). There is a clear relation between soil surface roughness and clay content of the soil. Influence of ploughing depth is not clear; the decrease of roughness at the very high clay contents might be influenced by the fact that no shallowly ploughed fields were found here. On experimental fields there is often a clear influence of ploughing depth, deeper ploughing giving a rougher soil surface. Very interesting is the difference, in roughness between different years in autumn. As is demonstrated for a light polder soil (Fig. 4), the same roughness in autumn can give different values in spring. The influence of ploughing speed and type of mouldboard on roughness is shown in Fig. 5. In most cases a higher speed gave a smoother surface. Generally speaking we can say that practically all the differences made in autumn reoccur in spring, though at another level.

c) The mean values of the height measurements offer the possibility to calculate mean pore space of the ploughed layer after ploughing (Andersson & Håkansson 1963, Burwell *et al.* 1963, Krupp 1963/1964, Kuipers 1960, Kuipers & van Ouwerkerk 1963, Ringelmann & Bourdelle 1931 and Wilton 1964). This might be a useful characteristic in judging the work performed by an implement. However, we should realize, that the equivalent height of 1 vol.% of pore space in a layer of 20 cm is only 2 mm. Therefore a change in height of the soil surface of a few centimeters has a tremendous influence on pore space. Con-

North East Polder Sandy loam.

Depth	Autumn Sh.	Autumn Md.	Autumn Dp.	Spring Sh.	Spring Md.	Spring Dp.
54/55	42	.	57	34	.	42
55/56	42	50	56	24	26	32
56/57	45	48	59	44	48	56
57/58	58	67	73	49	51	55

Fig. 4. Soil surface roughness after ploughing in autumn for different depths in four years (*Sh.* = 12 cm. *Md.* = 20 cm. *Dp.* = 28 cm.)

sequently we need indeed something like 400 figures to get an accurate enough estimate of the mean height of the soil surface. The figures should be related to a reference plane, that should be established with an accuracy of e.g. 1 mm, and moreover, ploughing depth and pore space before ploughing should be known sufficiently accurately. Experience in the Netherlands showed that this can be done, even with a simple instrument under field conditions (Kuipers & van Ouwerkerk 1963, van Ouwerkerk 1965).

For shallow operations the required accuracy of the height measurements is so high, that the method becomes unattractive.

One important fact should not be overlooked: the time elapsed since the operation may be important if this time is short. A study of soil settling after a tillage operation illustrates this point (Kuipers & van Ouwerkerk 1963). There seems to be a logarithmic relation between depth of the ploughed layer and time after ploughing.

If we measure upheaval immediately after ploughing even a few hours delay may cause a marked difference. Therefore, from the view-

Sand soil Odoorn · 1961/62.

Mouldboard	Autumn V_1	Autumn V_2	Autumn V_3	Spring V_1	Spring V_2	Spring V_3
Mélotte	39	35	22	22	18	11
Cappon	36	35	29	26	26	20
OM 25k	37	36	26	21	18	21
OMC 316	35	37	43	20	18	31
v.Rumpt Delta	32	22	21	15	7	13

Fig. 5. Soil surface roughness after ploughing in autumn for different speeds (V_1 = ±4.5, V_2 = ±6 and V_3 about 9.5 km/hr.) and different mouldboards.

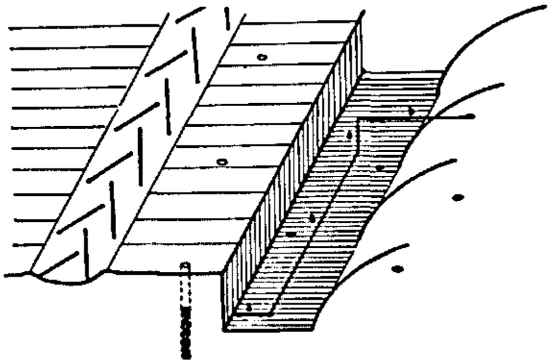

Fig. 6. Schematic drawing of displacement measurements at ploughing.

point of the characterization of structure changes produced by tillage operations, it is attractive to measure immediately after ploughing, but the result will be more reliable if we wait about one day. Unfortunately, weather conditions often make it necessary to start immediately, because it was also found that even on a heavy soil rain has a great influence on settling, especially when it is freshly ploughed.

d) A fourth set of determinations in use to characterize ploughing is more closely related to the ploughing operation itself. They try to characterize the displacement and deformation of the soil by reconstructing the position of certain marked soil particles after ploughing (Nichols & Reed 1934, Rid & Süss 1960, Söhne 1956, Steenberg & Njøs 1964). Here too we have to deal with the variability of the displacements. In the Netherlands we drill holes in the unploughed soil till about 4 cm beneath the expected ploughing depth (Fig. 6). In these holes 8 cm long pieces of chalk or 10 cm long sticks of modelling clay are put. Most of these are cut by the plough and then a white or coloured point on the bottom of the open furrow indicates the original position and the broken off piece on the ploughed land the position after ploughing. The change in position is measured in three directions and the original position is characterized by the distance from the new furrow wall. On one clay soil three hundred measurements were made at a plot with a speed of 3.6 km/hr (Fig. 7). There is a clear linear relationship between forward displacement and distance from the unploughed land and also, between sideward displacement and this distance. The regression coefficients (–0.88 and –2.51) indicate that roughly speaking the forward displacement is about equal to the distance from the open furrow before the plough passes. Sideward displacement is somewhat more than twice as much.

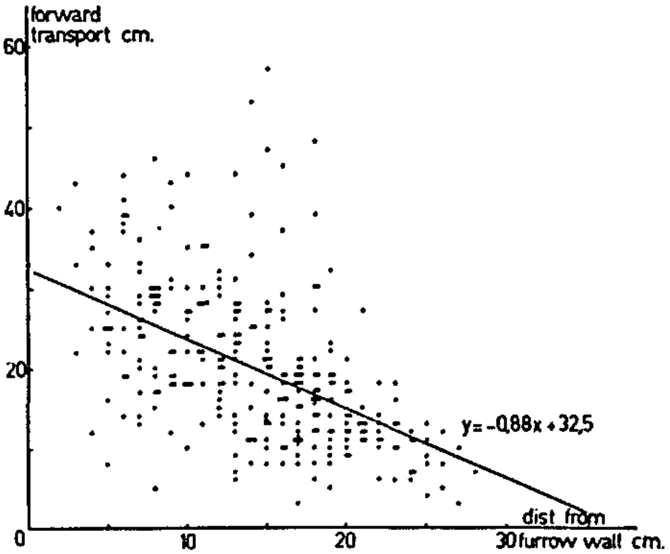

Fig. 7 a.

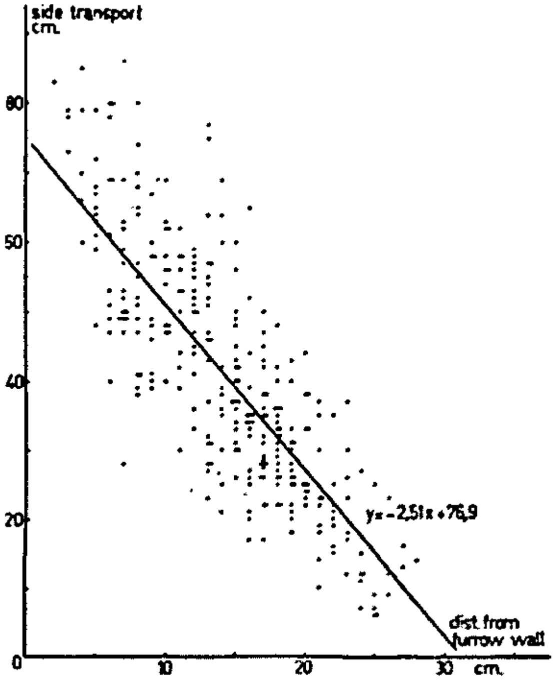

Fig. 7 b.

Figs. 7 a and b. **Forward and side-transport in relation to distance from the furrow wall on a clay soil.**

Forward-(A) and Side-(B)transport in cm's and standard deviations at two speeds. (n = about 60)

	A		B		S_A		S_B	
Speed km./hr.	4,5	10	4,5	10	4,5	10	4,5	10
Sandy loam Groningen								
v.Rumpt Delta	16	35	53	81	5,5	7,0	7,2	9,6
SCN-9k	18	32	56	74	6,0	7,5	7,4	9,8
v.Rumpt 0111	21	37	68	78	6,9	6,4	8,4	15,9
Löss Limburg								
v.Rumpt Delta	34	32	64	76	4,1	8,2	7,3	12,0
Mélotte P	19	20	50	60	4,2	2,9	12,6	10,7
Cappon TWZ	19	22	54	72	4,6	7,2	7,6	12,4

Fig. 8.

On a sand soil 265 measurements were made. Ploughing speed was 7.8 km/hr. Here the regression coefficients were 1.29 and 2.94. We could regard these coefficients as a measure for the relative mutual displacement of the soil particles as a strain we might say. On the sand at the higher speed the increase in distance between the soil particles was higher as well in forward as in sideward direction. It is very interesting to calculate the total increase in distance between two soil particles originally situated on the bottom of the furrow at a distance of 10 cm in a direction perpendicular to the direction of the furrow. For the clay soil we found that the distance was increased from 10 to 19.2 cm, i.e. an elongation of no less than 92 % ! For the sand soil where ploughing speed was higher this figure even amounted to 135 %. This points to a considerable straining effect of the plough.

A second interesting point is whether these characteristics are different for different ploughs and circumstances or not. On two soils for three different ploughs at 2 speeds (4.5 and 10 km/hr) the mean forward and sideward displacement and their variability was measured for points between 6 and 9 cm (Fig. 8) from the new furrow wall.

Mean forward displacement varied from 16 to 37 cm, side transport from 50 to 81 cm. So the range is resp. 21 and 31 cm. That means that a standard deviation of about 1 cm for the mean value seems to be small enough for characterization purposes. The higher range for the side transport indicates that here a somewhat higher value could be tolerated than for the forward transport. For forward transport the standard deviation of the single observation varied from 2.9 to 8.2 cm, so in most cases 50 observations were enough to obtain a standard error of 1 cm for the mean value. The variation in side transport was higher. Mean values of 50 observations had a standard deviation between 1.0 and 2.2 cm. At any rate this indicates that a number of 50 observations seems to be reasonable.

B. *Determinations in Spring*

Some of the determinations mentioned above may also be used in spring. On sandy soils which are often ploughed in spring and on autumn ploughed plots height measurements can be carried out. On autumn ploughed plots roughness is often sufficiently reduced for core sampling. In these cases calculated and measured pore space can be compared.

However, most activities in spring deal directly with the seedbed. This normally consists of a thin layer of fine, loose aggregates, overlying the wetter, denser rootbed, so the structural pattern is very clear and essential. Usually only the thin toplayer is characterized; this requires special methods.

a. *Sugarbeet*

For sugarbeet the depth of the seedbed, the variability of the depth and the distribution of aggregate sizes are used as parameters. Because we are trying to characterize a layer of a few cm instead of a few decimeters, depth is measured in mm with a semi-automatic recording reliefmeter with 10 needles at 2.5 cm spacing.

Although the height figures can be used for a micro-roughness determination this is not done up to now, because it is not obvious that determination of this micro-roughness is significative. Instead, the height figures are used to determine the depth of the seedbed, usually in 100 places.

This enables us to use not only the mean depth as a characteristic, but also the variability characterized by the standard deviation of the depth figures. Especially in the thin sugarbeet seedbeds the distribution of the depth figures is sometimes skew. This is obvious as negative depths of course do not occur. Up to now we did not normalize these distributions although in theory that would be more correct. From many measurements we learned that the depth of the seedbed as well as the standard deviation of the depth vary strongly. Of 78 practical fields 12% had a depth over 5 cm and 9% under 2 cm. The standard deviation in one regional investigation on fields with a depth between 4 and 5 cm i.e. in a group of more or less constant depths, varied from 7 to 20 mm.

Whether this is primarily due to differences in soil structure before seedbed preparation, or in the implements used, has still to be examined. Moreover, the reaction of the crop should still be studied. On one field we found that a relatively deep and coarse seedbed made mechanical harvesting more difficult, because either the harvester left too many beets in the soil or too much soil was picked up.

An aggregate size distribution and the determination of the pore space, air and water content with 2 cm high core samples may complete the description. These core samples show very clearly the large difference in bulk density between seedbed and rootbed.

As to the aggregate analysis the results are not very promising up to now. Sieving in the field is rather time-consuming; fine fractions (< 1 mm) are often too wet to be sieved in the field, the influence of transportation is doubtful and moreover the characterization as such is problematic. We feel the characteristic should depend on the really important qualities. If it is feared that too much fine material will make the soil too susceptible to rainfall, giving undesirable high moisture contents, the amount of aggregates smaller than e.g. 1 mm should be determined. If, on the contrary, it is expected that the seedbed will be too coarse, we'll have to take the coarse fractions as a characteristic. Perhaps for uniformity it will be best to use both. Of course there is no objection to distribution curves or determining as many fractions as possible, but if we really want to do something with our figures, we can use only one or two values, and they should be as effective as possible.

It is interesting to note, that sugarbeet seedbeds are likely to be quite different in different years. On one experimental farm the farmer is asked each year to make a fine shallow, a normal, and a coarse deep seedbed. The figures indicate that deep in one year may be shallow in another year. How the final stage in seedbed preparation is gradually reached by using different implements, is shown in Fig. 9. One point should still be mentioned, the influence of precision drills: in the rows the depth of the seedbed is strongly reduced.

b. *Potatoes*

As for potatoes our main interest is the amount of loose material that is needed to build up the ridges. In the Netherlands it is thought that on heavy soils, in spring only that part of the soil should be loosened that will really crumble.

It is supposed that this is not enough for the ridges and therefore

Depth and variability of depth in mm.'s of a seedbed for sugarbeets on a heavy river clay soil at Wageningen, at different stages of preparation.

Operation	Mean depth	Stand. dev. s.	Number of obs. n.	St.dev.of mean $s_{\bar{d}}$	St.dev.of s.
1) Field cultivator	39	17,5	80	1,9	1,4
2) 1 + leveller	22	10,5	120	1,0	0,7
3) 2 + roller	14	9,6	40	1,5	1,1
4) 3 + light tooth harrow	17	8,3	50	1,2	0,8
5) 4 + roller	13	6,6	120	1,0	0,7

Fig. 9.

we use a sequence of operations in the time of sprouting and early growth, that loosen the soil gradually. Each time a thin layer of loose soil is brought upon the potato ridges. In this way we avoid making clods. A good weed control is a secondary benefit from this system. In evaluating the structure changes we are using the same techniques as for sugarbeet: height measurements (up to $^1/_2$ cm over a length equal to rowdistance) and aggregate analysis. There will only be dealt with the height measurements.

From a first investigation on farmers fields we learned that in potato ridges there is less loose material than may be expected. The average value, i.e. the mean depth if we imagine the loose material spread over the entire surface, was only about 5–7 cm. Therefore, the next step was to study this depth in the course of the year.

The results of 14 practical fields with seed potatoes (Fig. 10) show, that the amount of loose material is highest before planting. None of the operations after planting gave an increase in the mean depth of

Mean depth of loose soil on 14 potatoe fields at different time

Main operation before planting	Number of fields	Mean depth of loose layer in cm.'s.			
		Before planting	After planting	Before closing	Before harvest
Rotavator	5	9,7	7,9	7,3	7,3
Powered harrow	5	11,0	8,3	7,9	8,6
Tooth harrow	4	6,7	5,6	6,8	6,5
Average		9,1	7,3	7,3	7,6

Fig. 10.

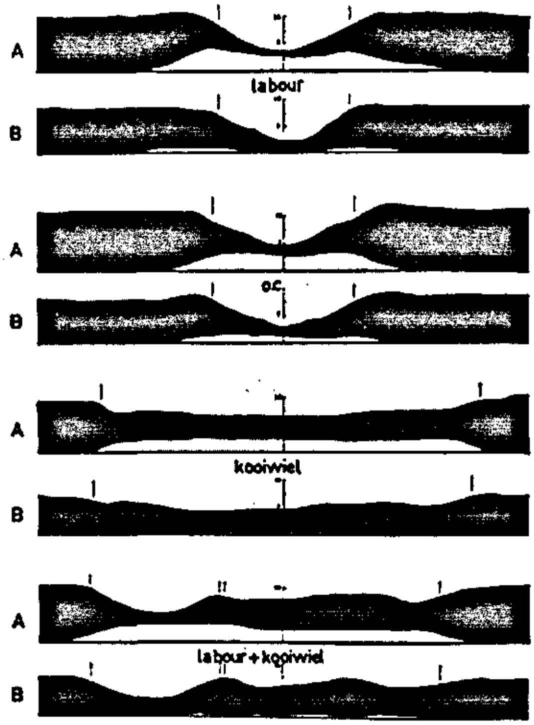

Fig. 11. Cross section of loose material in tractor ruts. A: initial depth 10 cm. B: initial depth 8 cm. From top to bottom: Hofka Nylabour tire. Open center tire, only cage wheel and Hofka Nylabour tire+cagewheel.

the loose layer. From this we should not conclude that the harrows and furrow-rotavators used, did not make any loose material. As a matter of fact, the profile of the boundary between the loose and more dense layer showed clearly that the rotavators cut into the denser material, but perhaps as much loose material is compacted by the tractor wheels as is loosened by the tillage operation. Although our measurements up to now do not indicate this, some settling of the soil in the ridges might be involved. However, the most striking point is, that before planting there seems to be by far the highest amount of loose material (Kuipers 1965).

Obviously this is compacted by the traffic in the field and it seems very difficult to regain this loss. The logical conclusion is to try to avoid this compaction. Experiments are being carried out, in which the loose material is pushed away in front of the tractor wheels and in practice there is some success in building up the ridges in one operation, avoiding undue traffic.

This last point, the striking effect of the tractor wheels on the

Mean influence of two different tires and two cage wheels on loose soil at two initial depths of seedbed and one tractor run per two meter.

	Decrease of total amount	Mean decrease in rut	Depth of rut
A. 10 cm. initial depth			
Tires absolute cm's.	2,4	6,2	6,3
Tires relative	100	100	100
Cage wheels relative	148	81	42
B. 8 cm. initial depth			
Tires absolute cm's.	1,2	3,8	5,6
Tires relative	100	100	100
Cage wheels relative	118	50	43

Fig. 12.

workability of the soil in spring is the last example of measurements used to characterize structure changes at tillage operations, because the effects of tractor wheels which might be called an unintended effect of tillage operations, is extremely important.

In spring many farmers use cage wheels to diminish the compaction of the soil. The effect is clear enough because deep ruts are avoided. However, deep ruts are a better indication for the flow of soil than for compaction, because the change in height of the soil surface necessary for a severe compaction is rather small. Nevertheless cage wheels may be very useful, but perhaps not for avoiding compaction. Therefore, we measured the amount of loose material in ruts of different wheels (Kouwenhoven 1965); a normal tire, a tire with high and widely spaced studs, the same tire plus a cage wheel and only cage wheels. The tractor with the test wheels towed a second tractor which stayed outside the field. The field was specially prepared for this test, one half with a tooth harrow giving a loose layer of 8 cm and one half with a powered harrow giving a loose layer of 10 cm. The results are shown in a diagram (Fig. 11). The deep loose layer will have been wetter at the bottom, and the first effect we see, is that the loss of loose material is relatively much higher.

Assuming that the tractor passes over the field every 2 m, we see that the total amount of compacted loose soil is by far the highest when using the wide cage wheels. However, in these wide ruts the depth of the remaining loose material is much greater (Fig. 12). So cage wheels give a much higher homogeneity than the normal wheels. Perhaps in some cases this is more important than the total amount of loose material. In other cases the reverse may be true. In this last example it is clear we have to describe a horizontal and vertical pattern in order to understand what is changed by a certain operation.

In spring there is much traffic on the field. In many cases the horizontal pattern will disappear by the overlapping of ruts, which facilitates characterization but interferes with a good understanding about what happened.

In this type of research we touch one of the common problems in applied sciences. For a practical application we can only use simple characteristics. This normally involves that we have to compromise with theory. However, in a theoretical approach we can also only deal with very simple situations. So simple, that we'll never find them in practice. This involves that our compromises should be theoretically as sound as possible, but also as suited for application in practice as possible.

In the first part of this paper some ideas are explained on the theoretical aspects of the characterization of structure changes involved in tillage operations. In the second part the application in practice is shown. There is no full agreement between these two parts. Perhaps it will never be obtained. But the feeling of being on our way is much better than the feeling of having arrived. This certainly holds for science!

Sammanfattning

Karakterisering av förändringar i matjordsstrukturen orsakade av bearbetningsåtgärder

I Nederländerna har i det senaste decenniets jordbearbetningsforskning tillämpats en uppdelning, så att jordbearbetningens effekt på markstrukturen resp. relationen mellan markstruktur och gröda studerats separat. Detta har visat sig mycket värdefullt. De teknologiska verkningarna av jordbearbetningen kan vanligen beskrivas som en ändring av volymvikten, homogeniteten och jordens hållfasthet. Homogenitetsbegreppet tas upp till närmare diskussion.

Större delen av uppsatsen behandlar karakteriseringsmetoder, som är i bruk i Nederländerna, bl. a. följande. Före plöjning bestäms standardavvikelsen för porvolymen i cylindriska provproppar. Porvolymen efter plöjning beräknas från mätningar av markytans höjning under plöjningen. Markytans ojämnhet efter plöjningen karakteriseras med ett råhetsvärde $R = 100 \cdot \log s$, där s är standardavvikelsen för markytans höjdläge mätt i cm. Förflyttningen och deformationen av jorden

under en plöjning mäts med hjälp av särskilda märken anbragta i jorden före plöjningen.

Vid vårbruket koncentreras mätningarna i regel till själva såbädden. Sålunda undersöks för sockerbetor bearbetningsdjupet och dettas variabilitet, aggregatstorleksfördelningen, porvolymen samt vatten- och luftinnehållet. I potatisodlingar undersöks bl. a. mängden lös jord i kupkammarna.

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