Deep Tillage

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DEEP tillage has been practised in parts of Britain for nearly 200 years on light sands, and for 100 years on heavier soils, although it was a very laborious operation until the introduction of the steam engine to the farm over 80 years ago. Deep tillage has become even easier during the past 20 years with the introduction of large track laying tractors. In spite of its long history, deep ploughing is still an operation on which different successful farmers, farming on apparently similar soils and following the same general methods of farming, hold diametrically opposed views. It would therefore appear that deep ploughing can be of benefit only under certain conditions, for otherwise it would not be possible for competent farmers to be in disagreement on such an essential part of the technique of cultivation. There is still very little knowledge of just what consequences deep tillage, either subsoiling or deep ploughing, has on a soil or crop, and it was to learn something about the subject that the Agricultural Improvement Council, with the encouragement of the Agricultural Research Council, initiated a series of deep tillage experiments that are being carried out on farms all over the country. These experiments were started in the autumn of 1944, and only slowly can the consequences of the various effects deep tillage has on the general management of arable land be unravelled.

In this article, deep tillage operations are considered as falling into two groups: those that are primarily subsoiling, or the loosening of the subsoil without bringing it to the surface; and those that are primarily deep ploughing, or the inversion of the soil so that much of the subsoil is brought to the surface. In practice, the division is not always quite so clear cut, as on the one hand the design or equipment of the plough can be changed to allow a greater or lesser proportion of the surface soil to be buried deeply, and on the other hand there are implements such as the gyrotiller that can be regarded mainly as subsoilers but are capable of bringing up varying proportions of subsoil to the surface.

Deep tillage has one obvious consequence. The soil is loosened and the number and size of the large pockets of air in the soil are increased. If the base of the loosened layer is impermeable to water, and rain follows the deep tillage before the next crop is able to use much of the water, the air pockets will become full of water, and the soil will be turned into a marsh. Hence, the first point that should always be borne in mind is that deep tillage must only

be practised on drained land. Land with impermeable subsoils, or high water-tables, must never have the subsoil loosened. However, deep tillage, whether subsoiling or deep ploughing, can improve drainage by increasing the size of the air spaces in the soil, provided that the water percolating through the loosened layer can get away into drains or into deep ground water. It is not yet known if subsoiling and deep ploughing are equally effective for this purpose, but it is possible that deep ploughing is the more reliable method of improving the ease of drainage. When the subsoil is dry, subsoiling is probably as efficient as deep ploughing in this respect, but in some years this condition occurs only in summer and under a standing crop. Also, it is possible that on some soils such as silts, where the soil particles run together easily, deep ploughing, by bringing the subsoil to the influence of the sun, mellows it so that the clods when wet do not run together as easily as they did when they were in the subsoil. However, these points of difference between subsoiling and deep ploughing as they affect drainage have not yet been proved by rigorous experiments. Deep tillage can increase the air content of the subsoil, and hence improve the aeration of the soil around the roots of plants.

It can also increase the amount of water the soil can hold when it becomes water-logged; but it cannot increase the amount of water a well-drained soil can hold, that is usable by crops. If deep tillage improves the drought resistance of crops, it is for reasons other than this.

Deep ploughing differs from subsoiling in that the surface soil is buried under a layer of subsoil. This has three distinct consequences: surface weeds and weed seeds are buried deep; the deep roots of pernicious perennial weeds, such as dock and thistle, are brought to the surface; and manure, lime, fertilizers, or more fertile friable soils, are distributed through a deeper layer.

The power of deep ploughing to control weeds can be remarkable. In all the experiments recently carried out in England, deep ploughing—ploughing, that is, from 4 to 6 inches more than the customary depth—has never brought up weed seeds, although ploughing that has been only 1 or 2 inches deeper than usual has brought up many buried seeds. When some strips of land have been ploughed deep and others shallow in autumn, the shallow ploughed strips have sometimes been green in spring while the other strips have always been practically free from weeds, provided that the ploughing has been done well. In several areas the chief difficulty of making a good job of deep ploughing is that the subsoil sticks to the mouldboard. Also, it is difficult to set some multi-furrow ploughs to bury all surface weed seeds and rubbish very deep, because they cannot be set to cut a sufficiently wide furrow for good inversion when they are working deep, although the depth may well be within the capability of the mould-board. The power of autumn deep ploughing to give cleaner land in the spring can be of very great value if for any reason a farmer is late with his spring work, as was frequently so last year; he is able to prepare the top few inches of surface soil into a seed bed rapidly, without risk of it drying out. An example of the benefit of this extra cleanness of the soil is furnished by deep ploughing experiments at Rothamsted in the spring of 1947. The land to be sown with sugar-beet was worked quickly and apparently well, and was drilled in late April. However, annual weed seeds germinated with the sugar-beet on plots ploughed 6 inches deep, while

none germinated on those ploughed 12 inches deep. Although germination was rather slower and not so even on the plots ploughed deep, the beet grew quicker than that of the shallower ploughed plots, even though the latter plots were horse-hoed, singled, and hand-hoed, as early as possible, and at harvest, probably largely in consequence of the freedom from early weeds, the yields of beet on the deep ploughed plots were over 3 tons an acre higher than on the other plots. This greater freedom from weeds often persisted throughout the season, although there always were some fields where they appeared worse on the deeper ploughed plots. These differences from the usual behaviour, however, were noticed only in the summer and not in the spring.

A second possible consequence of deep ploughing is that it enables nutrients to be incorporated more deeply than when shallow ploughing is practised. This effect is important only when the nutrients cannot move easily in the soil, and therefore applies to lime, potash, phosphate, and farmyard manure, but not to nitrogen. These materials fall into two classes: lime and plant foods. If the subsoil is very acid, the spreading of lime on the soil surface, followed by deep ploughing and a further spreading of lime, will quickly sweeten a much greater depth of soil than if the lime were incorporated in only the top few inches of soil. The advantage of sweetening the soil in this way can be very striking in short periods of drought, for deepening the sweetened layer of soil allows the roots to penetrate more deeply and to take more water from the soil. The depth to which farmyard manure is ploughed-in the soil seems to have no effect on its value to the crop. In the Rothamsted experiments, farmyard manure that was spread on the land in the autumn and then ploughed-in either 6 or 12 inches deep increased the yield of potatoes and sugar-beet equally for both the deep and the shallow ploughed plots. The responsiveness of the crop to potash and phosphate may depend on the depth to which these nutrients are ploughed-in.

It would be thought that deep incorporation of these fertilizers would benefit during dry periods those crops, such as sugar-beet, that grow fast in mid-summer, for plant roots can only extract their food from moist soil, and during a dry period the crop tends to dry the soil from the surface downwards. Hence the deeper the fertilizer is placed in the soil, the longer it will remain moist and the longer it will be available to the growing crop. If this is correct, it would be expected that the poorer the subsoil the more desirable it would be to plough the soil deep, in order to bury the nutrients in the subsoil and make it possible for the poor soil brought up to be enriched. Yet these are the very soils that many farmers, who practise deep ploughing, suggest should not be ploughed deep, or at least, should be increased in depth only slowly year by year.

The experimental results so far obtained are not yet numerous enough to be conclusive, but they suggest that yields of sugar-beet can be increased if potash and phosphate are applied in the autumn instead of the spring, and the land then ploughed between 6 and 9 inches deep. In 1946, autumn ploughing-in of fertilizers on some soils increased the yield of beet by a ton an acre, which is not a poor reward to receive for the extra trouble of having to drill potash and phosphate in the autumn, and nitrogen in the spring. However, on land ploughed to 12 inches or more in depth the results have been much more erratic, possibly because not enough care had been taken to

ensure that adequate quantities of fertilizer were added to the seed bed, which was composed mainly of weathered subsoil, to overcome the harmful effects of its poverty. There is some evidence that on land with a poor subsoil, crops will respond more profitably to large amounts of phosphate and potash if the soil has been ploughed deep, provided the fertilizer is given in two dressings, one before and one after the ploughing.

CONCLUSIONS

Deep tillage should only be practised on drained land. If the field has a drainage system already installed, or has a naturally free-draining subsoil, deep tillage will often increase the speed of drainage. There is an indication not yet well established that deep ploughing is rather more efficient than subsoiling for this purpose.

Deep ploughing usually gives a better control of weeds in the early part of the growing season, and in consequence may allow spring-sown crops to be planted earlier with less loss of water from the seed bed than is possible on shallow ploughed land.

Deep ploughing enables the depth of fertile soil to be increased. It has not yet been possible to demonstrate rigorously under what conditions this extra depth results in increased yield.

Provided that adequate fertilizer is added to the seed bed to ensure that it is not too poor, that the field is well drained, and that the subsoil does not consist of broken pieces of limestone or large lumps of solid chalk, there is no indication that deep ploughing will depress crop yields no matter what kind of sand or clay is brought up. It is not therefore a dangerous operation under the conditions specified.