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Possibilities for the application of implements in soil tillage

G. J. Poesse and U. D. Perdok

Institute of Agricultural Engineering, Wageningen, the Netherlands

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Summary

Mechanization changed soil tillage and increased soil compaction. Although from a technical point of view a dense soil with a flat surface is attractive, problems involved in sowing, harvesting and crop management make it less likely that tillage will be abandoned. Moreover, the effect of tillage on weed control is still important and the technical possibilities for a tillage system that matches adequately in a modern production system, are very attractive. P.t.o.-driven implements are likely to play an important role in such systems.

Mechanization and soil tillage

Soil tillage is one of those agricultural activities to which already at an early stage various implements, if necessary drawn by draught-animals, were applied. Despite this fact, prior to the introduction of the modern farm tractor, man himself remained closely and strenuously involved in the tilling process. In these days the operator used to walk behind the tillage tool to control its proper direction and working depth as well as to lift and to turn it. The amount of energy applied to the soil in this way was determined, and at the same time restricted, both by the number and kind of draught animals and by the man who, walking over the clods, was anxious to spend least possible energy.

In many respects the increasing use and further improvement of farm tractors today have brought about great changes in soil tillage. The operator no longer needed to walk; he got seated at the steering wheel of the tractor and he was in front instead of in rear of the tillage tool he had to operate. This was quite a change in his direct contact with the tillage process. Moreover, the capability to transfer effectively the available power increased markedly owing to improvements such as power take-off, high working speeds, differential lock, four-wheel drive and weight transfer.

The effect on tillage was manifold. It gave, for instance, the opportunity to break up the soil thoroughly once a year by means of relatively deep tillage during autumn, irrespective of soil and weather conditions. Owing to the higher working speeds, in spring there was sufficient time for recurrent trips over the field to perform successive tilling. However soil density just after sowing in spring is almost equal to the original condition prior to autumn tillage (Fig. 1). This questions the considerable power input into the soil during the intervening period. The steady rise of herbicide chemistry tends to make soil tillage no longer compulsory for weed control. Besides, the loosening effect of soil tillage is in fact a serious drawback to the current highly mechanized cropping systems and the related transport problems. Both factors will tend towards reducing or even omitting tillage in future (minimum tillage and zero-tillage). Especially in view of the constantly intensifying mechanization the latter system seems particularly inviting if

mechanization itself would not impose overruling demands upon soil tillage. These demands pertain to the special ways of drilling or planting and also to the special husbandry and harvesting methods applied to certain crops.

Soil tillage and crop production

Sowing

As a rule it will predominantly depend on the climatic conditions whether the seed has to be put into the soil or not. Under Dutch conditions, for instance, the first method is to be preferred and therefore a certain form of tillage, be it over a very narrow stretch, is indispensable. Of course it is possible to construct a machine that makes only narrow furrows in which the seed can be deposited and subsequently covered.

A specimen of such a machine is the heavy seed drill that has been designed and successfully tried out by the Institute for Biological and Chemical Research on Field Crops and Herbage (see page 227 of this issue). Its great weight and high number of discs were choosen because often a hard soil surface covered with an abundance of organic matter has to be met. In practice the machine has already proved to be a feasible device. On the other hand, a combination of a driven tillage tool with a normal seed drill or planting machine as shown in Fig. 2, 3 and 4 is undoubtedly also an inviting solution of the problem.

Crop husbandry

However the harvest of certain crops might leave such plant remnants on the field that

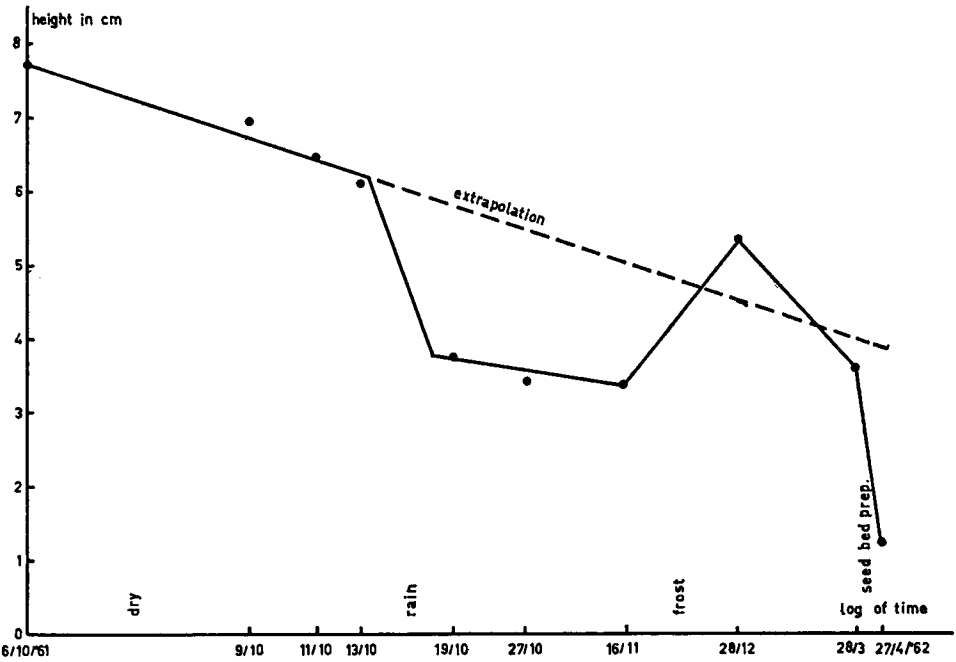

Fig. 1 Mean height of the soil surface in relation to log of time after ploughing. (From: H. Kuipers and C. van Ouwerkerk, 1963).

Fig. 2 A four-bar-powered harrow combined with a seed drill (Vicon NV).

the cultivation of the new crop would be hampered. Though mowing or spraying of chemicals could provide an adequate answer to this problem, a comparatively thick layer of organic matter would still be left on top of the mineral soil. In case such a layer would not impede sowing or planting of the new crop, it might eventually hamper husbandry because for a number of crops in both agriculture and horticulture an even spacing is crucial for achieving an optimum yield. Beet roots give a common example, but the same applies to a number of vegetables.

Up to now the eventual defects in the germinative capacity of these crops are met by drilling excessive amounts of seed per area and by afterwards adjusting the plant density by means of thinning. This singling can be performed either by hand or by machine. In view of the constantly shrinking labour force in farming, hand singling will be increasingly replaced by machine thinning. But machine thinning, whether blind or electronically controlled, makes strict demands upon the soil surface. All obstacles in the soil, even scarce plant remnants, can be harmful to the process. So successfull application of the method requires a clean and even surface. Therefore the first tillage should be deep enough as to allow the surface to be smoothed out sufficiently by one or several subsequent shallow tillage operations prior to sowing.

Fig. 3 A combination of a horizontal rotating powered harrow and a planting machine (van der Lely NV).

Fig. 4 A rotavator with times together with a potato planting machine (van Rumpt NV).

Of course drilling at final spacing disposes of the need for these precautions completely. But, in view of the still numerous unsolved questions around seed germination, this ultimate method, that could indeed make any preceding tillage obsolete, is not likely to be practiced on an operational scale very soon. This is especially applying to the Netherlands, where precarious weather conditions in spring are aggravating the problem.

Harvest

Finally, as we have already noticed, also the harvesting method can impose special demands upon soil tillage. This pertains in particular to those crops that bear their mature products below surface, predominantly bulbs and tuberous plants. Such crops use to be cultivated in ridges, composed of loose well-crumbled soil, out of which the harvester sieves the final product. The shape of the ridges prevents the harvester from handling an excessive amount of soil, whereas their fine structure facilitates the sieving action. Only in the culture of flower-bulbs on very light soils is ridge cropping abandoned and has the harvester to take up and handle the soil over its full working width. This is only feasible because of the almost complete absence of clods in these soils. On soils which are harder to crumble the method does not work and consequently an intensive tillage is a prerequisite for the harvesting methods presently applied. Tillage could only be avoided if it would prove possible to first tear up the soil and to subsequently pick up the product at the foliage. But such a procedure would require special plants which, at least for the time being, are not available. Apart from these considerations it is to be doubted whether the presumably high expenses on plant breeding would counterbalance the savings on tillage work.

If we consider its significance for mechanization merely, and given the present state of technology and man-power, the conclusion seems justified that soil tillage can only be abandoned in cultures requiring neither special husbandry methods nor subsurface harvesting methods.

Weed control

Although herbicides are making progress, soil tillage has still an important function in weed control. In this respect the plough is the most valuable tool (Fig. 5 and 6). By cutting the soil over the full width of the furrow and subsequently inverting the plough layer, thus burying the surface, the weed vegetation is lethally attacked. The cultivator (Fig. 7) is another effective tool, suited to both deep and shallow work. Its action is not primarily based on cutting and inverting the soil but predominantly on the recur-

Fig. 5 The stubble plough (van Rumpt NV).

Fig. 6 Modern mould-boards and their work (Fa. Iz. Cappon).

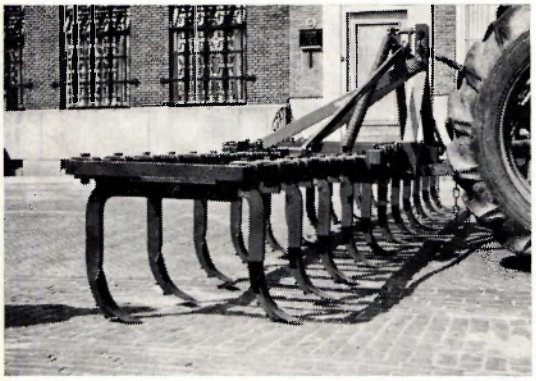

Fig. 7 A rigid tine cultivator for stubble and main cultivation (Fa. Iz. Cappon).

rence of the process. Finally, also the spading machine (Fig. 8) has to be mentioned. Although it is not frequently used and although the soil is less turned by it, this machine is an important tool, not because of its cutting action but because it breaks up the subsoil (Fig. 9) and mixes the top soil thoroughly. For this reason and because the power is transmitted by the power take-off, which practically prevents the tractor wheels from spinning, this tool is highly suited for deeper tillage of heavier soils.
Though tilling with one of the above tools may thus act as an effective means of weed control, it should of course not at the same time counteract the other tillage labour, which may be needed for other purposes.

Future development
Although mechanization in general is favoured by an even or properly shaped, clean surface, it is equally important to avoid excessive soil compaction which, as already noticed in Fig. 1, may easily result from frequent successive tillage operations in spring. So the comparatively deep or normal tillage operation should be aimed at an optimum result with regard to both its weed-controlling effect and its crumbling and levelling or shaping effect on the soil. Thus the preparation of the seed bed would require least possible operations and consequently much less trips over the field, resulting in minimum soil compaction.

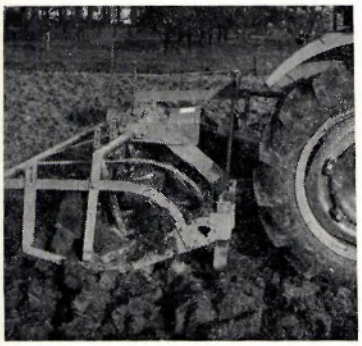

Fig. 8 A spading machine at work (photo: Laboratory of phytopathology - Howard Rotavators).

Fig. 9 The working of a spade (Vicon NV).

If possible, all necessary preparations such as shallow tillage should preferably be made at the same time as the sowing and planting of the crop. Of course the tillage practice should be adapted to the requirements for a particular seed bed or plant bed and a particular soil type and soil condition. However this adaptation is generally harder to achieve with drawn than with p.t.o.-driven tools. Especially on heavy soils drawn tools have to be fairly long to ensure satisfactory results under strongly varying conditions. Combination of such tools with seed drills or planting machines results in excessively long machine chains. Earlier investigations have shown that types of p.t.o.-driven tillage tools equipped with tines or knives are most preferable for such a combination. The capability to vary working speed and p.t.o. independently, to some extent, creates a versatile machine set that will match a wide range of conditions and minimize the risk of soil compaction. Fig. 2, 3 and 4 show several operational specimens of such machinery.
A system that might be most adequately called 'fixed-track cropping' would be an essentially different approach of the problem how to retain an optimum soil structure during the seed-bed and plant-bed preparation. The primary intention of this system is that the tractor follows one and the same track during the whole sequence of operations. So far properly marking of the track and adaptation of the working width of the tools seem to be the most serious problems. Yet this principle is undoubtedly very promising. From the foregoing it may be clear enough that the tillage field itself also procures opportunities to avoid excessive soil compaction due to frequent driving over the surface. In this way it seems quite possible that in future not only cultures for which tillage is still compulsory, but all cultures will continue to benefit from the varied advantages which mechanized tillage in particular still offers.

Reference

Kuipers, H. & C. van Ouwerkerk, 1963. Total pore-space estimations in freshly ploughed soil. *Neth. J. agric. Sci.* 11: 45–53.