ROTHAMSTED RESEARCH

The Art and Science of Cultivation

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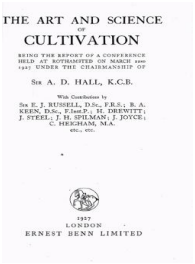

V. The Art and Science of Cultivation

Sir A. D. Hall

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THE ART AND SCIENCE OF CULTIVATION

BEING THE REPORT OF A CONFERENCE HELD AT ROTHAMSTED ON MARCH 22ND 1927 UNDER THE CHAIRMANSHIP OF

SIR A. D. HALL, K.C.B.

With Contributions by

SIR E. J. RUSSELL, D.Sc., F.R.S.; B. A. KEEN, D.Sc., F.Inst.P.; H. DREWITT; J. STEEL; J. H. SPILMAN; J. JOYCE; C. HEIGHAM, M.A.

etc., etc.

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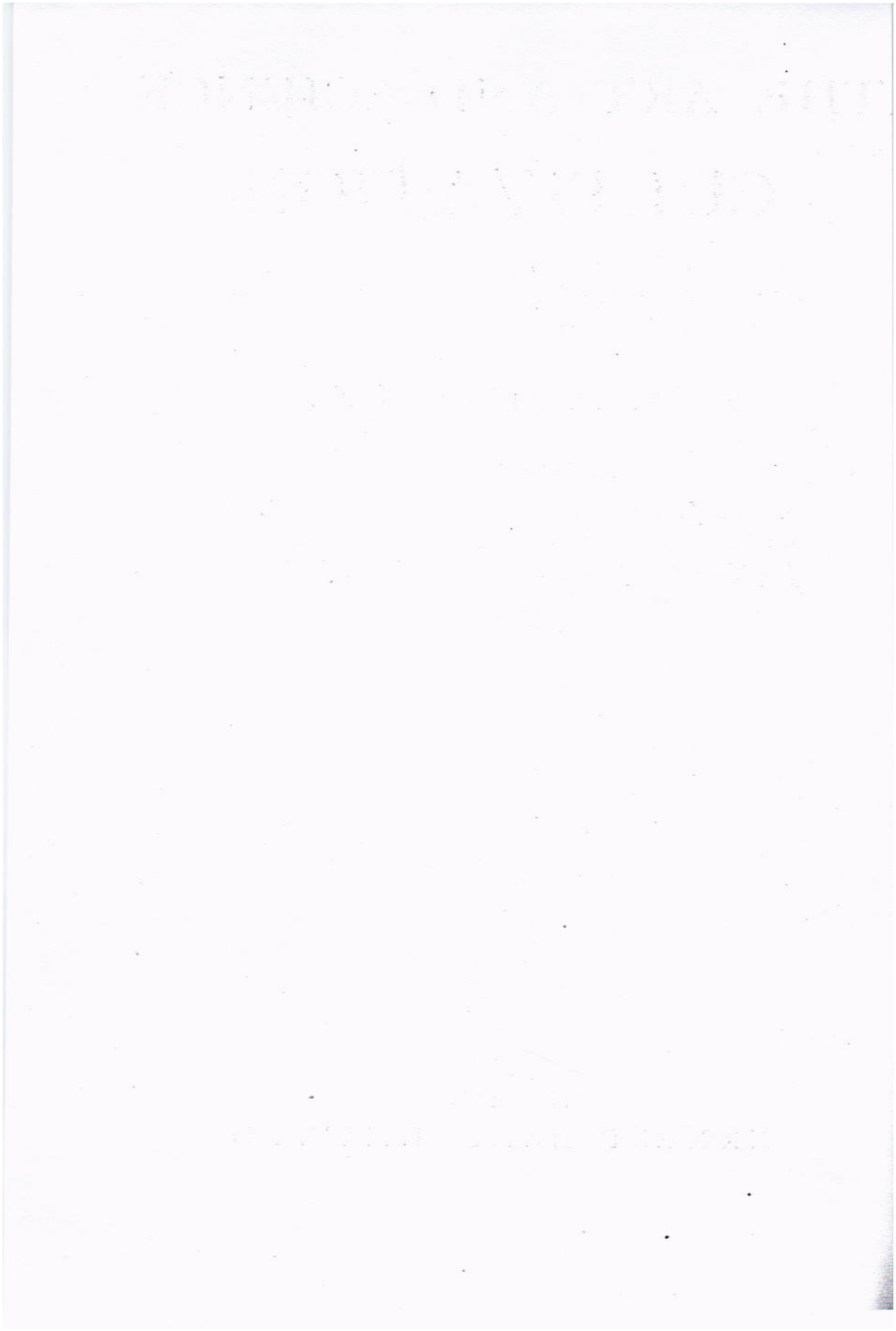

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PREFACE

THE purpose of the conference on cultivation was to bring together farmers, implement-makers, tractor-makers and scientific workers to hear an account of the practice of spring cultivation in different parts of the country. The papers were read by farmers who are themselves skilled cultivators, and the subsequent questions and discussions helped to bring out the facts and to clear up uncertain points. Cultivation is the most ancient of the farmer's arts, and it has received less aid from science (apart from engineering) than any of them. The purpose of the Soil Physics Department, under Dr B. A. Keen, is to obtain exact knowledge of what cultivation does to the soil and so to change the old art into a science. Eighty years ago chemists changed the art of manuring into a science and produced artificial fertilizers; the gain to agriculture was enormous. Whether physicists can do as much for cultivation remains to be seen. But the whole history of the last one hundred years shows that progress is rapid once science is really applied to any human activity: it will be surprising if science is unable to help the cultivator. The first step is to get at the facts, and here our farmer friends can help us; the rest is to try to explain these facts and so to discover the underlying principles, and here our farmer friends must have patience. Until the scientific worker knows his problem he cannot solve it; once a process can be explained some ingenious inventor finds an easier way of doing it.

E. J. R.

October 1927.

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CULTIVATION: THE ART AND THE SCIENCE

By B. A. KEEN, D.Sc., F.Inst.P.

Rothamsted Experimental Station

Cultivation in this country has reached a high level of development. The farmer has the accumulated experience of many hundreds of years on which to draw, and this great bulk of information has long since been crystallized into a mass of traditional knowledge in which are hidden, no doubt, many scientific principles. Speculations on cultivation problems are found in the earliest agricultural literature, and, on the whole, progress in some form was always going on. Nevertheless, just as in any other art, there were certain periods when a great acceleration occurred. Jethro Tull's seed-drill and horse-hoes eventually revolutionized our cultural methods; the Industrial Revolution of the last century and the growth of large manufacturing centres not only caused a large demand for foodstuffs, but it provided the specialized technical knowledge and constructional skill required for the manufacture of the new implements, without which the change of farming methods could scarcely have been effected. A great variety of implements sprang into existence between 1840 and 1875 to meet the more frequent and detailed cultivation operations necessitated by the new farming. Although the designs were empirical and the improvements based on the slow process of trial and error, exceedingly valuable work was done by the implement-makers, in modifying the old implements and increasing their efficiency. Yet, in spite of this great advance, the essential nature of the implements was not changed. Unlike the thresher and the binder, which are in no sense adaptations of the flail and the sickle, the tillage implements of to-day would be recognized without difficulty by the farmer of two centuries ago. He would also immediately recognize the actual operations. We still have to undertake a long series of operations—ploughing, cultivating, harrowing and rolling—to produce a tilth; we are still largely dependent on the weather, on winter frosts, and an alternation of dry and moist conditions in the spring, and we are still compelled, in adverse circumstances, to force a tilth and be content with a condition that does not really deserve to be called a tilth at all.

Another significant aspect of soil cultivation is the variation in practices in different parts of the country. A good farmer moving to another district has little real difficulty in adapting his

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crop and stock management to the new conditions, but some time passes before he feels thoroughly at home with his cultivations. He finds not only that the operations are modified from those he formerly used, but the implements differ in design. It is instructive to count up the variety of ploughs listed by any large implement firm. Even when every allowance is made for unimportant variations in design, the number of types remaining is surprising. To my mind it shows either that ploughing—the basic operation of all cultivation—is a very complex business, or else that there is still scope for further standardization of a few types of plough and the elimination of the remainder. It is possible, indeed probable, that both conclusions are true, but at present hardly any data exist on which a reliable opinion could be based. In spite of our wide practical experience, we know little or nothing of what really happens to the soil when it is ploughed or cultivated. We can recognize the final effects, certainly, and, from experience, we have found out how to arrange our operations so that there is a good chance of securing these effects or any reasonable degree of modification. But, except in a very general and incomplete way, the explanation of how the effects are produced and, indeed, the causes of tilth still escape us.

Although we have made little real change in the fundamental design of cultivation implements in the last century, improvements have been effected in important details that have resulted in better work and a definite reduction in draught. Had the cost of labour remained the same we should be tilling to-day more cheaply. But labour costs have increased to an extent that more than offsets this advantage. Tillage is still the most costly single item in arable farming.

It is evident that there is a sound case for systematic inquiry into cultivation matters. There is no reason to assume that we have reached finality either in implements or methods, and, even if there were, the important question of reducing tillage costs is still awaiting exploration. The necessity for inquiry is not of recent origin, so it is significant to find that there are very few tillage experiments recorded in the literature. Those found are almost entirely of American origin. Agricultural teachers and investigators are compelled to refer to them, and to assume that the conclusions apply unaltered to conditions in this country. Those who have had the opportunity of comparing British and American implements and methods must have the gravest doubts whether this assumption is correct. Unfortunately, owing to the absence of adequate cultivation experiments in this country, the assumption remains, neither controverted nor confirmed.

There is a most instructive comparison in this connexion between

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tillage and artificial fertilizers. Whereas tillage experiments are few and far between, there have been innumerable manurial experiments during the past seventy or eighty years, and there is no sign of their numbers decreasing. The advances in soil chemistry associated with Lawes and Gilbert formed the basis of the field trials of manures; theory and experiment mutually aided each other, and in a comparatively short period a science of manuring was evolved. Herein is the essential distinction between it and cultivation. Artificial manuring has grown up under the guidance and control of the laboratory; cultivation has not. It is far older than the physics and physical chemistry of soil, the branches of knowledge mainly concerned.

Only in recent years has any systematic study of the soil been made from these aspects. The laboratory results have been so satisfactory that for some time past it has also been possible to undertake with confidence investigations under practical field conditions. I shall give, with special reference to cultivations and the problem of soil tilth, an account of the main results obtained to date by Dr Haines and myself, and a statement of the promising extensions of this work.

The laboratory work revolves round the central fact that we cannot understand the causes of tilth until we have a further knowledge of the physical properties of soil.

The first stage was to sort out these factors and to devise methods and apparatus so that they could be studied singly. Such work is of necessity rather technical in character, and for the purpose of today's conference our field investigations are of more direct interest. It is sufficient to mention that the laboratory work includes a study of such factors as cohesion—the tendency of the soil to form hard clods when dry; plasticity—the ability to be moulded in the moist state, like modellers' clay; surface friction between soil and a metal surface; movement of moisture in the soil; flocculation, or the aggregation of individual soil particles into little crumbs or granules, that characterize a soil in good tilth. Studies of this kind, when combined with appropriate measurements in the field, are enabling us to understand what happens to the soil when it is cultivated. It will eventually be possible to give for any cultivation operation a specification of the soil properties concerned, analogous to those that, under the name of "properties of materials," the engineer already has for the metals used in the actual implements. In the field much use is made of the dynamometer, an instrument measuring the resistance offered by the soil to the passage of a cultivation implement. Our first experiments were done with a dynamometer suitable only for tractor work. We have now filled an important gap in our equipment by the construction of a very light dynamometer, suitable for all types of work, from the lightest horse-drawn implements to the

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heaviest steam tackle. Further, the records, being impressed on a celluloid ribbon, are permanent, and unaffected by oil, water or dirt.

Dealing now with the field investigations, they can be grouped into two main divisions:

(1) Comparison of various alternative forms of cultivations.
(2) The possibility of increasing the efficiency of cultivations.

The first of these two divisions may be illustrated by an experiment recently carried out at Rothamsted in comparing three different methods of preparing a seed-bed for roots. It is one of a series that we intend to carry on for several years. The three methods were (*a*) ridging, (*b*) an unridged seed-bed, (*c*) rotary cultivation. To eliminate soil variations, on which I shall have more to say later, each treatment was triplicated, so that there were, in all, nine plots. The whole area was autumn-ploughed, after wheat, and in February cross-ploughed, with the exception of the plots intended for rotary cultivation. The seed-beds were prepared in May, and immediately before and during the cultivations samples of the soil were passed through a series of sieves to obtain a measure of the amount of disintegration produced by each operation. As the soil was in excellent physical condition it readily broke down, hence the differences in the three treatments were not as great as might have been expected. However, it was evident that the rotary cultivator left very few large lumps behind it, and further, the seed-bed produced was much more spongy or "puffed up" in texture than with either of the other treatments. Germination of the swede seed was earlier on the rotary cultivation plots, and in the early stages of growth the plants were definitely better and more forward. Later on, however, a striking change took place. The tendency of the Rothamsted soil to "cap" or to harden down in the surface layers became greatly accentuated on these plots and, to judge by both the feel and appearance of the soil, the hard layer extended much deeper than with the other treatments. It is probable that the tendency to hardening was accentuated by the deep and uniformly fine tilth produced by the rotary tines, but, whatever the explanation, the results were very apparent. Growth was severely checked, the plants fell behind those on the other plots and remained so right up to harvest. The average yields of roots obtained in the experiments were:

Normal or ridge cultivation	11·81	tons	per acre
Cultivation on the flat	11·05	,,	,,
Rotary cultivation	9·40	,,	,,

These yields are well below what would have been secured by full manuring, which was withheld so as not to mask the cultivation differences. Attention is directed, not to the actual yields, but to

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the differences. The difference in the first two figures is not significant, but the difference between either of them and the rotary cultivation figures is statistically significant. We thus have the striking result that a form of cultivation definitely superior in the early and presumably critical stages of growth produces serious adverse effects at a later period.

As far as this single experiment goes, it could be taken as disproving the usefulness of rotary cultivation, but in my view such a conclusion is too drastic. It is true that in the soil and weather conditions of this particular experiment it failed in comparison with more orthodox treatments, but it cannot be condemned completely on this account. It is possible, for instance, that if the tines had been set to produce a coarser tilth—*i.e.* more of a digging spade-like action than the fine comminution actually produced—better results would have been secured. It is hoped to continue this work in a variety of different conditions, because there is something inherently attractive about the idea of rotary cultivation. The principle is, as far as I can judge, a sound one, and directly utilizes in a natural way the fundamental characteristic of the internal combustion engine, which is the production of circular motion. It may be legitimately argued that, if our next advance in cultivation is to be the production of a tillage *machine* as distinct from a series of tillage *implements*, rotary cultivation in some form will be the solution.

Turning now to the second division of the field investigations, the efficiency of cultivation processes may possibly be increased in one or all of several ways. We can modify the soil or improve the implement, or, again, reduce the actual costs of cultivation.

One method of modifying the soil is to reduce its resistance. The use of farmyard manure or green manure in this connexion has been known for a long while. Our dynamometer results show this effect very clearly. The reduction in draft may be as much as 20 per cent. in cases where very considerable qualities of farmyard manure are added, but in ordinary farming the reduction would be less, although the accompanying effects of improved tilth and better water relationships would of course be secured as well.

A second method of reducing draft that has definitely passed the experimental stage and is awaiting commercial exploitation has been devised by my colleagues, Dr Crowther and Dr Haines, as the direct outcome of laboratory investigations. It has been known for some time that soil possesses colloidal properties. Dr Crowther and Dr Haines have utilized the fact that when an electric current is passed through moist colloidal material there is a movement of water to one of the electrodes. By insulating the coulter from the framework of a plough and passing a current down it,

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and making the mould-board the negative electrode, a film of soil moisture becomes deposited on the mould-board and acts as an efficient lubricator. Field experiments showed that a reduction of draft was secured whenever the current was switched on, and there is little doubt that the device could be successfully developed. It is of especial interest in its possible adaptation to soils that are very difficult to work in normal circumstances and also to such operations as mole drainage.

A third method which has been followed up at Rothamsted for some years is the effect of chalking heavy land. The operation was extensively practised a century ago, but the increase in cost of labour has caused it to be largely abandoned. We have found from our dynamometer records that a chalking of 10 to 15 tons per acre applied sixteen years ago is still causing an appreciable reduction in the resistance to tillage implements. The effect is a variable one: in very dry or very wet conditions it is not marked, but when the soil is moist, reductions of 14 or 15 per cent. in draft have been obtained. Further, the chalked area is ready for cultivation earlier than the corresponding unchalked strips. This reduction in draft has not hitherto been generally recognized, and it constitutes an appreciable credit item to set against the initial heavy cost of chalking. The question also arises whether lime in smaller quantities would also produce a similar effect, and, thanks to the financial co-operation of lime-producing associations, we have been enabled this year to lay out some experiments to test this point.

In dealing with the effect of chalk I mentioned that the state of the soil affects the dynamometer records. In the course of our experimental work we have frequently observed such effects. Loose soil, for instance, may have a surprisingly high resistance. Instead of sliding smoothly and in a comparatively unbroken furrow slice over the surface of a mould-board, considerable friction is developed, not so much on the mould-board itself as between the large number of independent lumps of soil. It is necessary to allow for this effect in the interpretation of records obtained in a field of variable texture. In the early stages of our work we selected, as far as possible, fields which, to visual inspection, appeared quite uniform. We were surprised to find that such fields were by no means uniform in the resistance offered to the cultivation implements. Variations of as much as 50 per cent. were obtained in different parts of the field, and could not be attributed to differences in moisture-content nor by any means entirely to variations in the amount of clay present in the soil. They seem, however, to be closely associated with changes in such properties as cohesion and plasticity, which were mentioned earlier as forming

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part of the laboratory investigations into soil tilth. Their immediate practical interest is in the bearing they have on competitive implement trials or on tests of new patterns. If the particular field in question had been divided up into strips a chain wide and one of them allotted to each implement (the invariable procedure in such trials), differences in the average dynamometer records of over 10 per cent. would have resulted, due to the soil variations alone. It is apparent that in such a test no reliable information would have been obtained as to the relative efficiency of the different implements. In fact the relative order of the implements would have been decided more by the chance of which particular strips were allotted to them than by their innate merits. The soil variations, fortunately, can be ascertained by a previous experiment and allowed for in interpreting the final results. Several years' work at Rothamsted has also shown that they do not vary from season to season. Those interested are referred to my paper in the *Journal of the Royal Agricultural Society of England*, 1925, for practical details as to how implement trials and comparative tests should be arranged.

In addition to the possibilities of draft reduction by improved design we must also consider another possibility of even more direct economic importance. This is the question of increased speed of operation. Our results have shown that, even with our existing implements designed for work at speeds around 3 miles per hour, very little increase in draft takes place for a most appreciable increase in speed. In the case of ploughing, for instance, an increase from $2\frac{1}{2}$ to $4\frac{1}{2}$ miles per hour requires only an extra 7 per cent. pull on the plough. In tractor-ploughing it is highly unlikely that the cost of the extra fuel needed to sustain the 7 per cent. increase in the drawbar pull would be anything like sufficient to outweigh the large saving of time by ploughing at a 60 per cent. greater speed. The limit is set, of course, by the extra fuel needed to propel the weight of the tractor and by the increased wear and tear. Nevertheless, the direct and indirect advantages of increased speed in all our cultivation operations are of such supreme importance that an advance in this direction is highly desirable. The only feasible way is a greater use of mechanical power. There has already been one successful example in the form of steam tackle, and the tractor will, in my opinion, provide another. It is well to remember that the tractor in agriculture is still in its infancy. The first considerable use on British farms dates only from the later stages of the war. With the passing of the abnormal war conditions tractor cultivation declined, but recently there have been encouraging signs of a return to favour. The machines

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have greatly improved in simplicity and reliability, and, even in their present early stage of development, their value for autumn cultivations in both dry and wet weather and for spring work has been conclusively shown. Nevertheless, we still have much to learn in this new development. It is not simply a case of substituting one form of haulage for another; there is a host of concomitant problems in adapting implements and cultural methods to the new conditions. Such straightforward questions as the relative merits of deep cultivation and subsoiling still await solution. Some experiments appear to show no advantage, while others show a considerable benefit. Such divergent results are to be expected until our knowledge of the physical effects produced in the soil is extended.

The fundamental point to be borne in mind in all work of this nature is that the form of power and the implements are only a means to an end—the production of a suitable seed-bed for the given crop, and the maintenance of appropriate soil conditions for the plant over the whole of the growth period.

Our best hope of systematic advance is to pursue steadily our investigations into the soil properties on which tilth depends and, as opportunities offer, to test our conclusions by selecting outstanding problems for practical field trials under a variety of different conditions. It is essential for the progress of our work that it should be critically reviewed from time to time by the practical farmers, the implement- and tractor-makers, so that the field trials may be designed to give the maximum practical information to all concerned.

CULTIVATING THE CHALK & BRICK-EARTH SOILS OF WEST SUSSEX

By H. DREWITT

Colworth Manor, Chichester

To a farmer the subject of this conference is his daily concern, although perhaps he seldom tries to analyse the reasons for what he does.

Modern cultivation of the soil may be said to have begun when the common fields were enclosed and distributed among individual cultivators, each of whom was then, for the first time, able to carry out his own ideas on the subject without reference to what his neighbours were doing. Up to about forty years ago the preparation of the soil was carried out with the same implements, improved

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in detail perhaps, as had been used for centuries; then came the spring-tined cultivator, the disc harrow, and finally a machine of moderate power to draw them—I mean, of course, the tractor.

To understand what the farmer aims at it is necessary to understand why he directs his aim in the particular direction it takes, or, in other words, why he grows the crops he does. The chalk soils of the South Downs and the brick-earth of the plain between them and the sea require very different management and cropping. The soil overlying the chalk varies from patches of heavy clay, where beans can be grown, to the thin white soil 3 or 4 in. thick, where rabbits and stones are the only profitable products; but in many of the little valleys and combes there are pockets of reddish earth with a ragged flint, which are as highly esteemed for their cropping powers as the brick-earth. All these varieties of the chalk are easily worked with two horses, and although they dry quickly, crops upon them will withstand a considerable drought, as the chalk just below keeps the roots of the plant cool. These conditions largely govern the crops grown and therefore the cultivations made for them.

Wheat is not much grown; where it is, great care must be taken to consolidate properly the soil at seed-time and again after the winter frosts are over. Where a breeding flock of sheep is kept, they must have the first consideration; therefore no chance must be neglected to ensure the root crop being got in at the proper time. The stubbles will be ploughed the first time as soon as the winter catch crops are sown, ploughed again in early spring, worked to a tilth, and then after ploughing and working a third time there should be little difficulty in getting a plant of swedes or rape to stand, if care is taken to conserve the moisture while the seedling is making its first roots. Of course a good down to feed the ewes on is of the greatest assistance to the arable land, and although the sheep for generations have been carrying away the fertility of the down to the arable, it seems to make little difference to the grass. It is difficult to see what future these chalk farms have; a very large amount of capital is required to lay them to grass, fence and provide a water supply. Considerable tracts of the downs have already become covered with worthless bushes, thorns and brambles.

On the brick-earth of West Sussex practically any crop except beans and hops can be grown successfully; there is a sufficient depth of staple to conserve enough moisture to withstand almost any drought. Nearly all of it can be worked with two horses, so long as care is taken to avoid treading it when it is wet weather; in fact we have a saying that we often get on faster by keeping the horses in the stable than by letting them muddle the ground about when it is wet.

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Formerly the four-course or Norfolk rotation was strictly followed, now the aim seems to be to grow as few roots as possible; hence it follows that a much smaller head of stock can be carried, less capital is wanted, and a lower scale of production is aimed at. If an outlet can be found for it, sugar-beet looks like becoming a popular crop; 1000 acres were grown last year, and 4000 are promised for this season.

For wheat the land requires to be ploughed with two horses, pressed, and harrowed about six times. Much of the seed is broadcasted on a stale furrow; it is rolled and sometimes harrowed in the spring, the object being to get the ground thoroughly consolidated round the root; for this reason bare fallows are not much liked, as the land is left too light.

White winter oats frequently follow the wheat or, more rarely, take its place. After this crop is off the long preparation for the root crop comes. If time allows, the land is ploughed with two horses or a tractor directly after harvest, then ploughed again in the winter with two or three horses; the stale furrow is broken down in the spring with cultivators and rollers, and, after the final ploughing, is well worked to a fine tilth to get the seed well started—this is the place in the rotation where the tractor with a disc harrow is of the greatest assistance, enabling long hours to be worked to take advantage of the most favourable opportunities. After the root crops are fed off or removed the land is once ploughed, rolled and disked, or rolled and harrowed and drilled with oats; or, where fed off, late sugar-beet may be put in.

When hard roads became general a former generation spent a large amount of labour in chalking the brick-earths, very greatly to their benefit; as they lay within easy distance of the chalk formation this work was thought to pay quite as well from the lessening of the work to make a tilth as from the increase of crop. It was made possible by the large number of horses kept to cope with the pressure of spring work, for in those days four or five ploughings for roots, with innumerable rollings and harrowings, were the rule. I have here the tillage book made when my father entered my present farm in 1870; there were 4 ploughings, 25 drags, 10 small harrows, and 8 rolls to get a tilth for swedes, and this was in a dry season.

Another way to assist in promoting a tilth is to sow deep-rooted crops; a clover ley ploughed after it has been down for two years will generally work well, and my limited experience of sugar-beet seems to indicate that the land usually works well after it.

While we owe a deep debt of gratitude to the agricultural implement-makers for providing us with our present equipment, in my case it is only a lively sense of favours to come. What I want to see is a machine which can be drawn by a tractor that will rapidly

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and thoroughly move the top 3 in. of soil directly after harvest to start all the weed seeds growing. I want also a combined machine of light draft which will cultivate, roll and harrow in one operation; it would be a miniature edition of the combined implement moved by cable engines as used in Lincolnshire and Sussex. Finally, I want a tractor which will not take half the power it develops to move itself along and which will not consolidate the land—something like the dragons which move and have their being at Aldershot, I mean.

ON THE LAND IN SOUTH-EAST ESSEX

By J. STEEL

Burnawne, Rochford

Before going into the cultivations for the various crops I should like to draw your attention to the climate and the class of land I had to work. The south-east of Essex is without doubt the driest district in England, the rainfall hardly ever reaching 20 in. The district was subject to long periods of drought in the spring and summer, so spring cultivations had to be hurriedly carried out if successful crops were to be produced. With the dry east winds moisture evaporated quickly, making a good tilth difficult to get unless you had a good command of power just when wanted.

The farms were situated on the north bank of the Roach, a tidal river, with a gentle rise and facing south; land adjoining the river was light, lying on sand and gravel, always dry, and could be worked at any time of the year and producing early crops. The fields on the rise were a better class, lying on various subsoils, and on top of the rise it was gravelly and much given to burning in parts. A narrow band of clay ran across the farm, and to get early cultivation I had to do considerable draining, which was very successful, and let me get on with work that without the drains would have delayed getting in crops quite a fortnight owing to wet spots on every field. Had I known, I might have used the mole-plough, which I ultimately did in some fields with great success and at much less cost.

As a guide to system of working. The farms extended to 700 acres, about 400 arable, carrying a stock of 50 milk cows with followers, 150 breeding ewes, and latterly 50 sows. All the land before my tenure was farmed on the stitch; fields that were heavy I laid down to grass and kept arable only what could be worked on the flat. Cultivations were carried out with horses and tractors, and steam tackle was always available on hire when wanted. Having been an

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engineer I was favourably placed for keeping down expense in tractor repairs, this work all being done on the farm by myself and the drivers. I found the men took a more intelligent interest when once they learned to do the overhaul, and some of them turned out good mechanics.

I will deal first with potatoes, as being the principal crop on the farms. The stubbles got 15 loads of dung skimmed in with a two- or three-furrow tractor plough, and in October or November steam-ploughed and subsoiled, ploughing 10 in. and subsoiling 8 in. deep. Some of this work had to be done in the spring, at the earliest possible date in March as the weather suited: the autumn ploughing and subsoiling I always preferred, as it made the spring cultivations easy. When steamed in the spring the land ploughed whole and was difficult to break down, unless the weather was very favourable, and very often took the double of the work and never made such a fine seed-bed for the potato crop. I used the subsoil only once in six years; when not subsoiling a balance-plough was used with three horses or the tractor. The spring cultivations, before planting under ordinary circumstances, were set folding harrows, or disc, then cultivated both ways, set of harrows, open the land with double furrow combined manure-drill, sowing 8 cwt. artificial manure, planting—with eight women—out of chitting boxes, or bags if late variety, then covering with single baulker and doing 4 acres per day. I had a special two-wheel trolly for carrying the potato boxes in front of planters, the wheel shod divided to straddle the drills or baulks so that the land was not kneaded down where the potatoes were planted. Before the potatoes came up the drills were harrowed down, then a cultivator run along the rows, doing three rows at a time, hand-hoed, cultivated again, sometimes twice, according to the state of the land, then half moulded by cultivator with breasts, three rows at a time, and the final moulding by single baulker before the tops were met in the rows. My opinion is, in growing potatoes you must do your deep cultivations before planting; once planted you have done the deed, and no cultivations will ever get your land in condition for a successful crop. I have tried deep broadsharing, skimming after planting, but to me, on the land I had to deal with, it did more harm than good.

Wheat followed potato crops and clover leys, ploughed 5 or 6 in. deep. I always insisted on the ploughmen setting up the furrows when ploughing; it was an eyesore to me to see furrows flopped on their back; it makes the land easier to harrow and is drier right through the winter. The depth of the furrow is the guide to the width. Land ploughed well does not cap in the spring. If you have something on top you want buried then use a skim. Clover ley I balance-plough 6 in. deep. A set of harrows in front, a light set

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behind, should be ample to prepare and cover the wheat when drilled. In the spring a ring roll, with a heavy set of harrows fixed behind, pulled by a light tractor both ways, should be all that is required. If you are pushed for time, from daylight to dark you should cover 30 acres; it would take many horses to do that in one day. When clover is drilled I horse-hoe the rows. Barley I mostly put in after wheat or oats, using a broadshear or cultivator to clean the stubble and spear the fallen grain, then plough as for wheat, drilling in October or November with a dressing of 5 cwt. Liebig's manure; this produced 6 to 8 qrs. of good malting barley. Spring sowing never produced the quarters nor the sample on my land. I used Plumage Archers. The barley was generally my best paying crop. It was many years before I learned the value of autumn-sown barley.

Oats I put in, about half Grey Winter, drilled in September, and Abundance in the spring, drilling end of January or beginning of February; if later than the middle of March they were generally a failure—the weather got too dry and they bottled. After early potatoes I drilled rye in first week of August for feeding my ewes and lambs in February, when it was generally a foot high and had to be finished by the 1st of April or it ran to seed; this land was balance-ploughed, and put in with kohlrabi and mangel in April without manure, as the sheep were heavily fed for fat lambs to go to market at Easter. My light land near the river mostly produced three crops in two years. Mangel I gave up growing three years ago, unless a few for the sheep when feeding the rye. They became too expensive to grow to feed the dairy cows. I put the water before the cows; that cost me nothing, and the average yield of milk went up from 700 to 1000 gallons. Still I have no doubt they had a little extra meal.

If I had a field that wanted cleaning I put in tares and oats in the early autumn and either fed off with sheep or made it into hay, steamed it up with the cultivator, and followed with kohlrabi seed or turnips and fed off with sheep. I found this just as good as a fallow, and the crops paid for the work.

When I first started farming in Essex my expenses for ploughshares was a serious item to one who had not a penny to spare. I consulted an expert plough agent from the North, stating the stony nature of my land and the cost of shares—from 2s. to 5s. per acre for ploughing. He sent me on trial a chill digging plough with reversible points and shares, that reduced my costs of ploughing irons from shillings down to one or twopence per acre. The plough did better work, was easier to draw, and I never used any other ploughs till the tractor-plough came on the market.

In the last few years the tractors did practically all the ploughing,

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cultivating, rolling, harrowing, and cut most of the harvest. They pulled all the potatoes from the fields to the road for loading on the motor-lorry. I had a contract for delivery by motor-lorry to market or station at a price no horse-labour could touch. My horse-power was reduced by half and I always had the work well in hand. If you have heavy and deep cultivations to do, always get the steam tackle; you will only strain your tractors and make half a job. Never ask a tractor to take more than a comfortable load, and then you will find its capacity for work will more than satisfy any farmer. I have seen land in Lincolnshire, and even in south-east Essex, where you could put in a crop with little effort, shut the gate, and return in the autumn and get a rich reward. Lucky farmers who have it. But the great bulk of the land will not produce of its best without somebody sweating. I have tried to cheat the land of its cultivations when I was pressed for time, with the result I was poorer and sadder, but I hope a little wiser.

It takes a lifetime to learn the little one knows.

I have given you a rough outline of the cultivations in the district. No farmer can tell his neighbour exactly what cultivations will be needed to put a field in condition for a crop. The land varies from field to field, from farm to farm, and year to year. No book can give the information, yet something tells you after long experience and close attention to the weather conditions what implements to use, and when and how, to get the desired result.

Now I will tell you a story that has nothing to do with cultivations. In the dry summer of 1921 I had a 15-acre field named Stoneylayes, with white clover for sheep-feed. As the name suggests, it was the worst arable field I had on the farm and the crops that came off it were often in debt. The shepherd had the folds set, and the day before they were to be put on I chanced to go into the field, and finding it very forward and coming into flower it struck me it would be of little use for the flock as feed and might be of more value for seed. When I told the shepherd (feed was scarce) my intentions, I have seldom seen a more angry man. I cut the seed, but it was so short it had to be thrashed in the field. I had even to hand-rake it to gather the heads. I showed a sample to a merchant, who asked me to send it on at once to fill an order for New Zealand. When dressed by his machine the sample was very fine, and yielded over 9 bushels per acre. The sheep-feed value could not have improved my flock £50. When the cheque came from the merchant, that wretched poor field gave me a profit within a few pounds of £500! A bee-keeper, just before the clover came into flower, put a strong hive of bees in the corner of the field, and in the short time it was in bloom gathered 1 cwt. of honey. I wonder if the scientific staff of

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Rothamsted could tell me how much I was indebted to these busy little creatures for such a bumper crop of seed.

Never despair. You never know where golden treasure may be hiding, but keep your eyes open lest you miss it.

CULTIVATION OPERATIONS ON THE YORKSHIRE WOLDS

By J. H. SPILMAN

Gardham Farm, Beverley

It is only with the very greatest of misgivings that I venture to address you this afternoon. I am very far from considering myself either an authority on cultivation or yet a public speaker, and I must ask you to deal leniently with me as "a first offender."

It has been said that the best speakers are always the worst farmers, so I shall not trouble you with any further apologies, except to say that my only excuse for addressing you at all is a sense of gratitude for the help and assistance I have for many years received from Sir John Russell. Much as I appreciate the honour of addressing you, I should have hesitated to take advantage of the opportunity so kindly extended to me had it not been for a feeling of indebtedness and a desire to try to show my appreciation, if only in a very small and inadequate way.

I need perhaps only add, in justification of my presence here, that any information I may be able to give you is the outcome of a lifelong experience in the district of which I speak, farming on both light wold land and on heavy warp alongside the Humber Estuary.

The remarks which I am about to make apply to the East Yorkshire Wolds, which, for the most part, consist of only some 4 in. of soil overlying the chalk. There is considerable variation in the texture of this soil and there are at least three different types. The first contains a large proportion of small loose flints, and whilst spoken of as light land is nevertheless very heavy on implements in wear and tear. The best types of barley land are, however, those on which what we call chalk grits are freely mingled with the soil; while the third type, free of both flint and grits, is, contrary to what might be expected, generally the poorest of the three—so much so in fact that it is often referred to as "deaf" land. Such land as I am speaking of is generally farmed on the four-course system, the most favoured rotation being Roots, Barley, Seeds, Wheat or Oats. On some of the heavier lands at the foot of the Wolds a five-course system is often adopted, a second white crop

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being taken, with the assistance of artificial manure, after the wheat.

Before going any further it would perhaps be as well to point out that it is quite common for farms on such land as I am speaking of to run up to 600, 700, 800 and even 1000 acres, practically all of which is under the plough, pasture grasses being practically unmet with. It is on such land that sheep supply the keynote to the whole system followed, and the old axiom has it that a sheep to the acre is an essential to good farming. Cattle, which play a necessary part, are bought in in the autumn and wintered in the yards, where they are fattened and sold in the spring, often, unfortunately, at a very considerable loss in these days.

Throughout the winter the sheep are folded and fattened on the turnips, the treading and manuring which the land thus receives being a very essential feature of the rotation; it is on such land that the value of the golden hoof has probably its deepest meaning and significance. The manure left in the yards by the cattle is carted on to the land for the root crop, the greater part of which is generally swedes, which are also given a dressing of perhaps 3 cwt. of bones and 3 cwt. of superphosphate or other phosphatic manure. There is a common impression that bones in a dry form are preferable to dissolved bones or finer forms of bone-meal, the prevalent idea being that the decomposition of the bones is hastened and controlled by the amount of chalk in the soil, the coarser forms of bone manure consequently leaving a greater residue, which acts beneficially on the following barley crop. Some of you may perhaps be able to enlarge on the scientific aspects of that suggestion.

When manuring follows the lines I have just outlined, it is not as a rule found necessary to introduce any further artificials in such a rotation as I am speaking of, though a spring top-dressing may of course at times be found necessary for a backward corn crop.

Turning to the rotation as outlined, we are commencing with a bare fallow in preparation for roots in the form of swedes, white turnips and perhaps a few mangel.

When harvest is early and any part of the land is full of couch grass, or, as it is termed in Yorkshire, "Wicks," we plough over lightly and work the land down so that the fallow harrows will pull out the grass, which is rolled into heaps by a Parmiter harrow or a chain harrow, the rubbish being then loaded into carts and tipped into one huge heap and burnt, or in some cases raked into small heaps and burnt without carting; but I prefer one large heap, because the ash, when laid a year, is most useful to mix the artificial manures with, and when drilled with the seed helps it to germinate very much better.

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It might perhaps be as well here to explain that the method of sowing turnip seeds, almost universally followed, is by means of a drill known locally as a "Kirby Moorside," which combines the two operations of drilling and manure-distributing in one.

After the rubbish is heaped up and burnt the land should be ploughed over and left until mid-winter, when, if it is still dry enough, or slightly frozen, it should be again ploughed, thus leaving all weeds such as buttercups and the short couch grass to be more easily worked out in the spring.

Before the war it was customary to row and manure with farmyard dung, which had been in a hill for some time, all the land required for swedes, and to sow the soft turnips on the level; but now the greater quantity of roots are drilled on the level on account of the saving of labour and time, and by getting more rows to the acre quite as much weight is secured, but the individual roots are not so large.

In a very dry season there is a custom in Yorkshire which has proved successful—that is, to only top-work the land in the spring and, just previous to sowing the swedes, to manure with well-rotted dung and instead of ploughing in to drill the seed amongst the manure and follow with harrows only, thus saving the turning up of the soil and the consequent loss of moisture.

Plumage is the favourite barley at the present time in the East Riding, followed by Plumage Archer, but the last two or three seasons have not favoured the growing of best malting barley in that district, the cause being unfavourable weather at a particular period, possibly a slight frost at ripening time.

During the war, tractors were used a great deal for the preparation of the root land, but since the price of horses and oats have fallen so much, it is found cheaper to depend upon the latter, except in very busy seasons and dry periods.

After the turnips have been eaten on by sheep, to which oil-cake and corn have been given, the land is ploughed very lightly; in fact there is a saying in the East Riding that "the more baulks the more barley," signifying that the lighter the ploughing the better. I perhaps should say here that the clovers are sown along with the barley, and they are usually the best plant where sown early. Frost does not appear to injure the young plant, and they get established before the long dry days. The custom in regard to grazing seeds is to sow rye-grass (Italian) upon half the land, the other half being sown with clovers only, and at the end of the four years the seeding is reversed, so that wheat follows the clovers and oats the rye-grass.

Very little clover or grass is cut for hay upon the Wolds, both usually being grazed by sheep and cattle, so that fog or aftermath

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is very scarce; and thousand-headed kale, rape and mustard are usually sown for the first eating, followed by a break of beefheart or early mammoth turnips.

This being a period (August) when the lambs are difficult to manage, the best and safest food is early turnips, even if a few have run to seed.

After the clovers have been summer-grazed, half are sown with Little Joss Wheat, the land being ploughed with double-furrowed ploughs, harrowed down and drilled at the rate of 3 bushels per acre early on, and increasing the quantity as the season becomes advanced; if the land is wet enough, 1st October is the time to commence.

Should the weather be very unsettled, the press-drill is used, so that all may be kept worked close up to the plough. The remaining old seeds are useful to run the ewes on when the turnip land is extra dirty, where they are usually folded behind the hoggs. The hoggs are folded in front of the ewes and given the first bite of the turnips, which the following ewes eat down and clean up. The greater number of ewes the more quickly the ground is travelled over, which is of considerable advantage to the hoggs and brings them to market at an earlier date than when left for any considerable time on any one fold.

In the large folds of sheep it is now customary to use a combined petrol-engine and turnip-cutter, which greatly assists in getting the sheep quickly fed.

About January the rye-grass seeds are ploughed and pressed, double-furrow ploughs being used and three horses to a plough, or the seeds are left until early February, and should the weather be open they are press-drilled, preferably with Goldfinder oats; but should the season be later for any reason, an earlier oat such as Abundance or Victory should be sown, and the surface well rolled to ensure solidity, as it is very seldom old seeds are solid enough, particularly when containing rye-grass.

I mentioned earlier that the deeper Wold land or land at the foot of the Wolds is farmed on the five-course system, where sugar-beet, potatoes and beans are grown, but the four-course is considered to be the cheaper way and less labour is required, the land being automatically kept clean by the quick recurrence of the fallow or root crop.

Having endeavoured to give you some indication of the methods followed on the Yorkshire Wolds, it will hardly be necessary for me to point out that the Wold farmer is at present going through a very trying time, with his necessarily heavy labour bill and fat sheep, cattle and barley as his main sources of income. He has to seek consolation in such remarks as those of Mr H. German, an

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ex-President of the National Farmers' Union, who, after an extensive tour of the district last spring, stated publicly that he was prepared to go into any county in England and say that nowhere had he seen land better farmed than on the Wolds of East Yorkshire.

SPRING CULTIVATIONS IN THE WEST

By J. JOYCE

Preston Bowyer, Milverton, Somerset

In the successful cultivation of a farm no idea can be entertained of cultivating it intermittingly, spasmodically, or as an off-and-on business.

The farmer's watchfulness, attention and desire to do what is needful to be done must constitute a continuous weight of responsibility on the mind. To do the right thing in the right time, or as near to that time as possible, involves keen personal watchfulness of every operation for every crop, and that attention must be unceasing.

The novel, *Sussex Gorse*, by Sheila Kaye-Smith, which I read a year or two ago, if stripped of its slight exaggeration describes truthfully, I think, what takes place in the life of a successful cultivator of the soil. His care and love for the farm and the continuous pressing forward with the work even when things look their worst is a good description of his life's work.

Spring Cultivations in the West must mean, I take it, cultivations applied to the soil by farmers in the West of England from after Christmas each year until the late summer.

Taking over from the autumn in describing spring cultivations, no matter whether in the east or in the west, it must be taken for granted that the previous autumn cultivations on the farm have been attended to and that we take over in January, say, lands that have been properly managed during the previous four or five months. We must assume, for instance, on the heavier land, that that portion of it which has not been planted in the autumn and which is intended for spring crops has been ploughed up rough and deep, so that the hoped-for frost and thaw have what we call "weathered" this exposed soil and rendered it amenable, with a very little scratching, to the production of a fine tilth and an ashy surface.

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We must also assume that on the lighter soils, apart from those portions that are in to "leys," root ground seeds and catch crops—and by "catch crops" I mean trifolium, trefoil, vetches, rye, etc.—that those fields which were not clean enough to be thus seeded out the previous spring or last autumn after cleaning—that these also should have been ploughed up, like the heavy lands, in the late autumn or winter, ready for cleaning in the spring or summer.

Objects

The main objects of cultivation are:

To so thoroughly move the entire soil to such a depth that the rootlets growing out of the seed sown or out of the plants inserted will readily and freely be able to penetrate round them, below them and above them, and so be easily able to acquire the nourishment they need, or at any rate to get at what nourishment that particular soil contains for them.

To so pulverize the soil thoroughly and deeply as to leave no hard places in it, but rendering it consistently all alike down to a sufficient depth, so as to increase its powers for the absorption of moisture, and for the retention of that moisture for a good long period in the dry weather.

This stirring and mixing also equalizes and distributes the plant food in the soil, and by hoeing, spudding and other operations to destroy the weeds injurious to plants.

Cereal Crops

We will take, first, the spring cereal crops and the cultivations necessary and helpful to them—cereals such as oats, barley, dredge corn, tares or vetches, etc.

Returning first to our heavy land again, where it has been ploughed and "weathered" by the frosts and thaws. Provided that such natural events have happened to them, and that the month of March is also a genial one—dry, with a few showers—these lands are as easily cultivated for spring cereals as any land you could wish for, but, of course, provided these things have happened.

We just harrow the furrows the same way as it was ploughed, with sharp-tined harrows, and then harrow crossways with the same; we apply, perhaps, a spring tooth harrow a little deeper but not too deeply, then another harrow in front of the drill and a harrow after, and generally we should have a good seed-bed.

On the lighter loams and more friable soils such as the "leys," and where the trefoil or other catch crops were growing, these

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should be ploughed down, and in doing so, all that which was on the top should be turned well underneath. And in the West we have come to use for these light soils the turn-over or one-way plough, either with a digger plate or the longer broadside, and we also use the spiner.

Personally, I use a digger plate always, for everything, and never change them, except for new ones, and nearly always use the spiner.

This ploughing should be performed during the months of January and February. Then in late February and March opportunities in the weather are waited for, and all available teams and horses are out to till the best lands first, the poorer lands a little later; and I may say here that the poorer our land is in heart, or the more deficient it is in residual manures, the more particular we must be in the cultivation, and an ideal seed-bed must be secured in order to grow a crop.

Conversely, the saying exists in the West that a farmer whose land is in tiptop condition and fertility may cultivate and drill his land when he likes and how he likes, and still will grow a good crop. This is not altogether true; but what is true in it is that crops in land which is in good heart will get over difficulties much more easily than those on poor land. But I still hold that no matter how good a condition the land is in, the best that is known suitable for that soil and crop should always be done to it. Although a farmer may get what looks to be a good crop on good land in good heart *put in badly*, yet it may not be a good crop to him; and there is always this unknown factor, What would that crop have been had it been put in in first-class condition?

There is an old saying, and a true one, "Better to be out of time than be out of tune." Better to be late and the crop put in well than to be early and the crop put in badly.

With all spring cereal crops, at the time of drilling the seed the soil should be fine, loose, and well mixed, so that one can easily drag one's toe along the soil to a depth nearly up to the instep, and, if called upon, be able to drag it from one end of the field to the other without coming across any entanglements, hard places, bulges or lumps. What I generally do on entering a field just ready to be tilled is to search for the worst places and try dragging along my toe there, and if my foot will not go easily, then the soil of that field is not fit to take the crop, and further cultivations must be transacted to make it answer this test.

On the land where roots have been during the autumn and winter, and these have been folded down with sheep, there has always been a contention as to what depth this land should be ploughed for spring oats and barley.

Now if the land is otherwise poor except for this crop of roots

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which has been grown, and the manure resulting from the same, I have no doubt, to get as much back again as possible in the coming cereal crop, it would be wise, perhaps, to plough only 4 or 5 in. deep, work it with implements at that depth, render it loose and fine, and put in the crop. But where the land is in good heart, and has been previously well managed and farmed, and the soil will allow of it, I prefer the deep ploughing—about 7 or 8 in. even here; mix it all up together, get the soil evenly fine and loose, 6 in. deep, and put in the crop. Now the cereals are in. The only thing that remains to be done to this soil if the weather keeps fine is, before the grain appears above ground, to give it another harrowing, and when it has appeared, and got well up and strong in the blade, we then put in the seeds in the land that has previously been to roots, or in the land that is in rotation for seeds, clover seeds, etc., for hay fourteen months after; while in the remaining part that is not intended for hay the year after the corn is harvested, and yet is free from couch, we seed out in the corn trefoil, at the rate of about 12 lb. an acre without Italian, and 8 to 10 lb. an acre with about 1 peck of Italian.

Cultivations for the seed, provided the corn was put in as described, would be a light roll, sow the seed, then drag light seed harrows or chain harrows over to cover—for the seed should be only just covered—then roll with a rather heavier roller.

Mangold Crops

Probably the cultivation of beet is similar to that of mangolds, but my experience of beet-growing has been for only three years, and I feel I may have much to learn respecting it.

I maintain that where either mangels or beet are grown, to save expensive hauling, both of the farmyard manure for these crops and also hauling away the roots when grown, a course of cropping should be adopted, and a long-sighted plan should be made for the growth of these crops, so as to save as much long-distance cartage as possible. That would mean that a certain number of fields or parts of fields should be selected near a good road if possible, and also not too far from the buildings where the manure is made; and as mangolds can be grown often on the same land, much economy of labour and expense can be afforded by this sort of long planning.

Personally, I have six fields, all of them abutting on to a good highway—three on one side and three on the other of it—on to which the dung can be carted up in a heap at any time there is to spare. At a place where these six fields converge we place our mangold clamp every year. It is a fairly long clamp to the inside of the road hedge, and we have three gates leading from the road to this clamp—

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one at the far end of the clamp, one at the near end, and one in the middle—and thus we have a hard road to most of the mangold clamp for the purpose of carting the roots both *on to it* and *out of it*, and also the dung for them earlier.

The mangold crop is usually taken in the West after a cereal crop the previous year, although some farmers lately have come to put them in after swedes or kale, fed off late in the spring.

Personally, on a loam fairly light, I grow the mangolds every year after a catch crop of early trifolium and vetches mixed. This trifolium and vetches is the first crop to be tilled the previous August. After the corn is carried, the field is skim-ploughed and rubbed out fine with chain harrows, early trifolium sowed in at the rate of 20 lb. an acre and 1 to 2 pecks of vetches broadcasted by hand. The stubble and any weeds that were rubbed out by the chain harrows are ignored while seeding, then when dry flung about over the surface plant of trifolium. This trifolium crop is begun to be folded about the middle of April. The farmyard manure, which has been carted out in a heap all ready during the winter, is put on it as the sheep leave the folds, and dunging and ploughing about 8 in. deep is kept up to the hurdles with the one-way plough. Part of the field is put in to mangolds about the 7th or 8th of May. The sheep generally have finished and come out on the 10th or 12th May, and the remaining part of the field is got in by the 15th or 16th May.

Those who put their mangolds in after their last pieces of swedes are folded off treat the soil for mangolds in much the same way as I do after the catch crops which I have described.

In a very dry spring, possibly, the mangolds after swedes or kale, or after a winter fallow, would start away a little faster than after the trifolium and vetches, though for thirty years I have followed the other course and never failed to have a fair crop of mangels or a good one.

On heavy land it is very necessary to plough down the dung deeply in late autumn or early winter, and allow the frost, and thaw after, to pulverize it; and I notice the best managers on this kind of land do not give it a lot of spring cultivation, except with the sharp-tined harrows, to get an even, fine surface at a depth of 2 or 3 in., and they generally put in the mangolds at the end of April or just the beginning of May.

With the loams and lighter soils, other than after the catch and swede crops that I have described, the dung may be ploughed down later in the winter or spring, but the ploughing should be as deep as the soil will admit of, up to 8 or 9 in., both where there has been a catch crop and where not. And I like a good deal of stirring and mixing, gradually rising in depth with the implements

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to finally shallow harrowing and rolling, and this leaves a fine, loose tilth for 2 or 3 in. only on the top, with the remainder of the 8 in. of soil gradually tightening as it goes down. This can be accomplished by first loosening and mixing the soil as deep as one can without pulling up too much manure in the earlier workings, and with the treading of the horses, and the harrowing and rolling later, this firmness in the bottom and fineness and looseness on top may generally be accomplished.

We drill the mangold and beet crop with drills 18 in. apart, putting in plenty of seed. A harrow over after the drill completes the process of planting.

The Swede and Turnip Crop

In the far west counties—Somerset, Devon and Cornwall—swedes are not planted until June, and in my immediate neighbourhood, and the red soil from Taunton down to Exeter and below, not generally until nearly midsummer. Common turnips follow in July.

First-class feeding for ewes and lambs in the spring can be got with mixed swedes and kale planted as late as the 10th July, and this date is about the ideal time for turnips if they are not required early in the autumn.

We need not deal with these crops on heavy land, for they are seldom planted in it. On the lighter soils, where the climate is good, early and late trifolium and vetches are often grown as catch crops in the same year previous to these root crops. Personally, I grow mangolds after trifolium, beet after trefoil, swedes and kale after trifolium and winter vetches, and common turnips after vetches and rape sown in the early spring, keeping the whole of the land constantly cropped.

In order to grow roots successfully after catch crops—that is, the two crops in the one year—it is necessary for the plough to follow tightly up to the sheep-folding, and that all the machinery, horses and man power be kept up to the mark; and the farmer himself must be able to "catch" opportunities as they occur, and the land must never be allowed to be foul, although with these crops always growing it is difficult for the farmer to boast absolute immunity from couch.

In the hill country and less favourable climates in the West, where catch crops are not suitable, swedes and kale and turnips are grown after a corn crop has been taken the previous year, with the errish ploughed in the autumn, the land allowed to lie during the winter, and cross-ploughing taking place as early as possible after the cereals in the other lands have been put in

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and teams are available; then after cross-ploughing thorough cleaning of the couch and other weeds takes place, and the land is ploughed often two or three times more, the last ploughing taking place in June for swedes, and the end of June or July for turnips.

This constitutes a thorough pulverization and cleaning of the swedes and turnip land on the hills where a five-course system is generally adopted, and with two years down to temporary grasses and one year to roots and two to corn.

Weeds and their Eradication, etc.

I now deal with the third object of cultivation. A maximum crop cannot be grown on any land encumbered with weeds, so that the killing and clearance of them is absolutely necessary and must be proceeded with. They cannot, as the Scriptures say, be allowed to grow together till harvest.

With the crops that are drilled, such as the root crops, we use the horse-hoe and the hand-hoe, which not only kills these weeds, but also moves and aerates the soil; and the old saying is that the more the roots are pulled about the faster they grow, and the soil also seems better able to retain the moisture in a dry time with plenty of early hoeings.

Corn crops are often pestered with thistles, dock weeds, poppies, wild oats and the charlock plant, and many other smaller weeds of less consequence.

Thistles, if not cut out and fought with, will greatly lessen any crop. I have found the best way to tackle the common thistle in arable land is by constant deep ploughing for all the crops, and then most of them will disappear in time. One never sees the best farmers with a large amount of thistles growing, and it is to this one thing that I principally attribute their disappearance: most good farmers plough and cultivate deeply, or as deep as their soil will admit. My father impressed on me that neither thistles nor coltsfoot could live long on the same farm with a good farmer.

Charlock. I maintain that it is not economy to grow charlock and crops together, even in cereal crops. For myself, if I had now a charlock field—and I had over 20 acres thirty years ago where charlock was as thick as the corn—I should decide on one of two courses: either to get rid of the charlock, or lay down the land to grass.

Charlock can be got rid of, and it will pay for ridding, if arable crops are persisted with; and the same man who gets rid of it will never allow it to get back again, but another man may who comes

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after him and who has not seen the successful fight which caused its disappearance.

Docks, of course, are not difficult on most lands, but they need hand-digging and pulling, and to clear them there must be rigid picking after the plough and harrows. The easiest weeds to destroy, I am told, are widow's weeds, for a man has only to say, "Wilt thou?" and they generally wilt.

There are other weeds to contend with, but my time is gone, and there may be questions which I shall be delighted to answer.

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THE DISCUSSION

Sir Daniel Hall, in opening the proceedings, said that the business of cultivation ranks as one of the most pressing economic problems of agriculture.

The methods and systems in use at the present time are for the most part closely related to those which were existing in the middle of the eighteenth century. Given plenty of cheap labour these methods may be effective in producing good and profitable crops, but when the cost of labour is high in relation to the value of the produce, the profit coming to the farmer from the use of them is seriously diminished. In 1750, when our methods of cultivation were systematized in their present form, the wages of a full-grown agricultural labourer were about 7s. per week. At the same time the price of wheat was from 50s. to 60s. per quarter.

Putting the wages in terms of wheat, one quarter would pay one man for seven or eight weeks' work.

In July 1927 the price of wheat was about the same (50s. to 60s.), but the price of labour was very different, and one quarter of wheat would pay one man for about ten days only.

It is obvious that where such changes of economic balance have occurred, readjustments of farming methods must be considered, and a great problem which arable farmers have to face at present is that of remoulding their practice to suit a period of dear labour and cheap produce.

Mr J. R. Bond, in congratulating Sir John Russell on arranging a conference of such wide interest, remarked that cultivation was undoubtedly the most costly single item which appeared in the budget of an arable farmer, and it was in all probability the one on which he had the least detailed information. From the papers which had just been read one could not help arriving at the conclusion that the actual principles of cultivation have not as yet been arrived at, for what one farmer laid down as essential, another immediately contradicted.

As an example of the chaos of principle which exists he called the attention of the meeting to the fact that most farmers use implements of compression (rollers, etc.) on their land, whereas gardeners and allotment-holders avoid compression at all costs, even laying down boards on the soil to walk on.

Mr H. Inskip said that during the course of the conference it had been stated that deep ploughing was an essential.

Speaking from many years' experience on his own land (light

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loam), he entirely agreed with this principle, and would even go so far as to say that nine out of ten farmers do not plough deep enough. In answer to a question relating to the depth of his ploughing, Mr Inskip replied that he "varied in depth from 12 to 15 in. with a furrow 15 in. wide." He obtained this with a "Single Furrow Oliver Plough," drawn by a Fordson tractor.

Deeply ploughed land stood the drought well, and one only had to consider the cultivation given for such plants as sweet-peas, which involved deep trenching, in order to realize that on some lands the principle of making the crops search downwards for their food and water could be used with profit.

Mr W. HASLER, whose land embraced the heavy clays of Essex, stressed the present cost of production coupled with the low price of the products. He thought that there had never been a more pressing need for a reduction in the cost of cultivation operations than at the present time.

The problem of deep ploughing was one which, in his opinion, needed careful consideration; for should the ploughing be too bold, the ultimate result would be the laying on the surface of the field a large amount of useless soil. This applied especially to steam-ploughing; and the depth at which the plough was to be set, when such tackle was used, was one which only the farmer with a full knowledge of his field could answer.

Mr J. G. STEWART stated that he had been very interested in the results obtained from the experiments in Rotary Cultivation. He was of the opinion that more beneficial results would have been obtained on a different soil.

In the south of England one of the most difficult operations to perform was that of obtaining a level crop with all under-sown "seeds." The headlands and the portions of the field by gateways invariably showed a good crop. In mid-field, however, the result was inclined to be thin. Mr Stewart put forward the idea that this difference might be accounted for by the fact that the headlands, having had more traffic on them, would naturally be more compressed, and the "seeds" would therefore be only very lightly covered, but at the same time would rest on a moist bed; whereas in the centre of the field they would most certainly be sown deeper, and on a looser bed. It seems therefore that there is a general tendency to cover seeds too deeply.

In drawing attention to the many multiple and labour-saving agricultural implements which were in everyday use in America Mr Stewart remarked that he rather thought they were "children of necessity, rather than of perfection," and were the outcome of an

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endeavour to cultivate and harvest immense areas with the minimum amount of man labour.

Substitution of crops might in some cases save labour, and kale was perhaps to be preferred to turnips, since there was a definite saving of labour in the cultivation of the crop.

Mr J. H. SPILMAN did not agree with the last speaker (Mr Stewart), and said that, in his opinion, there was not a crop which keeps the sheep so long on the land as that of turnips.

On the Wolds the practice of growing turnips for sheep-feed, in preference to kale, was almost universal. He supposed that the reasons were, first, that turnips did not exhaust the land so much as kale, and secondly, that the crop went further. In his district they reckoned that one acre of turnips would winter ten sheep.

The sowing of turnips was performed mainly by the use of the "Kirby Moorside" drill—an implement which sowed the seed and manure in one operation, and therefore effected a considerable saving of man- and horse-power.

Mr SHORTEN (Howard & Son, Bedford) said that it was only natural that his firm should take a very keen and live interest in this conference, for it was their business to manufacture the implements of cultivation required by the farmer, and if possible to embody their own experiences coupled with the results of soil cultivation as carried out by the scientific investigator, in order to produce better, and perhaps more economic, instruments. Mr Shorten held the opinion that the more modern implements which were now available for the farmer were not being used to full advantage, and that a great improvement in the destruction of many weeds could be brought about by the use of modern and correct cultivation implements at the same time that adequate tilths were being obtained.

Mr W. LAWSON admitted that in certain parts of the country improvements might be made in relation to the destruction of weeds by using modern machinery. In the south of England, where weeds grew all the year round, the problem was one of great difficulty.

Speaking of the depth of ploughing, he said that, as far as his experience went, it was a question which the soil on the particular field answered for itself. He believed that good cultivation always meant an enormous amount of cultivation, and that at the present time the subject had to be viewed from two different angles. In the first place there was the matter of cultivation as viewed academically and fundamentally. Taking this view, it appeared that we

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know very little of the underlying principles of the operations which we perform, and that there is a very large field for fundamental research in the matter. In the second view the economic balance between cost and return had to be considered, and he thought that there is a very excellent opportunity for the use and popularization of both labour-saving crops (such as kale) and machinery.

Mr J. W. Colles (Caterpillar Tractors) said that he had sometimes heard the merits of various tractors being discussed in terms of speed. Speed was not an essential factor in the manufacture of an agricultural tractor. What was required in such an implement was reliability. A machine which was slow, but could be relied upon to give steady and reliable work, was worth far more than one which covered the ground at a great speed, but at uncertain times. One of the difficulties that makers of the more powerful tractors meet with at present is the dearth of implements suitable to really deep ploughing and subsoiling, and he thought that there was room for a good deal of practical research.

Mr J. Porter remarked that drainage is very often the forerunner of cultivation, and as an instance quoted some of the heavy soils in Buckinghamshire, where four horses and two men were required for a single-plough team. In many of the cases cultivation would be rendered far more easy if the draining and liming were first attended to. Another fact of topical interest bearing on the same point—of the necessity for adequate drainage if good tilth is to be obtained—is found in the preference shown by the Eastern Counties farmers for ridge as against flat sowing for sugar-beet.

Sir John Russell, in summing up the discussion, expressed his thanks to all the speakers, and mentioned that this was the fifth of the Rothamsted Conferences, and from the interest which had been taken in this and the previous ones it was evident that they were fulfilling the objects for which they were started.

Referring to the discussion which had just taken place, he said that the three chief objects of cultivation were:

(1) Preparation of the seed-bed.
(2) Conservation of moisture.
(3) Removal of weeds.

At the present time not so much stress was laid upon the aeration of the soil as had been done in the past.

With regard to the correct depth of ploughing, it was evident from the discussion that very little agreement could be arrived at on the subject. The fact that one season differs from another,

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and that farm differs from farm, acre from acre, and field from field, made the reduction of cultivation to a set of rules impossible. There seemed to be, however, certain underlying principles which exist through many temporary conditions, and which form the basis of all successful operations.

Two points of interest arising from recent laboratory work were found in the lessening of the resistance of land to the passage of implements after the application of chalk, and by the considerable reduction of friction on plough breasts which appear when an electric current is passed through them, and induce a lubricating film of moisture to form upon them.

SUMMARY OF POINTS: GENERAL

By C. HEIGHAM, M. A.

Rothamsted Experimental Station

(1) The objects of cultivation are threefold:

(*a*) The elimination of weeds and unwanted plants.
(*b*) The control of soil moisture in relation to the crop.
(*c*) The production of a condition of soil favourable to plant growth—*i.e.* the making of "tilth."

(2) Cultivation processes as we have them are for the most part the outcome of many years of practical experience on the land, and can be traced through many stages of gradual improvement.

(3) From time to time startling innovations have appeared, and a few of these have remained to revolutionize some of the operations of agriculture. The name of Jethro Tull, who invented the seed-drill and the system of horse-hoeing husbandry, is particularly associated with one of the greatest of these steps in progress.

(4) The great development of industry and mechanics during the nineteenth and twentieth centuries made possible great developments in the construction of implements of tillage, but this was not accompanied by any great change in principle, and the form of the early types has remained easily recognizable in many of the most modern productions.

(5) Despite the accumulation of many centuries of experience, we still know very little of what really happens to the soil when it is cultivated, or when the forces of the weather act upon it; and it seems that a close study of the intimate relations of soil particles to each other and to moisture should form the basis of any further advance both in implement design and in systems of cultivation.

(6) The level of cultivation maintained at any period depends

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partly upon the type of machinery and power which is available for the production of a perfect tilth and partly upon the amount of labour which a farmer can afford to use for any particular crop. It may often happen that good and thorough cultivation is unsound in the economic sense.

(7) The existing methods of cultivation depend for continued success upon a large supply of cheap man labour. Such labour is no longer to be obtained, and in consequence the economic principles upon which the older systems were founded have ceased to apply. The comparative values of such matters as speed, depth and high finish in ploughing and other operations, which were fairly well established all over the country, are now once more in question.

(8) There is a considerable divergence of opinion among farmers as to the value of deep ploughing. It is claimed, on the one hand, that it will make possible the preparation of a deep seed-bed in which plant roots may penetrate quickly to a constant water supply. On the other hand, it is said that it may lead to the transference to the surface of raw subsoil, or to the drying out of the top soil to a considerable depth.

Despite this clash of opinion, it appears that bold and thorough ploughing in autumn and winter is the best foundation for good cultivation on most soils. The depth of ploughing must depend in each case upon the depth of the top soil and the nature of the subsoil. Where it is intended to deepen the ploughing, care should be taken to avoid the exposure of more than an inch or so of unkindly subsoil at one time.

(9) There appears to be very little reliable information as to the value of subsoiling, and there is need for widespread and well-designed investigation on this point.

(10) There is a curious clash of opinion as between the farmer, who rolls his land and uses sheep in order to obtain compression of the surface, and the gardener, who takes particular care to keep his soil loose and friable. In both cases it is claimed that the control of the soil moisture in relation to the crop is improved. It would appear that this apparent contradiction can be reconciled to some extent by the adaptability of the plant. In the first case the amount of water relative to the bulk of the top soil is increased and the plant roots have no need to travel far for their supplies. In the second case a deep-rooting habit is definitely encouraged by the looseness of the soil and the drying of the surface layers, and the plant is encouraged to get its nourishment from a depth where the water supply remains constant.

(11) In the economic field there would seem to be a good case for the use of cheap feeding crops such as kale and mixed leys in place of the more expensive root crops. This is in reality

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an avoidance of cultivation, but it may be well justified under conditions of high cost and cheap product.

(12) The sources of power available for the work of cultivation are increasing, and already many farmers have found that an intelligent use of petrol- and paraffin-driven tractors has enabled them to keep up the working force of arable farms at a reasonable cost. The case of the heavy land farm in Essex adduced in Mr Steel's paper is particularly striking in this respect. It may be noted that Mr Steel was a trained engineer and that his power machinery was well looked after.

(13) The speed of work of agricultural implements becomes a matter of great importance as the sources of power are developing. It appears that the soil-resistance to ploughing at $4\frac{1}{2}$ miles per hour increases only 7 per cent. from what it is at $2\frac{1}{2}$ miles per hour. This plain fact suggests great possibilities for development both of implements and tractors in the future.

(14) Certain new implements of a rotary type and driven by internal combustion engines are now available. These would appear to have many uses on the more intensive farms and in market gardens, but at present there is very little evidence available for their performance in comparison to the older and better-known implements of tillage.

(15) There would appear to be a general agreement that in the direction of the cultivations on his farm the farmer is called upon to exercise to the full his personal knowledge of the land and his judgment of the prevailing conditions.

While it is admitted that there is a great deal to be learned about the underlying principles, or the science of cultivation, it appears certain that the art of it as it appears in the work of an individual farmer on a field which he knows well must be maintained as the vital link between precept and practice.

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