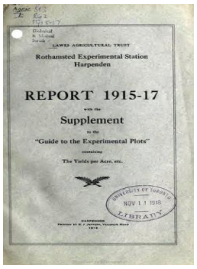
Report 1915-17 With the Supplement to the Guide to the Experimental Plots Containing the Yields per Acre Etc.



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Technical Papers

Rothamsted Research

Rothamsted Research (1917) *Technical Papers ;* Report 1915-17 With The Supplement To The Guide To The Experimental Plots Containing The Yields Per Acre Etc., pp 40 - 48 **- DOI: https://doi.org/10.23637/ERADOC-1-108**

are able to retain their vitality for many years. Many of the seeds die comparatively soon after burial, and as time goes on the number of living seeds gradually becomes less, though the evidence shows that some seeds will survive burial for at least 58 years. Usually most of the older arable seeds survive in the lower depths of the soil where the conditions are less variable, whereas the shorter the time that land has been under grass the greater the proportion of arable seeds found near the surface. While the stock of arable seeds is diminishing with the lapse of time, the supply of grassland seeds is being augmented by fresh seeds ripened by the surface vegetation and gradually carried down into the soil. Naturally the greater proportion of these seeds are found in the upper inches of soil, comparatively few penetrating below the eighth inch.

TECHNICAL PAPERS.

XXXII. *"West Country Grasslands."* WINIFRED E. BRENCHLEY. Journal of Bath and West and Southern Counties Society, 1917. 11, 85-112.

During the summer of 1916 a survey was made of some of the grassland in Gloucester and Somerset with special reference to the weed flora. In this paper an account is given of the association of some of the chief grassland weeds with alluvium, clay soils, peat, calcareous and non-calcareous sandy soil, and also of the effect of herbage on stock in some special cases.

Some weeds were found to be specially obnoxious because they tainted the milk or had bad effects upon the animals themselves. Garlick, ramsons, hemlock, moon-daisy and woodwax were all accused of tainting the milk. Horsetail has a bad reputation for causing scour, and huffcap is disliked by animals and is regarded as being very detrimental to them.

Besides these directly harmful weeds a number of plants require special attention; these include nettles, creeping thistle, black-bull thistle, yellow rattle, bindweed, hardhead, and others.

Some parts of the fields were characterised by a special flora. Round the gates and along paths where the soil becomes much trodden, greater plantain, silverweed and rough meadow grass were common. The site of an old manure heap was marked by arable weeds derived from seeds carried in the manure, as knotgrass, groundsel, fat hen and shepherd's purse; and on the site of old ricks strong growths of broad dock, dandelion and nettle were often seen.

Under the shadow of trees the herbage takes on a distinctive character, particular species growing in definite association. Cocksfoot, foxtail and rough meadow grass are the three most marked species in these situations, but a few others are found occasionally, as buttercups, dock, sorrel and pignut.

Bindweed = *Convolvulus arvensis.*
Black Bull Thistle = *Cirsium lanceolatum.*
Broad Dock = *Rumex obtusifolium.*
Buttercup = *Ranunculus sp.*
Cocksfoot = *Dactylis glomerata.*
Dandelion = *Taraxacum vulgare.*
Dock = *Rumex crispus.*
Fat Hen = *Chenopodium album.*
Foxtail = *Alopecurus pratensis.*
Garlic = *Allium vineale.*
Greater Plantain = *Plantago major*
Groundsel = *Senecio vulgaris.*
Hard-head = *Centaurea nigra.*
Hemlock = *Conium maculatum*
Horsetail = *Equisetum arvense.*
Huffcap = *Aira caespitosa.*
Knotgrass = *Polygonum aviculare.*
Moon-daisy = *Chrysanthemum leucanthemum.*
Nettle = *Urtica dioica.*
Pignut = *Conopodium denudatum.*
Ramsons = *Allium ursinum.*
Rough Meadowgrass = *Poa trivialis.*
Shepherd's Purse = *Capsella bursa-pastoris.*
Silverweed = *Potentilla anserina.*
Sorrel = *Rumex Acetosa.*
Thistle = *Cirsium arvense.*
Woodwax = *Genista tinctoria.*
Yellow Rattle = *Rhinanthus crista-galli*

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XXXIII. *"Weeds on Arable Land and their Suppression."* WINIFRED E. BRENCHLEY. Journal of the Royal Agricultural Society of England, 1915. 76, 14-37.

During the summer of 1914 a careful survey was made of the weeds of arable land in parts of Nottinghamshire and Derbyshire, and in the present paper the results are correlated with those obtained in other parts of the country.

Although many weeds are of general occurrence, some are more definitely associated with particular types of soil, and a partial classification may be made as follows :—

1.—Weeds that are indifferent to the soil type. These include some of the most common and troublesome weeds, as knotgrass, shepherd's purse, chickweed, groundsel, curled dock, creeping thistle, mayweed, horsetail, ivy-leaved speedwell and couch grass. Willow-weed and hempnettle are found on all soils except chalk.

2.—Weeds that are more general on medium or heavy land, as orache, charlock, coltsfoot, creeping buttercup, sowthistle, bindweed, corn buttercup.

3.—Weeds that are common on heavy loam and clay, as greater plantain, goosegrass.

4.—Weeds characteristic of very light sandy land, as poppy on calcareous soil, and corn marigold, spurry, sheep's sorrel and annual knawel on non-calcareous land.

5.—Weeds associated with chalk, as white mustard, toad-flax, wild mignonette.

Local peculiarities occur, however, so that a plant that is usually of wide distribution may be confined to or absent from a particular soil in a district, or may be so abundant as to be characteristic of some particular type of soil. The shepherd's needle will apparently grow on any soil, but it is characteristic of chalk in Wiltshire, absent from chalk in Norfolk, absent from sand in Bedfordshire, absent from peat in Nottinghamshire. Again, the field forget-me-not is never seen on sand in Notts (being chiefly found on heavy soils), whereas in Norfolk it is usually found on sand, and in Wiltshire it is confined to chalk. Although chickweed, horsetail and shepherd's purse are really universal in distribution, yet in Nottinghamshire the two former are more common on the heavier soils, while the latter is more frequent on light soils, such as sand and gravel. Many other instances could be cited, but with due reservation on account of these local differences the commoner arable weeds can be classified according to the soils they frequent.

Annual Knawel = *Scleranthus annuus.*
Charlock = *Brassica sinapis.*
Chickweed = *Stellaria media*
Coltsfoot = *Tussilago farfara.*
Corn Buttercup = *Ranunculus arvensis.*
Corn Marigold = *Chrysanthemum segetum.*
Couch Grass = *Triticum repens.*
Creeping Buttercup = *Ranunculus repens.*
Field Forget-me-not = *Myosotis arvensis.*
Goosegrass = *Galium aparine.*
Hemp Nettle = *Galeopsis Tetrahit.*
Ivy-leaved Speedwell = *Veronica hederæfolia.*
Mayweed = *Matricaria inodora.*
Orache = *Atriplex patula.*
Poppy = *Papaver rhœas.*
Sheep's sorrel = *Rumex Acetosella.*
Shepherd's Needle = *Scandix pecten*
Spurry = *Spergula arvensis.*
Sowthistle = *Sonchus arvensis.*
Toad-flax = *Linaria vulgaris.*
White Mustard = *Brassica alba.*
Wild Mignonette = *Reseda lutea.*
Willow-weed = *Polygonum persecaria.*

XXXIV. *"The Comparative Yield of Second Rate Arable and Pasture-land."* E. J. RUSSELL. Journal of the Farmers' Club. November, 1917.

The subject is discussed from the standpoint of food production and of the profit of the individual farmer. It is shown that arable land

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produces considerably more food than grassland; one acre of arable land yields on an average more than half a ton of flour and over five tons of potatoes, but it commonly gives less than one hundredweight of beef, and sometimes considerably less. Translated into food units, one acre of arable land furnishes sufficient calories to keep a man going for 500 to 1,500 days, according as cereals or potatoes are grown; while an acre of grass will only furnish sufficient calories to keep him going for 6 to 200 days, according as it is used for rough grazing or as good pasture for dairy stock.

On the other hand the cost of working the arable land is considerably higher. Numerous estimates are available of the cost of growing wheat. These show that prior to the War it was about £6 to £8 per acre; during the War it has risen to £10 to £12 per acre. Less information is available as to the cost of growing other crops, but at Rothamsted barley and oats cost sometimes more and sometimes less. but on an average almost as much as wheat; mangolds cost £14 per acre before the War, but £18 now; while potatoes cost £20 before the War and £24 now. Moreover, the farmer has to stand out of his money for many months. Grassland, on the other hand, costs much less per acre, and the money is turned over more quickly. Less capital is therefore required for grass than for arable land.

But if the cost of working arable land is greater than that for grassland the returns are also higher. Recent instances are quoted in which grassland that only yielded 10 to 15 cwts. of hay per acre, or kept only one sheep or less per acre, gave, when ploughed up, from 40 to 70 bushels of oats, and similarly good yields of other crops. Further, arable farming presents far greater possibilities of improvement than grass farming. Ordinary grassland can rarely be made to yield more than 40 cwts. of hay or 2 cwts. of beef per acre, but the possibilities of arable land are considerably greater, and the gross returns may be pushed up very considerably. There is, of course, a corresponding increase in risk, but this can be diminished by the adoption of co-operative methods and by the technical improvements that one hopes will be forthcoming.

XXXV. *"How can Crops be Grown without Potash Manures next Year?"* E. J. Russell. Journal of the Board of Agriculture, 1915. **22**, 393-406.

Two methods can be adopted (1) other sources of potash can be used instead of the usual Stassfurt salts, (2) the reserves of potash in the soil can be made available. It is shown that various plant ashes, bonfire ashes, etc., contain about 10 per cent. of potash (K_2O), not much less than is present in kainit. Sheltering the manure heap was found to reduce loss of potash considerably, an exposed heap losing 30 per cent. of its total potash, while a corresponding sheltered heap lost 12 per cent. only. The ploughing up of grassland and clover leys also sets free potash stored up in the root residues. The utilisation of potash stored in the soil is made possible by liming the land or applying dressings of sodium salts, such as agricultural salt or sulphate of soda. Salt has long been known to benefit mangolds, and on light land it has good effects on most other crops. Sodium salts have the further advantage of economising the supplies of potassium salts. The application of these various methods to different crops is discussed.

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XXXVI. *"On Growing Two White Straw Crops in Succession."* E. J. RUSSELL. Journal of the Board of Agriculture. 1915. **22**, 533-542.

It has long been a tradition of good farming that two white straw crops should not be grown in succession, and this still survives in spite of many instances to the contrary, including the classical case of Broadbalk Field, where wheat crops have been grown every year since 1843. Two conditions are necessary: the land must be reasonably clean, and the crop must be supplied with satisfactory spring dressings. The most suitable fertilisers are nitrate of soda or sulphate of ammonia and superphosphate; these must go on early in the year, it is not safe to wait until the crop shows signs of starvation. Suitable dressings are suggested.

XXXVII. *"The Washing out of Nitrates from Arable Soils during the Past Winter."* E. J. RUSSELL and A. APPLEYARD. Journal of the Board of Agriculture, 1916. **23**, 22-27.

The rainfall during the winter months of 1915-16 had been exceptionally heavy, and the amount of percolation through the soil was correspondingly above the average. There had been an unusual loss of nitrates from the soil, varying in the different cases examined, from 5 to 125 lbs. per acre (reckoned as nitrogen); in the case of a field worked as part of the ordinary farm the loss was 30 lbs. of nitrogen per acre, equivalent to 190 lbs. per acre of nitrate of soda, this being as much as is contained in eighteen bushels of wheat and the corresponding quantity of straw. A piece of fallow land lost very heavily. The actual figures were:—

	Nitrogen as nitrate: lb. per acre, top 18 ins.		
	Autumn. 1915	Feb. 1916	Loss.
Broadbalk, dunged, fallow	175	50	125
,, ,, cropped (wheat)	90	47	43
Great Harpenden Field, cropped (wheat)	70	40	30
Broadbalk, unmanured, fallow	68	40	28
,, ,, cropped (wheat)	51	46	5
Hoos, unmanured, fallow	34	9	25
,, ,, cropped (wheat)	32	12	20

In addition to the losses of nitrate the soil also suffers through defloculation of the clay. Thus, at the time of writing the land was depleted of its nitrates, and the clay had passed into a sticky unworkable state. Much of the damage could have been avoided had a catch crop or a green crop to be ploughed in for manure been grown in the previous autumn. The best remedies now available are soot, sulphate of ammonia and lime; methods of using these are indicated.

XXXVIII. *"Soil Analysis."* E. J. RUSSELL. Journal of the Board of Agriculture, 1915. **22**, 116-119.

The value of soil analysis to the farmer is discussed. It mainly serves to effect comparisons and may be of help in at least three cases:—

1.—When the farmer wishes to know whether he has a reasonable

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chance of obtaining results with particular fertilisers, similar to those demonstrated by field experiments on another farm in the locality.

2.—When he decides to adopt some system of cropping or soil treatment known to give good results elsewhere, but before embarking on it wishes to ascertain how closely his soil conditions resemble those where the method is known to answer.

3.—When he is entering on a new farm and wishes to obtain as complete information as possible about the soil. This is the most difficult case of all, and much time is saved by going over the land with an expert and discussing with him on the spot the various points on which information is desired. If no satisfactory field experiments have been made on similar soils and no soil survey has been carried out, the problem becomes more difficult, and the analyst cannot be expected to do more than give a general opinion or submit schemes for consideration and trial.

XXXIX. "*On Taking Samples of Soil for Soil Surveys.*" E. J. Russell. Journal of the Board of Agriculture. 1916. **23**, 342-349.

The investigator should go over the district with the map and divide it up into areas within which similar agricultural and vegetation characteristics prevail. In moderately level regions these areas agree tolerably well with those differentiated on the geological map so long as the nature of the soil is fairly uniform throughout. Where the formation consists of alternations of sands and clays of no great thickness the soil belts are neither wide nor very definite; in this case the soils should be graded between two limits, the lighter and the heavier types being described in some detail, and the various intervening grades dealt with in a more general way.

In hill districts it is necessary to distinguish between high land and low land.

The selection of spots for the final sampling presents some difficulty, but the variations reported by the farmers often cause less trouble than might be expected and arise from small differences in the amount of calcium carbonate or organic matter, or in the water supply or management. It is immaterial for the purposes of the survey whether the samples are taken from pasture land or arable land, but it is well to have samples from both.

Very full information should be collected as to the agricultural value of the land, the crops and manures most suitable, the behaviour of the soil during drought and wet weather, and any special points to be observed during cultivation. Note should also be taken of the position of the soil in regard to water supply, the relation of the strata to the permanent water table, etc.

XL. "*The Possibilities of Increased Crop Production.*" E. J. Russell. Presidential Address to the Agricultural Section of the British Association, 1916. Transactions of the British Association.

The three great lines of agricultural development in the United Kingdom in the past have been (*a*) the introduction, usually from

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Flanders, of crops that had not previously been grown on British farms, (*b*) the removal of obstacles which prevented crops from making as full growth as they might, (*c*) the introduction of new methods for increasing the growth of the plant.

On *light* soil the two great obstacles to be overcome are the lack of water and the poverty in plant nutrients. The problem can be dealt with by increasing the depth of soil through which the roots can range, or by adding the necessary colloidal substances—clay, marl, or organic matter. As regards depth of soil, where a thin layer of rock separates the top soil of sand from a great depth of sand below, improvement can be effected by removing the rock—a cheap method being possibly the use of the high explosives available at the end of the war; to prevent reforming of the rock occasional deep ploughing must be carried out. The process of adding marl to sand has disappeared in England on account of transit difficulties; the usual methods are to add organic matter, either by dressings of farmyard manure, by feeding crops to sheep on the land, or by ploughing crops and crop residues straight into the soil; the addition of organic matter must generally be accompanied by the addition of lime or limestone (otherwise the soil may become sour), and all the plant nutrients, nitrogen, potash, and phosphates, as well as by constant cultivation to keep down weeds and retain soil moisture. When all this is done, light soils become very productive; they will grow almost any crops, and they can be cultivated easily and almost (but not quite) at any time. On account of the cost of the above processes crops must be grown which bring in a high money return, potatoes, greens, peas, sugar-beet, or two crops in a season, although the money-finding crop need not be taken very often. The best hope for improvement of light soils lies in increasing the number of money-finding crops, improving the methods of growing them and their relation to the other crops or the livestock, so that farmers will feel justified in spending the rather considerable sums of money without which these light soils cannot be successfully managed.

Heavy land can be improved by liming or chalking, followed by drainage. Mole drainage promises to be an efficient and much cheaper substitute for the old system of tile drainage, but co-ordination and a certain amount of control over the whole drainage area is needed, it being undesirable that a great fundamental improvement should be at the mercy of individuals. The cultivation of clay lands is always risky, however, as it is suited only to a limited number of crops, and is difficult to cultivate, and hence most men lay down this land to permanent grass. The risk can be reduced:

(*a*) By quicker ploughing in autumn, so as to bring the work well forward; this seems only possible by the use of the motor plough.

(*b*) By keeping up the supplies of organic matter in the soil; the simplest plan seems to be the adoption of the North Country system, in which the land is alternately in grass and in tillage.

There will always be some grass on the clays and this must be improved, in most cases by basic slag, with possibly further treatment of the improved herbage.

Loams present no special difficulties. The crop may be hampered by lack of root room, in which case periodical deep ploughing or sub-

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soiling may bring about a substantial improvement; sub-soiling at Rothamsted was followed by an increased yield per acre of 10 cwt. of potatoes.

All the above soils can be still further improved by proper treatment with fertilisers. There comes a point, however, where further increases in fertiliser dressings cease to be effective, because the plant cannot grow any bigger, or it cannot stand up any longer, or its resistance to disease is weakened; here, therefore, new varieties must be found that can grow bigger or stand up better or are more resistant to disease. Considerable improvements may be anticipated from a closer co-ordination of crop variety and soil and climatic conditions.

It is also necessary to reduce the cost per acre and to increase the certainty of production. One of the most hopeful ways of attacking this problem is to increase the efficiency of the manurial treatment; the whole of the fertilising constituents applied to the soil are never recovered in the crops, but by arranging a proper rotation and properly balanced manurial dressings the loss can be reduced.

Economy is also possible in the management of farmyard manure, and of the soil; where there is no crop there is loss of valuable nitrates during the winter, the heaviest loss occurring on the best manured land.

Again, it is necessary to keep close accounts so as to replace unprofitable crops by profitable ones. Steps must be also taken to raise by educational methods the ordinary farmers to the level of the good ones.

There is, however, a factor which operates against increased crop production, which we can never hope to see entirely destroyed. The farmer has to get his pleasure as well as his work out of the countryside, so that trees, hedges, and copses are left, pheasants are bred, foxes and hares preserved, and rabbits spared. It would be wholly unreasonable to expect the farmer to lead a life of blameless crop-production unrelieved by any pleasure. The amenities and pleasures of the countryside will probably always be kept up, and we must maintain the best equilibrium possible between them and the crops.

XLI. "*Chalking, a useful Improvement for Clays overlying the Chalk.*" E. J. Russell. Journal of the Board of Agriculture, 1916. **23**, 625-632.

This paper contains a description of the method of applying chalk to the land as adopted in Hertfordshire and neighbouring districts, where a layer of heavy soil overlies the chalk. The method has the advantage that it requires very little materials, no horses and only a minimum of skilled labour. A well is sunk to the chalk and excavation is continued until a bell-shaped chamber is formed; the chalk is hauled to the surface, carried in wheel-barrows to the proper position in the field, and then spread. One well furnishes sufficient material for three or four acres. The cost of sinking the well is usually 6d. per foot depth, and it is commonly necessary to go down about 20-25 ft. Hauling, barrowing, and spreading cost 7d. per load of 20 buckets, each bucket holding approximately a bushel. The total cost is about £2 to £3 for a dressing of 50 to 60 loads per acre.

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XLII. "*The Composition of Army Stable Manure.*" E. J. RUSSELL. Journal of the Board of Agriculture, 1917. **23**, 1053-1065.

Samples of army stable manure collected during the summer of 1916 were found to have the following composition :—

	ARMY STABLE MANURE				FARMYARD MANURE, ROTHAMSTED		
	A From Dumps 8 months old (Sling)	B Old Dump (Cross Belt)	C New Manure (Bustard)	D New Manure (Colchester)	Farm Stable Manure (Rothamsted)	Cake Fed	No Cake Fed
Organic matter	20.7	28.3	22.2	19.6	20.5	—	—
Mineral matter	13.1	24.1	30.8	41.3	4.6	—	—
Moisture .	66.2	47.6	47.0	39.1	74.9	72.6	72.8
Total dry matter	33.8	52.4	53.0	60.9	25.1	27.4	27.2
Total nitrogen	0.524	0.563	0.470	0.475	0.442	0.77	0.54
Nitrogen as ammonia	0.105	0.140	0.106	0.126	0.10	0.18	0.04
Potash (K_2O)	0.82	0.94	0.87	0.53	0.73	0.60	0.67
Phosphoric acid (P_2O_5)	0.20	0.33	0.40	0.31	0.24	0.39	0.23

Unfortunately from the farmers' point of view much of the urine is lost so that the manure is not as rich as it might be. Another characteristic is that Army manure contains only little litter; it consists mainly of solid excreta.

XLIII. "*Report on Humogen.*" E. J. RUSSELL. Journal of the Board of Agriculture, 1917. **24**, 11-20.

Field and pot experiments were made both at Rothamsted and at the Harper Adams Agricultural College, with samples of humogen especially supplied by the makers, but no positive results could be obtained. It was, however, subsequently claimed by the makers that the material had not been properly prepared.

XLIV. "*Comparative Field Trials with Dried and Degreased Sewage Sludges at Rothamsted.*" E. J. RUSSELL and E. H. RICHARDS. 9th Report of the Sewage Commissioners, 1915. **2**, 158-160 (Cd. 7820).

Experiments were made on permanent grass laid up for hay and on oats. The dried sludge contained 1.76 per cent. of nitrogen, and the degreased sludge 1.55 per cent.; they were applied at a rate sufficient to give 20 lbs. of nitrogen per acre, and nitrate of soda and nitrolim were given at the same rate to the other plots.

The nitrate of soda proved the most effective on hay, raising the yield from 15.6 to 26 cwts. per acre. Nitrolim was less effective, producing 21.6 cwts. per acre ; the sludges, on the other hand, had no appreciable effect. The experiments with oats had a similar result ; the control plot gave 41.3 bushels of grain and 4,040 lbs. of total produce ; nitrate of soda and nitrolim gave respectively 44.1 and 46.0 bushels of grain, and 4,700 and 4,900 lbs. of total produce, while the sludges gave only 36 and 37.4 bushels of grain and 3,600 and 3,800 lbs. of total produce, thus showing no increase, but an apparent decrease as compared with the control plots.

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XLV. "*The Use of Charcoal as a Medium for Plant Growth.*" A. APPLEYARD. Journal of the Royal Horticultural Society, 1915. **40**, 473-5.

A considerable number of experiments are on record in Horticultural Journals, which seem to show that charcoal has considerable value in increasing soil fertility. A summary of the evidence is given with a view to further work on the subject.

PAPERS SUMMARISING RECENT PROGRESS IN AGRICULTURAL INVESTIGATIONS.

I. "*The Principles of Crop Production.*" E. J. RUSSELL. Transactions of the Chemical Society, 1915. **107**, 1838-1858.

II. "*Artificial Fertilisers, their Present use and Future Prospects.*" E. J. RUSSELL. Journal of the Society of Chemical Industry. 1917. **36**, 250-261.

III. "*The Masters' Lectures : Recent Investigations on the Production of Plant Food in the Soil.*" E. J. RUSSELL. Journal of the Royal Horticultural Society, 1916. **41**, 173-199.

IV. "*The Recent Work at Rothamsted on the Partial Sterilisation of Soil.*" E. J. RUSSELL. Bulletin of the International Institute of Agriculture, Rome. 1917. **8**, 1-11.

V. "*The Making of Soil.*" E. J. RUSSELL. Transactions of the Highland and Agricultural Society of Scotland, 1916. **28**, 1-32

A description of the processes involved in the making of the soil as they are at present understood. So far as the mineral particles are concerned, the processes are largely beyond control, but the organic constituents can be altered more readily, especially by green manuring and clover and grass leys of varying duration. The micro-organic population which brings about the necessary changes in the organic matter is hardly yet under control, though a beginning has been made ; attempts are also in progress to deal with the various insects, etc., which play an important part in agriculture.

BOOKS PUBLISHED.

The following books and new editions have been published during the past two years :—

I. "*Manuring for Higher Crop Production.*" E. J. RUSSELL. Cambridge University Press.
1st edition, 1916. 2nd edition, revised and enlarged, 1917.

II. "*Soil Conditions and Plant Growth.*" E. J. RUSSELL. Longman, Green & Co.
3rd edition, revised and enlarged, 1917.

III. "*Soils and Manures.*" E. J. RUSSELL. Cambridge University Press.
2nd edition (in the press).

IV. "*The Book of the Rothamsted Experiments.*" A. D. HALL. 2nd edition, revised by E. J. Russell, 1917. John Murray.

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