Report for 1931

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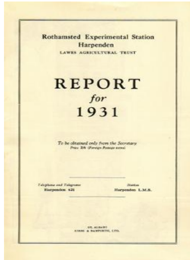

Rothamsted Experimental Station Report for 1931

Rothamsted Research

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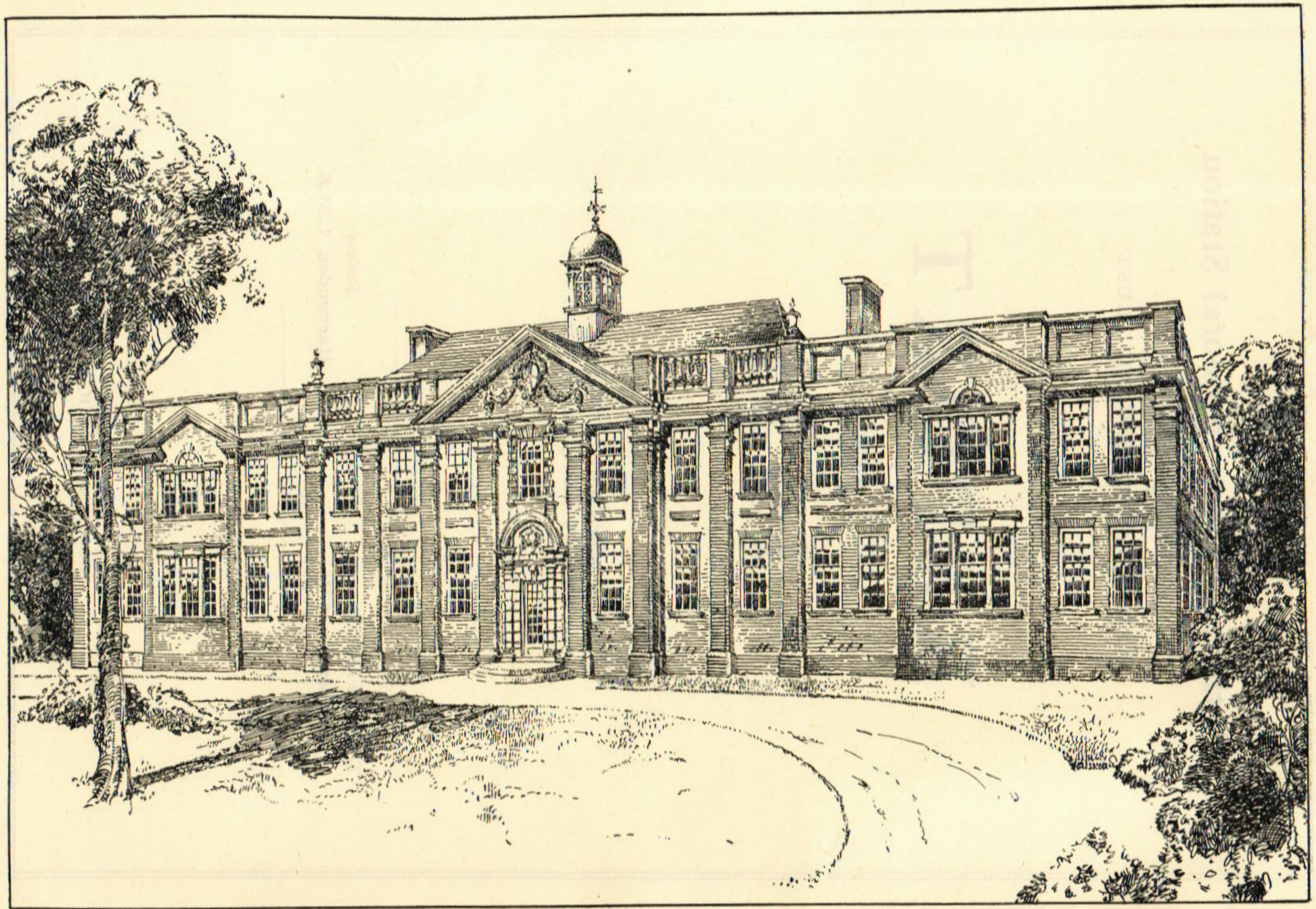

THE ROTHAMSTED LABORATORIES FOR SOIL AND PLANT NUTRITION, ERECTED 1914-1916

REPORT FOR 1931

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Assistant Director: B. A. KEEN, D.SC., F.INST.P.

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Stockmen	E. Davies
	J. R. Davies
	R. Davies
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Labourers	W. Holland
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Assistant Caretaker ..	F. K. Hawkins

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Assistant Director ..	H. H. Mann, D.Sc., F.I.C. (Kaisar-i-Hind Gold Medal)
Chemist	T. W. Barnes, M.Sc.
Laboratory Assistant ..	R. Deacon

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Ploughmen	G. Tyler
	J. McCallum
Stockman	W. McCallum
Assistant Stockman ..	D. McCallum
Labourer	K. McCallum

Members who have left since last Report and the Appointments to which they proceeded

A. D. Imms, M.A., D.Sc., F.R.S.	University Reader in Entomology, Cambridge.
J. O. Irwin, M.A., D.Sc. ..	Member of Staff of Statistical Committee, Medical Research Council, London
J. Wishart, M.A., D.Sc. ..	Reader in Statistics, Cambridge University
A. F. Joseph, D.Sc., F.I.C.	Resigned, August, 1931

TEMPORARY WORKERS, 1931

In addition to those temporary workers recorded in the list of staff, the following sent officially by Governments or Universities, or coming on their own resources, have worked at the Station for various periods during the year 1931 :

(1) From the Empire :

Colonial Office Agricultural Officers: H. R. Hosking (Uganda), C. G. Trapnell (Northern Rhodesia), J. H. Simmonds (Queensland).

Australia: Miss E. C. Andrews (Perth), E. C. Tommerup (Queensland).

Canada: Professor R. F. Summerby.

India: C. G. Hawes, T. J. Mirchandani.

New Zealand: J. T. Campbell.

Federated Malay States: F. Billington.

(2) From Foreign Countries :

Rockefeller Foundation Fellows: Dr. F. R. Immer (United States of America), Dr. H. Janert (Germany).

France: Dr. C. Zinzadze.

Holland: N. J. Cramer, J. Hudig, S. H. Justensen, Miss H. Van Straaten.

Hungary: Dr. L. de Telegdy-Kovats.

Japan: S. Kageyama.

Poland: Dr. Hedviga de Ziemiecka.

Siam: S. Sharasuvarana.

United States of America: Mrs. M. L. Immer, Miss N. Riches.

(3) From British Isles:

G. C. Ainsworth, H. B. Bescoby, Miss G. E. M. Clark, A. L. Murray, O. Milburn, E. McCallan, R. L. Reed, Miss G. Rotter, Miss J. E. Taudevin.

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Director : Sir E. J. Russell, D.Sc., F.R.S.
Acting Deputy Director : G. V. Jacks, M.A., B.Sc.
Scientific Assistants : A. J. Lloyd Lawrence, M.A., Helen Scherbatoff
Assistant Abstractor : Janet N. Combe
Private Secretary : Lyla V. Ives
Clerk : Mona B. Staines

The function of the Bureau is to assist workers in soil science throughout the Empire by providing technical information, by promoting contact between them, and by rendering any technical assistance possible when they are in this country. To facilitate its work, the Bureau seeks to be well informed as to the personnel engaged in soil work in the Empire and the problems on which they are engaged. Each Government has been requested to nominate one of its staff as Official Correspondent to the Bureau, who will act generally as liaison officer in Bureau matters and assist in the collection and distribution of information. The issue of technical information is not confined to Official Correspondents, but extends to all workers in soil science who ask the assistance of the Bureau. Special arrangements have been made to get in touch with Forest Officers interested in soil problems.

Publications of the Rothamsted Experimental Station

For Farmers

"MANURING FOR HIGHER CROP PRODUCTION," by Sir E. J. Russell, D.Sc., F.R.S. 1917. The University Press, Cambridge. 5/6.

"ARTIFICIAL FERTILISERS IN MODERN AGRICULTURE," by Sir E. J. Russell, D.Sc., F.R.S. Bulletin No. 28, Ministry of Agriculture and Fisheries, 1931. H.M. Stationery Office, or from the Secretary, Rothamsted Experimental Station, Harpenden. Cloth, 4/6 post free; or paper cover, 3/5 post free.

"WEEDS OF FARMLAND," by Winifred E. Brenchley, D.Sc., F.L.S. 1920. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 12/6.

ROTHAMSTED CONFERENCE REPORTS; being papers by practical farmers and scientific experts. Obtainable from the Secretary, Rothamsted Experimental Station, Harpenden, Herts.

"THE MANURING OF POTATOES." 1/6.

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Numbers 1 to 10 inclusive are also published in book form :—
Vol. I (1-5), Vol. II (6-10), 10/- each, postage extra.

*Out of print in separate copies.

For Students and Agricultural Experts

"The Rothamsted Memoirs on Agricultural Science." Octavo Series, vols. 1-7 (1847-1898), 30/- each. Royal octavo, vol. 8 (1900-1912), vol. 9 (1909-1916), vol. 10 (1916-1920), vol. 11 (1920-1922), 32/6 each, vol. 12 (1922-1925), vol. 13 (1925-1927), 33/6 each, vol. 14 (1928-1930), 35/-. Postage extra. Obtainable from the Secretary, Rothamsted Experimental Station, Harpenden, Herts.

"The Rothamsted Monographs on Agricultural Science," edited by Sir E. J. Russell, D.Sc., F.R.S.

"Soil Conditions and Plant Growth," by E. J. Russell, D.Sc., F.R.S. Sixth Edition. 1931. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 21/-.

"The Micro-Organisms of the Soil," by E. J. Russell and Staff of the Rothamsted Experimental Station, 1923. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 7/6.

"Manuring of Grassland for Hay," by Winifred E. Brenchley, D.Sc., F.L.S. 1924. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 12/6.

"A List of British Aphides" (including notes on their recorded distribution and food-plants in Britain and a food-plant index), by J. Davidson, D.Sc., F.L.S. 1925. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 12/6.

"The Physical Properties of the Soil" (with illustrations and diagrams), by B. A. Keen, D.Sc. 1931. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 21/-.

"Plant Nutrition and Crop Production" (being the Hitchcock Lectures, 1924, University of California), by E. J. Russell, D.Sc., F.R.S. The University of California Press and the University Press, Cambridge. 12/6.

"Inorganic Plant Poisons and Stimulants," by Winifred E. Brenchley, D.Sc., F.L.S. Second Edition, revised and enlarged, 1927. The University Press, Cambridge. 10/6.

"Recent Advances in Entomology," by A. D. Imms, M.A., D.Sc., F.R.S. (with illustrations), 1930. J. & A. Churchill, 40 Gloucester Place, London, W.1. 12/6.

"A General Textbook of Entomology," by A. D. Imms, M.A., D.Sc., F.R.S. Second Edition, revised, 1930. Methuen & Co., Essex Street, Strand, London, W.C.2. 36/-.

"Social Behaviour in Insects," 1931, by A. D. Imms, M.A., D.Sc., F.R.S. Methuen's Monographs on Biological Subjects, 3/6.

"Statistical Methods for Research Workers," by R. A. Fisher, M.A., Sc.D., F.R.S. Third Edition, revised and enlarged, 1930. Oliver & Boyd, Edinburgh. 15/-.

"The Composition and Distribution of the Protozoan Fauna of the Soil," by H. Sandon, M.A. 1927. Oliver & Boyd, Edinburgh. 15/-.

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The following are obtainable from the Secretary, Rothamsted Experimental Station, Harpenden, Herts :—

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" GUIDE TO THE EXPERIMENTAL PLOTS, ROTHAMSTED EXPERIMENTAL STATION, HARPENDEN." 1913. John Murray 50 Albemarle Street, W. 1/-.

" GUIDE TO THE EXPERIMENTAL FARM," ROTHAMSTED.

" GUIDE FOR VISITORS TO THE FARM AND LABORATORY." Woburn. 1929.

" CATALOGUE OF JOURNALS AND PERIODICALS IN THE ROTHAMSTED LIBRARY." 1921. 2/6.

" A DESCRIPTIVE CATALOGUE OF PRINTED BOOKS ON AGRICULTURE FROM 1471 TO 1840, CONTAINED IN THE ROTHAMSTED LIBRARY " (including Biographical notices of the authors and short descriptions of the important books). 1925. 331 pp. 22 illustrations. Cloth cover, 12/- ; paper cover, 10/-. Packing and postage extra :—British Isles, 9d. ; Overseas, Dominions and other countries, 1/3.

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For use in Farm Institutes

" A STUDENT'S BOOK ON SOILS AND MANURES," by E. J. Russell, D.Sc., F.R.S. The University Press, Cambridge. 8/-.

For use in Schools

" LESSONS ON SOIL," by E. J. Russell, D.Sc., F.R.S. 1926. The University Press, Cambridge. 3/-.

For General Readers

"The Fertility of the Soil," by E. J. Russell. The University Press, Cambridge. 4/-.

"The Possibilities of British Agriculture," by Sir Henry Rew, K.C.B., and Sir E. J. Russell, D.Sc., F.R.S. 1923. 1s. Obtainable from the Secretary, Rothamsted Experimental Station, Harpenden, Herts,

'Personal Reminiscences of Rothamsted Experimental Station," 1872-1922, by E. Grey, formerly Superintendent of the Experimental Fields. 5/-. Obtainable from the Secretary, Rothamsted Experimental Station, Harpenden, Herts.

Other Books by Members of the Staff

"Evolution, Heredity and Variation," by D. W. Cutler, M.A., F.L.S. 1925. Christophers, 22 Berners Street, London, W.1. 4/6.

"The Genetical Theory of Natural Selection," by R. A. Fisher, M.A., Sc.D., F.R.S. 1930. Clarendon Press, Oxford. 17/6.

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These drawings show the old Rothamsted Laboratory erected in 1851, the first important laboratory devoted to agricultural science, and the one in which much of the classical work of Lawes and Gilbert was done ; it survived till 1914.

The size of the volume is 21½ in. by 14½ in. ; it consists of four full page lithographs made from drawings by Charles Lawes, son of Sir J. B. Lawes. £1 per copy (post free).

INTRODUCTION

The Rothamsted Experimental Station was founded in 1843 by the late Sir J. B. Lawes, with whom was associated Sir J. H. Gilbert for a period of nearly 60 years. Lawes died in 1900 and Gilbert in 1901; they were succeeded by Sir A. D. Hall from 1902 to 1912, when the present Director, Sir E. J. Russell, was appointed.

For many years the work was maintained entirely at the expense of Sir J. B. Lawes, at first by direct payment, and from 1899 onwards out of an annual income of £2,400 arising from the endowment fund of £100,000 given by him to the Lawes Agricultural Trust. In 1904, the Society for Extending the Rothamsted Experiments was instituted for the purpose of providing funds for expansion. In 1906, Mr. J. F. Mason built the Bacteriological Laboratory; in 1907, the Goldsmiths' Company generously provided a further endowment of £10,000, the income of which—since augmented by the Company—is to be devoted to the investigation of the soil. In 1911, the Development Commissioners made their first grant to the Station. Since then, Government grants have been made annually, and, for the year 1931-32, the Ministry of Agriculture has made a grant of £27,600 for the work of the Station. Lord Iveagh has generously borne the cost of a chemist and a special assistant for field experiments for studying farmyard manure, both natural and artificial; while other donors have, from time to time, generously provided funds for special apparatus and equipment. The Fertiliser Manufacturers' Association and the United Potash Company provide considerable funds for the rather expensive field work. Imperial Chemical Industries help to defray the cost of a Guide Demonstrator for the field plots besides helping with the actual cost of the work. In addition, Beet Sugar Factories Committee of Great Britain, Beet Sugar Factories, Anglo-Dutch Group, British Basic Slag, Basic Slag and Phosphates Companies, Messrs. George Monro, the Empire Marketing Board, the Royal Agricultural Society, the Institute of Brewing and the Department of Scientific and Industrial Research make grants for specific purposes. The result is that the Station is able to deal with problems affecting modern farming in a far more complete manner than would otherwise be possible.

The main block of laboratories was opened in 1919, and is devoted to the study of soil and plant nutrition problems; another block was erected in 1924 for plant pathology at a cost of £21,135 provided by the Ministry of Agriculture out of the Development Fund; and Red Gables, the house adjoining the laboratories on the north side, has been converted into an Administration Building to hold the Imperial Soil Bureau, part of the Records and Statistical Department, Staff Common Room and Conference Room.

Large glasshouses, including special insect-proof houses for Virus studies, were added in 1926, 1928, and 1931 by aid of generous grants from the International Education Board, Rockefeller Foundation, the Empire Marketing Board and the Ministry of Agriculture.

The laboratories were completely reorganized in 1922.

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From 1926 onwards great changes took place on the farm. New and greatly improved methods of field experimentation were adopted in 1926 on all but the classical plots, which remain in every way unchanged; and the non-experimental farm was reorganized in 1928, considerable numbers of live stock being introduced, and much of the land being laid down to grass. The farm buildings were considerably enlarged in 1930 with the aid of a grant of £1,700 given by the Ministry of Agriculture and a new block of buildings containing the demonstration room, work-rooms for the experimental staff, office and store-rooms were erected in 1931-32 at a cost of £1,300 collected by public subscription.

The Library is steadily growing, and now contains some 23,000 volumes dealing with agriculture and cognate subjects. The catalogue of the old printed books on agriculture was published in 1926, and every effort is made to obtain any that we do not possess. A collection is also being made of prints of farm animals, of old letters on agriculture, and farm account books. Many of these lie in farm-houses, unused and inaccessible, not in themselves valuable, but often of great help to students of agricultural history and economics when brought together as we are doing. Gifts of books and documents to the Library will be greatly appreciated.

The extension of the experiments to various outside centres in Great Britain, begun in 1921, has proved so advantageous that it has been developed. Not only is useful information spread among farmers, but the Station itself gains considerably by this closer association with practical men. As part of this extension, the Station, in 1926, with the consent of His Grace the Duke of Bedford, took over from Dr. J. A. Voelcker the lease of the Woburn Experimental Farm, so that this now becomes a part of the Rothamsted organization, allowing us to make experiments simultaneously on a light and on a heavy soil: a very advantageous arrangement. Through the generosity of His Grace certain necessary changes have been made in the farm equipment, and the grass fields have been grouped and watered for intensive grazing. The Agricultural and Road Machinery Manufacturers' Association also rendered assistance. Harold H. Mann, formerly Director of Agriculture, Bombay Presidency, India, and Agricultural Adviser H.E.H. the Nizam's Government, Hyderabad, India, has been appointed Assistant Director, with T. W. Barnes as Chemist, and the laboratories, pot-culture station and meteorological station have been re-equipped and reorganized. A grant from the Royal Agricultural Society of England has enabled us to appoint an additional assistant in the Statistical Department to prepare the material for a full summary and discussion of the results of the last fifty years of experiments there.

The activities of Rothamsted, however, are not confined to the British Isles, but are gradually spreading out to the Empire and other countries abroad. The International Education Board sends workers from all parts of the world to study in these laboratories. The Empire Cotton Growing Corporation has, since 1923, made a grant of £1,000 per annum for the development of investigations in Soil Physics, while the Empire Marketing Board has recently invited the co-operation of the Station in solving certain agricultural problems of great importance to the Empire.

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At the invitation of the proper authorities, the Director and other members of the staff have already visited the Sudan, Palestine, Australia, New Zealand, South Africa, and Canada to discuss agricultural problems and possibilities of co-operation ; in addition, visits are paid to the United States and to European countries, including Russia, to discuss problems and methods with experts there, and generally to improve the equipment of the Institution and widen the knowledge and experience of the staff.

More and more workers are coming from the overseas Dominions to carry on their studies at Rothamsted. None but University graduates are eligible, and most are, or are about to be, on the staffs of Government or other Agricultural Departments : men who will become leaders in the agricultural communities of their respective countries. To our great regret, lack of accommodation has compelled us to refuse some who wished to come. This is highly unfortunate.

The most important of all these Empire developments was inaugurated in 1929. At the Imperial Agricultural Conference of 1927 it was decided to set up in this country a series of Bureaux to act as central clearing houses of information and to promote interchange of ideas and methods between the agricultural experts of the different parts of the Empire. The Soil Bureau is located at Rothamsted and began operations on May 1st, 1929. A. F. Joseph, late Chief Chemist to the Sudan Government, was appointed Deputy Director ; with H. Scherbatoff and A. J. L. Lawrence as Scientific Assistants. In 1931 A. F. Joseph resigned and his place was taken by G. V. Jacks.

In view of the great expansion of the work in the last ten years, the Committee has deemed it advisable to acquire the sites adjoining the laboratory in readiness for the time when further accommodation will be necessary.

REPORT ON THE WORK OF THE ROTHAMSTED EXPERIMENTAL STATION DURING THE SEASON 1931

The purpose of the work is to obtain information about the soil and the growing plant, and to put this information in a form in which agricultural experts and good farmers can use it. The work is done partly in the laboratory, partly in the pot culture house, and partly on the two experimental farms, the heavy land at Rothamsted and the light land farm at Woburn.

Broadly speaking, the laboratory work is concerned with the acquiring of information, while the field work aims at testing the applicability of this information on the farm and also at finding solutions for important practical problems of present-day agriculture.

THE FIELD EXPERIMENTS

The Conferences held at Rothamsted, and the visits made by members of the Staff to farms in different parts of the country, show that certain general problems are of great importance to large numbers of farmers: these are studied in the field.

(1) The most efficient use of artificial fertilisers on grass and arable land.

(2) The provision of keep for animals when grass supplies fall short.

(3) The maintenance of soil fertility in regions where mechanization is advancing and live stock is being reduced.

THE EFFICIENT USE OF FERTILIZERS

I. Grassland

Our earlier investigations have shown that the full value of fertilizers on grass land is obtained only when the grass is properly used. Seeding, manuring and management are closely connected; we shall therefore describe all the grassland work in this section.

The older Rothamsted experiments dealt only with the manuring of grass for hay; in 1921, however, experiments were begun on the phosphatic manuring of grazing land in Great Field, the results being expressed as live weight increase of the sheep in accordance with the method of the late Sir William Somerville. These experiments* showed that the method, while giving striking results on poor land such as that of Cockle Park, was quite unsuited to land in better condition. It is liable to serious errors arising from differences in the sheep themselves and differences in rate of stocking, and in our

* Report 1923-4, p. 21; Report 1925-6, p. 25; Report 1927-8, p. 33.

experience it can work only on poor land capable of considerable improvement: land, for example, which without manure will produce only about 50 lb. live weight increase of the sheep per acre during the season while after manuring it will produce 75 or even 100 lb. per acre. On more normal grass land, producing some 150-200 lb. live weight increase during the season, the method fails; we accordingly gave it up in 1929.

In later experiments we have used instead the method designed by the late T. B. Wood of Cambridge. The grass is cut repeatedly during the growing season and the separate cuttings are weighed and analysed. This reproduces part of the effect of the animal, but not all; it removes the grass but returns no manure. In spite of this weakness, however, the method has been found to give useful results.

The more recent experiments on grass land fall into three groups, dealing respectively with the laying down to grass, the manuring and treatment of the grass, and the utilisation of the grass.

1. *The laying down to grass.* Up to 1925 there was only one grass field on the farm, Great Field, which had been laid down in the 1870's, a small grass field, New Zealand (7½ acres) laid down in 1907 having been broken up during the war, in 1915*. In 1925 we sowed down Little Knott (10½ acres), and in 1928 other fields also, thereby considerably altering the distribution of the land on the farm.

The areas are:

	Before 1925.	1928 to present time.
Arable	225	122½
Grass	27½	130
Roads, buildings and enclosures	27½	27½
Total	280	280

In the sowing down various mixtures were used, some with indigenous and some with commercial strains; various previous treatments were also given. By reason of our heavy head of stock —220 breeding ewes (half-bred, Cheviot ewe by Border Leicester ram), producing 340 lambs; some 60 head of cattle (mostly young), and some 25 breeding sows (mostly Wessex Saddleback)—it is possible to graze the land thoroughly, and the management has been consistently good. At first the herbage on each of the different areas had its characteristic appearance, but under similar treatment these differences began to lessen, and now, 4 years after sowing, the general type of herbage is much the same on all the grassland whatever the original seeding. On Sawyer's field six widely different mixtures were tested, yet the herbage is now fairly similar on all the plots. Rye grass and wild white clover form about 70 to 80 per cent. of the whole; the rest is chiefly cocksfoot, now 15 to 20 per cent. on all plots, though the original seeding of 5 to 10 lb. per acre had corresponded to a variation from 15 to 40 per cent. of the numbers of seed sown. Timothy forms about 5 per cent. of the herbage. The actual figures vary from spring to autumn and from season to season, but the order is the same. Of the other plants sown little survives beyond some red clover. (Table I.)

* See Report for 1915-17, p. 9.

TABLE I.—Comparison of weights of seed sown with percentage area now occupied by the various groups of plants.

†*Composition of Mixtures Sown* 1928. *lb. per acre.*†

Mixtures.	I.	IV.	V.	VI.	VII.	VIII.
Grasses	24	30.5	40	29	29	27
Clovers	4	5	1	5	7	5
Miscellaneous ..	2	—	—	2	—	—

Percentage area now occupied by the various groups.

1931—*Spring.*

Mixtures.	I.	IV.	V	VI.	VII.	VIII.
Grasses	55.4	49.4	50.7	51.6	46.1	54.0
Clovers	40.1	45.0	40.9	41.9	48.5	39.6
Weeds	0.1	0.2	0.1	0.2		0.2
Chicory	—	—	—	0.7	—	—
Bare Space ..	4.4	5.4	8.3	5.6	5.4	6.2

1931—*Autumn.*

Mixtures	I.	IV.	V.	VI.	VII.	VIII.
Grasses	35.15	31.6	16.3	40.2	44.5	35.7
Clovers	64.05	67.5	82.3	55.1	54.95	64.0
Weeds	0.1	0.3	0.3	0.05	0.1	—
Chicory	0.2	—	—	4.6	—	—
Bare Space ..	0.5	0.6	1.0	0.05	0.45	0.3

1932—*Spring.*

	I.	IV.	V.	VI.	VII.	VIII.
Grasses	62.6	40.65	37.45	60.2	43.6	48.3
Clovers	35.5	57.05	58.73	37.5	54.6	49.7
Weeds	0.2	—	—	0.05	0.3	—
Chicory	0.1	—	—	0.35	—	—
Bare Space ..	1.6	2.3	3.62	1.9	1.5	2.0

† For percentage numbers of seeds of the different plants see Report for 1929, p. 24.

in the next. The gain in protein may be considerable, much greater than the gain in dry matter; superphosphate gave the following increases in the first year in grass laid in for hay:

Percentage gain in—

	Dry Matter.	Protein.	Phosphoric Oxide P_2O_5.
Braintree (1930)	42	102	97
Northallerton (1931) ..	47	78	195

These results depend entirely on the solubility of the phosphate. In the first year after application water soluble phosphate is most effective, so that superphosphate comes out best. Citric soluble phosphate comes next, hence high soluble basic slag is second. Mineral phosphate and low soluble basic slag are less effective. The value of mineral phosphate as compared with the others changes a good deal according to soil and season. In the drier conditions of Hertfordshire and the Eastern counties it came a long way behind high soluble slag and was very similar to low soluble slag; in the moister, warmer conditions of Devonshire it acted more like high soluble slag and was much superior to the low soluble slag.

In the second year the high soluble basic slag did better than superphosphate at several of the centres, both on the hay land and on the grass repeatedly mown, though it has not yet caught up with superphosphate. At the Devonshire centre mineral phosphate acted as well as high soluble slag, though it is still behind on the two years' programme, but the low soluble slag showed no sign of improvement.

The experiment is being continued to see what happens in the third and fourth years.

Soluble phosphates (both water soluble and citric soluble) increase the amount of phosphoric oxide (P_2O_5) in the herbage by some 50 or 60 per cent.; sometimes as at Northallerton, by much more; and of course this improves its value for forming bone and building up the animal's frame. The amounts involved are, however, only small, and in none of these experiments has much of the added phosphate been recovered in the herbage; at two of the centres the results have been:

Percentage of added P_2O_5 recovered in repeatedly mown herbage.

	Mineral Phosphate.	Low soluble Slag.	High soluble Slag.	Super
Dartington, 1st year ..	4	1	8	11
,, 2nd ,, ..	12	—1	11	10
,, both years	16	0	19	21
Much Hadham, 1st year	3	4	14	17

Here, again, the difference between low soluble and high soluble slags is well shown.

Low soluble slag has given poor results in practically all of our

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of nitrogenous manure so far studied, and also for mixtures of cereals with leguminous plants such as are used for fodder mixtures. On the grass land the increased growth is obtained chiefly in spring ; in summer and autumn the increase is less, or it may even vanish.* The effect of reducing the leguminous plants is to cut down the protein content of the whole herbage so that the net gain of nitrogen by the whole crop is only small. Non-leguminous crops usually recover 50 per cent. or more of the nitrogen added in the manure, and the recovery is increased by giving a complete fertiliser ; grass land herbage, on the other hand, shows a much smaller recovery—on the Park grass hay plots our highest figure is 37 per cent., when sulphate of ammonia only was given—and the recovery is decreased by using complete fertilisers, it may then fall as low as 14 per cent.

Recovery of added nitrogen in the hay.
Park grass first 18 years.†

Source of nitrogen.	*Other manures.* None.	Phosphate and Potash.
Sulphate of Ammonia ..	37	20
Nitrate of Soda	35	14

For fodder mixtures the recovery was even less ; in some experiments‡ it was even nil.

As against these, the figures for the recovery of nitrogen by non-leguminous crops grown singly are :

Cereals 40—50
Mangolds 60—70
Potatoes 50—70||

In contradistinction to mixed grass and leguminous herbage the recovery of nitrogen is increased by adding potassic and phosphatic fertilisers. When nitrogenous fertilisers are dear they are not very suitable for grazing land unless special precautions are taken to keep the grass young and leafy by frequent and intense rotational grazing. Otherwise the small amount of nitrogen recovered and the depressing effect on the clover are serious disadvantages.

The increase in amount of early growth brought about by nitrogenous fertilisers has the great advantage that it enables the spring grazing to start earlier than would otherwise be possible, and this may often be a great convenience, especially if supplies of roots, silage or other succulent foods have given out—as not infrequently happens. When nitrogenous fertilisers are as cheap as at present they may advantageously be used for accelerating the early grazing whenever this is needed.

Effects of Phosphatic Manures. Phosphates, unlike the nitrogenous fertilisers, increase the proportion of clover in the herbage, and so add greatly to its protein content. This increase is not confined to the spring months, as happens with nitrogenous fertilisers ; it is maintained throughout the season, and is continued

* Summer manuring has not yet been studied.
† In this period complications due to change in reaction were not serious.
‡ Report for 1930, p. 36 ; the results were confirmed in 1931.
|| For details see Artificial Fertilisers Bull. 28, Ministry of Agriculture, pp. 15-18.

This tendency towards uniformity of herbage comes about for two reasons: species which are unsuited to the conditions soon die; and those which, while well enough suited, cannot stand up against competition, are soon crowded out. In order to obtain further information on this important subject, experiments were started by A. R. Clapham and F. J. Richards, in 1928, and developed later by D. J. Watson. These experiments show that Italian rye grass reduces the growth of perennial rye grass mixed with it, perennial rye grass reduces the growth of cocksfoot, cocksfoot reduces the growth of timothy, and timothy reduces the growth of rough stalked meadow grass; in Clapham's phrase the grasses acted as "aggressors" in this order. The order varied somewhat with season; in another year timothy was more "aggressive" than cocksfoot. Watson has extended the observations by introducing clover (late flowering red) and varying the manurial treatments. He finds that the heaviest yield per unit area is obtained by seeding with rye grass and giving a complete manure; if, however, alternate plants of rye grass are replaced by cocksfoot or by clover, the remaining rye grass plants grow much bigger, though the other plants grow much smaller than if they were alone and the total weight of all the herbage per unit area is reduced. In other words, a plant of rye grass suffers less from the competition of a plant of cocksfoot or clover (Montgomery late flowering red) than it does from the competition of another plant of rye grass. The effect of omitting phosphate from the manuring, however, is to cut down the aggressiveness of the grasses considerably, leaving the clover freer to develop; the omission of potash from the manuring proved a greater handicap to the clover. (Table II.)

TABLE II.—Mean yield of dry matter in grms. per square foot.

Seedings.	*Manurial treatments.*				
	Complete Manure.	No N.	No P.	No K.	No Manure.
Ryegrass	68.8	40.3	46.4	45.1	39.2
Cocksfoot	46.4	46.9	33.4	39.0	23.7
Clover..	38.6	34.1	30.3	25.6	24.6
Ryegrass and Cocksfoot ..	52.7	62.8	45.5	65.1	37.0
Ryegrass and Clover ..	62.2	43.3	31.1	43.6	37.7
Cocksfoot and Clover ..	41.3	36.9	29.8	48.2	30.8

In the experiments just described the plants were allowed to complete their growth; they were neither grazed nor mown. This same order of aggressiveness, however, is indicated by the final state of the herbage in the different fields: rye grass, the most aggressive, dominates the rest; among the grasses cocksfoot comes next; then timothy and the others come a long way after or not at all. In other circumstances other grasses, Yorkshire fog, agrostis, sheeps' fescue, become more "aggressive" and may dominate the herbage.

2. *Manuring of Grass Land.*

The experiments on the manuring of grass land have led to some important results. Nitrogenous manuring has increased the growth of grass but depressed the growth of clover. This holds for all forms

TABLE I (continued)—Percentage Botanical Composition.

1930—*Spring*.

	I.	IV.	V.	VI.	VII.	VIII.
Perennial Rye ..	77.5	57.4	61.7	—	—	} 53.7
Italian Rye ..	—	—	—	49.2	57.5	
Cocksfoot ..	3.3	13.4	17.3	15.5	12.6	18.7
Timothy	4.9	8.8	0.7	4.8	9.4	5.1
Fescue	0.3	—	—	3.2	1.4	2.7
Agrostis	0.2	—	—	—	—	—
Red Clover ..	2.1	6.6	0.2	5.2	6.4	6.6
Wild White Clover	6.6	5.6	2.9	11.2	5.5	5.4
Trefoil	—	—	—	—	0.7	—
Chicory	1.4	—	—	5.3	—	—
Weeds	1.4	3.5	2.2	1.7	1.0	2.7
Bare Space ..	2.4	4.7	15.0	3.9	5.5	5.1

1930—*Autumn*.

	I.	IV.	V.	VI.	VII.	VIII.
Perennial Rye ..	44.6	35.3	43.4	—	—	} 30.1
Italian Rye ..	—	—	—	23.8	25.9	
Cocksfoot ..	8.4	21.1	18.6	19.9	16.2	21.7
Timothy	2.1	4.2	0.5	1.5	7.5	4.7
Fescue	0.2	—	0.1	8.6	—	0.9
Agrostis	1.3	—	—	0.1	0.1	—
Red Clover ..	8.1	12.2	0.7	8.9	7.7	14.1
Wild White Clover	28.6	22.0	29.5	31.1	35.5	22.6
Trefoil	—	—	—	—	—	0.7
Chicory	3.4	—	—	2.6	—	—
Weeds	1.2	0.1	0.4	0.6	0.2	0.3
Bare Space ..	2.1	5.1	6.8	2.9	6.9	4.9

For previous measurements see Report for 1930, p. 44 and for 1929, p. 24.
For particulars of seeding see Report for 1928, p. 101.

The most obvious difference between one mixture and another has been that Italian rye grass has persisted as the dominant grass where it was sown without perennial rye grass; otherwise little difference between cheap mixtures and dearer mixtures persisted by the end of four years. It seems clear that, if the farmer is to recover the extra money spent on costly mixtures he must do it within the first few years, or he may never do it at all.

In the intervening years there were differences in yield and composition of the herbage, and in the density of the plants on the ground. The mixtures were sown on April 25th, 1928; in July, 1929. only about 70 per cent. of the land was covered with vegetation, the remaining 30 per cent. being bare; by the spring of 1930 the bare space was reduced to about 5 per cent. The figures were much the same for all the mixtures. Variations in previous treatment, however, caused considerable differences. West Barn, sown on August 29th, 1928, and therefore very late, and Great Knott (A) (S.E. part), sown on May 29th, 1928, on weedy land and without a cover crop, have both been slower in filling up.

experiments, especially in the South Eastern Counties. It is said to be more effective in acid soils in Scotland and in the North of England, and if this be so it might be attributed as much to the lime as to the phosphate. Precise comparisons are difficult to make, but the lime value of slag approaches that of an equal amount of ground limestone. There may also be an advantage in supplying lime and phosphate together ; at any rate, on some acid soils phosphates rapidly lose their availability as the result of chemical reactions in the soil.

HOME-GROWN FOOD FOR ANIMALS

Several methods are studied for providing *keep for animals* when grain supplies fall short.

Fodder Mixtures. Mixtures of leguminous and cereal crops are grown (e.g. vetches, barley, beans), cut green, converted into hay or silage, or allowed to ripen for use as straw and crushed grain. These crops are cheap and easy to grow ; they keep down weeds, and they have proved of great value as food stuffs because of this elasticity in use ; no other crops can be consumed in such a variety of ways. The manuring of a mixture, however, differs from that of a single crop because the element of competition comes in. The crops grown without manure, or with potash or phosphate only, are rich in protein and starch equivalent ; they make excellent feeds. Nitrogenous manures, such as sulphate of ammonia and nitrate of soda, increase the growth of the cereal considerably, but reduce the vetches and peas ; the total weight of crop per acre is greater, but the feeding value is entirely changed. The new crop contains no more protein, but more starch equivalent per acre ; it resembles hay of moderate quality.

Several different mixtures are being sown at different times of the year to see how far it is possible to arrange for a sequence of these crops suitable for the needs of a flock master, a dairy farmer, or a crop-drying apparatus.

Lucerne. The work on inoculation of lucerne is continuing, and search is being made for new strains of organisms more efficient than the one at present being distributed to farmers. These experiments have revealed great differences in effectiveness between different strains occurring in different soils ; none, so far, is as good as the one we use. But the smallness of the number so far studied gives us grounds for hoping that our search may be rewarded by the discovery of one that is far better.

Nitrogenous manuring proved ineffective in pot experiments to raise the yield of lucerne grown by itself, and it lowered the yield of lucerne grown with grass, besides depressing the formation of nodules, apparently by reducing the root development. The protein content of the mixed herbage was decreased by the nitrogenous manure.

Sales of cultures to farmers have again exceeded all records, amounting to over 9,000 during the season, enough to inoculate over 4,500 acres.

POTATOES

The year 1931 concludes the series of large replicated experiments with potatoes using a 9-block design, which has been found to give particularly precise comparisons. The experiment has been tried four times at Rothamsted, in 1927, 1929, 1930 and 1931, and once at Woburn, in 1929.

The comparisons to be made consisted of all combinations of 0, 1 and 2 unit applications of ammonium sulphate, 0, 1 and 2 units of potash, applied as sulphate, chloride, or potash salt containing potassium chloride. Thus, without replication, 27 different plots would have been required, of which 21 would have been treated differently. The design adopted was to assign 81 plots to the experiment arranged in 9 blocks of 9 plots each, such that within each block, 3 plots without potash received respectively 0, 1, 2 units of nitrogen, and likewise the three plots with single potash, and the 3 with double potash. The 3 plots with single or double potash within each block again were assigned to the 3 types of potash manure. The blocks thus differed only in the association of the 3 kinds of potash with the 3 quantities of nitrogen, and in different blocks each kind of potash occurs 3 times with each quantity of nitrogen.

The effect of this arrangement is to give to the comparisons of primary interest the full precision of replication within small blocks, while sacrificing information on possible hypothetical but highly complex interactions between the different manures. In all experiments save the first, each plot also was divided into two halves, ascribed independently at random to receive or not to receive a dressing of superphosphate.

The response to nitrogen in the five experiments is shown in Table III.

Table III.—Average response to Nitrogen as Sulphate of Ammonia.

Yields in tons per acre.

	Sulphate of Ammonia applied			Size of Single Dressing	Average increased yield of potatoes. Tons per cwt. of N. per acre.		
	None	Single Dressing	Double Dressing	Cwt. Nitrogen per acre	Single Dressing	Additional Dressing	Both Dressings
Rothamsted—							
1927 ..	6.42	7.27	7.32	.42	2.02	0.12	1.07
1929 ..	4.78	5.48	5.85	.30	2.33	1.23	1.78
1930 ..	8.04	9.22	9.65	.20	5.90	2.15	4.02
1931 ..	10.70	11.62	12.37	.20	4.60	3.75	4.18
Woburn—							
1929 ..	4.85	5.11	5.17	.30	0.87	0.20	0.53

Average response to Potash

Yields in tons per acre.

	Yield in tons per acre. Potash applied.			Size of Single dressing. cwt. K_2O per acre	Average increase or decrease in yield of Potatoes. Tons per cwt. K_2O per acre.		
	None.	Single Dressing	Double Dressing		Single dressing	Additional dressing	Both dressings
Rothamsted—							
1927 ..	6.92	7.13	6.95	1.0	0.21	—0.18	0.02
1929 ..	5.21	5.45	5.45	0.50	0.48	0.00	0.24
1930 ..	8.40	9.04	9.48	0.40	1.60	1.10	1.35
1931 ..	11.60	11.40	11.70	0.40	—0 50	0.75	0.12
Woburn—							
1929 ..	4.83	5.04	5 25	0.50	0.42	0.42	0.42

The returns in tons per cwt. of nitrogen are all significant. The variation between the different years at Rothamsted is evidently ascribable to two main causes : (1) The unit quantity of nitrogenous application has been varied, and as is only to be expected, the highest returns per cwt. are found when the unit employed is smallest; (2) There is great variation in the yield from year to year, and the highest return is to be expected, as is indeed found to be the case, in the years of highest yield. These appear to be the major factors in determining the return per cwt. of nitrogen.

A second respect in which the plots treated with more nitrogen differed from those treated with less, lies in the response to superphosphate. The average difference in yield between the sub-plots receiving superphosphate and the twin sub-plots receiving none is given in Table IV.

TABLE IV.—Increased yield of potatoes: tons per acre given by superphosphate with varying supplies of sulphate of ammonia.

	No Sulphate of Ammonia.	Single Dressing.	Double Dressing.	Cwt. P_2O_5 per acre supplied.
1929	0.23	0.51	0.78	.4
1930	0.62	0.49	1.30	.5
1931	—0.08	0.44	0.63	.5
Average : Rothamsted ..	0.26	0.48	0.90	—
Woburn 1929	0.36	—0.14	—0.29	.4

At Rothamsted it is seen that there is a very general and pronounced tendency for the plots receiving more nitrogen to respond better to superphosphate than the plots receiving less, or, what amounts to the same thing, for the plots receiving superphosphate to respond better to nitrogenous manures than the plots receiving none. At Woburn, in the one year tested, there is a marked and

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statistically significant reversal of this effect. The yields in this experiment were very small, but this does not impugn the significance of the result, which it is hoped to examine more fully by later experiments.

The interaction of response to nitrogenous and phosphatic manures is the only interaction to show itself significantly in this series of experiments; this supplies an *a posteriori* justification for sacrificing information in a group of the remote interactions, for the sake of added precision in the main effects. The actual data, moreover, for each year, show that the interactions sacrificed are in fact unimportant, while the comparisons which have been made more precise are of direct interest.

An effect on which higher precision than that actually attained would be most desirable concerns the contrast between sulphate, muriate and potash salt as sources of potash.

Table V gives the average yields in the five experiments, together with the two comparisons muriate *v.* potash salt, and sulphate *v.* the average of the other two. Only in 1927, when the precision of the experiment was considerably higher than has since been attained, could the results for a single year be judged significant.

TABLE V.

Comparison of Sulphate of Potash (S) with Muriate of Potash (M) and Potash Salt (P) as Fertilisers for Potatoes. Yields of Potatoes, tons per acre.

	S	M	P	M–P	S–½ (M+P)
1927	7.36	7.08	6.59	+.49	+.52
1929	5.47	5.45	5.44	+.01	+.03
1930	9.47	9.42	9.10	+.32	+.16
1931	11.80	11.31	11.68	—.37	+.21
Woburn, 1929..	5.28	5.05	5.20	—.15	+.30
Mean	7.88	7.66	7.60	+.06	+.25

Nevertheless, in all five comparisons sulphate has shown a positive advantage over the two forms of chloride, in such a way as to confirm unmistakably the 1927 result. The average gain is only about ¼ ton to the acre, or 2 to 3 per cent. of a fair yield. As between the muriate and the potash salt, however, the five experiments show no significant or consistent advantage.

FERTILISERS AND MATURATION OF BARLEY

Studies by W. E. Brenchley in the Botanical Department have shown that the different fertilisers influence the maturation of barley in different ways.

Phosphatic fertilisers hasten the maturation both of the straw and of the grain. On the other hand, nitrogenous fertiliser and sulphate, whether of potassium, calcium or ammonium, hasten maturity of straw but not of grain.

Mustard is also slightly hastened in maturation by sulphate, but not on all soils; the effect was not shown, for example, on a fen soil from Cambridgeshire.

RELATIVE IMPORTANCE OF NUTRIENTS AT DIFFERENT STAGES OF PLANT GROWTH

In water culture experiments barley deprived of nitrogen during early growth, but receiving it later, was soft and sappy, tillered little and formed little grain, showing that the addition of nitrogen at a later stage did not enable it to make up for the early deficiency, as compared with plants that had had nitrogen from the start. In some instances late additions of extra nitrogen reduced grain formation by promoting fresh tiller formation. Spratt Archer suffered more than the earlier ripening Goldthorpe, which continued filling its grain in spite of the lateness of the nitrogen application.

SUGAR BEET

Sugar beet is included in the new rotation experiments at Rothamsted and Woburn which measure each year the effects of sulphate of ammonia, superphosphate and muriate of potash on crops grown without dung in a six course rotation. In 1931 sulphate of ammonia gave large and significant increases in yield at both Rothamsted and Woburn and muriate of potash a large and significant increase at Woburn ; superphosphate gave small non-significant increases at both centres. (Table VI.)

TABLE VI.

Average increased yield in cwt. of sugar beet per acre given by :—

		Sulphate of Ammonia. 1 cwt. per acre.	Muriate of Potash. 1 cwt. per acre.	Superphosphate 1 cwt. per acre.
Rothamsted	Roots ..	12*	4†	2†
	Tops	16†	0†	—11†
Woburn	Roots ..	11*	19*	4†
	Tops	15†	47*	5†

* Significant. † Non-Significant.

In view of the poor responses to fertilisers sometimes obtained at Rothamsted where the soil is too heavy and sticky to be favourable to sugar beet, different methods of cultivating the crop were tried. Loosening the subsoil had a negligible effect, delay in ploughing under the dung reduced the yield, whilst reducing the distance between the rows increased the yield. The last point has special interest since precautions were taken to have the same number of plants per acre in both comparisons. Other experiments have shown that the yield may be increased by putting the rows closer together but it was not clear whether the advantage was from the closeness of the plants or, what is more likely, from the increase in the total number of plants per acre. In the 1931 Rothamsted experiment the rows were in one case 24 inches apart with plants $10\frac{2}{3}$ inches apart within the rows and in the other the rows were 16 inches apart and the plants also 16 inches apart with the rows, thus giving equal numbers of plants per unit area. The fact that there was a significant advantage of the square over the oblong spacing shows that the yield of beet depends not only on the numbers of plants but also on their arrangement in the field.

	Yield of roots. tons per acre	Yield of tops. tons per acre
Square spacing (16 ins. rows by 16 ins.) ..	13.2	16.2
Oblong spacing (24 ins. rows by 10⅔ins.) ..	12.1	15.6
Dung ploughed in at once	13.0	16.8
Dung left on land 3 weeks before ploughing under	12.3	15.1
Ploughed only	12.8	16.0
Ploughed and subsoil loosened	12.5	15.9

At Woburn where the soil is lighter and cultivation for sugar beet is easier, experiments were made (1) to compare sulphate of ammonia and nitrate of soda applied at different times, (2) to test the effect of salt, (3) with different methods of incorporating the fertilisers into the soil. On the Continent it is common practice to give nitrogenous fertilisers well in advance of sowing the sugar beet and in some cases even in the autumn. At Woburn in the wet spring and summer of 1931 the application of sulphate of ammonia and nitrate of soda three weeks before sowing gave on the average 1.51 tons per acre less sugar beet roots and 1·58 tons per acre less tops than application at the time of sowing. The reduction of yield was doubtless due to the washing out of nitrate by heavy rainfall on a light soil. Sulphate of ammonia gave more roots and a better sugar content than nitrate of soda, and, contrary to the results of earlier years, common salt had no effect. There was no advantage from thoroughly incorporating the fertilisers into the soil by means of a rotary cultivator as compared with harrowing. A number of experiments over several years at Woburn and elsewhere have shown no very marked differences in comparing nitrate of soda given in the seed bed with that top dressed but on the whole the evidence favours the seed bed application.

Fertiliser experiments on two fenland soils produced only small and uncertain effects. The experiments on mineral soils at other centres were in general harmony with conclusions drawn in earlier years, which may be summarised as follows. For equal amounts of nitrogen there is little difference between the alternative forms of fertiliser except that nitrate of soda tends to produce more top, and to depress the sugar content more than sulphate of ammonia, whilst calcium cyanamide sometimes gives rather inferior results. Potash salt is generally superior to muriate of potash, doubtless on account of the common salt it contains. If low grade potash manures are not used, it is generally advisable to give common salt. On good quality clay and silt loams farmyard manure supplies most of the nutrients needed and only a light dressing of a complete fertiliser mixture is required. On light soils good returns are obtained from complete fertiliser mixtures even when used in conjunction with dung. A suitable mixture would be 2-3 cwt. sulphate of ammonia, 2-3 cwt. potash salt (20 per cent.) and 3-4 cwt. superphosphate per acre.

EXPERIMENTS AT OUTSIDE CENTRES

Many experiments are made under the direction of H. V. Garner at outside centres where the crop in question is well understood and where therefore proper cultivation and management is assured. These experiments are of great value in showing how far the Rothamsted results are generally applicable and what modifications are caused by differences in soil, climate, or general husbandry conditions. Full accounts are given in H. V. Garner's articles in the Journal of the Ministry of Agriculture.

Broadly speaking the Rothamsted results usually represent pretty well the average results from the outside centres.

POTATOES. *Phosphatic manuring.* The effect of superphosphate on potatoes has been tested at nine of the outside centres. On the fen soils marked increases were obtained not only from a dressing of 5 cwt. superphosphate, but even from the additional 5 cwt. making 10 cwt. in all. A similar big increase was obtained on the oolite limestone at Burford: 4 cwt. super added 1½ tons per acre to the yield which without phosphate had reached only the low figure of 4.1 tons per acre. On the other hand a rich silt at Wisbech, which has been in the past heavily manured with super, responded only to the first dose of 2 cwt. super and not at all to additional dressings. Two centres showed no response: Owmby and Biggleswade: Owmby has in all the tests shown a response only once. At Rothamsted the response was this season only slight: 2 cwt. potatoes per cwt. super.

Early potatoes on an acid sand at Potton did not respond to superphosphate. The yields are given in Table VII.

TABLE VII. Effect of superphosphate on potatoes at different outside centres

Centre	Soil	Yield tons per acre No Phosphate	Cwt. per acre increase over No Phosphate			Size of dose of Superphosphate. Cwt.
			1st dose	2nd dose	3rd dose*	
Main Crop.						
March	Peaty Fen.	6.46	18	28	—	5
Ely	Rich Clay Fen	7.72	29	55	—	5
Wisbech (G. Major, Esq.)	Rich Silt	11.18	8	Nil	Nil	2½
Wisbech (Messrs. Hickman & Co.)	Rich Silt	12.30	17	16	15	2
Burford	Limestone	4.13	32	30	23	2
Owmby Cliff	Limestone	7.01	—4	—1	—8	2
Biggleswade	Sandy Gravel	10.70	Nil	—	—	2½
Tunstall	Sand	9.85	32	—	—	4
Earlies.						
Potton	Sand	4.05	—4	5	—4	2

* The third dose is double the second dose.

This year potassic fertilisers had but little effect either at the outside centres or at Rothamsted. March had been sunny but from April onwards till October the months had been much wetter, more

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sunless and colder than usual : in general character the season was not unlike those of 1913 and 1926, yet 1926 had been a good potash year. Information is steadily being accumulated about the relation between character of the season and fertiliser efficiency, but the subject is full of difficulties.

Nitrogenous fertilisers on the other hand were distinctly effective, the increase per cwt. sulphate of ammonia being in cwt. potatoes :

	1st dose.	2nd dose.
Rothamsted	18	15
Biggleswade	14	10
Midland Agricultural College	14	20
Ely	16	—
March	6	—

These last two were black fen soils on which responses would not usually be expected, though in our earlier experiments on black soils we have obtained quite good responses : they have been, for 2 cwt. Sulphate of Ammonia :

	Cwt. potatoes. additional crop.
1928 Stourbridge	38
1929 Bourne	20

In comparisons with Nitrate of Soda and Cyanamide, Sulphate of Ammonia gave on the whole the best results for main crop potatoes. Nitrate of Soda came next and Cyanamide third.

For early potatoes, on the other hand nitrogenous fertilisers were practically ineffective : only Nitrate of Soda showed any sign of acting : this is the first set of experiments we have made with this crop and we intend to continue them.

Winter cabbages grown immediately after lifting the potatoes however, benefited by the nitrogen.

Organic Manures. On potatoes organic manures have again proved less effective than the standard artificials. The experiment was made this time by the staff of the Midland Agricultural College : fish manure was tested against home mixed artificials and the I.C.I. compounds ; fish manure gave the smallest and I.C.I. compound the largest increase.

Brussels Sprouts. On Brussels sprouts at the Swanley Horticultural College, however, both poultry manure and high-grade guano proved better than artificials : the results were :

Brussels Sprouts, Cwt. per acre.

	No Nitrogen	Poultry Manure	High Grade Guano	Artificials Full N	Artificials Half N
Sprouts	48.05	53.96	51.79	47.16	45.60
Blown Sprouts ..	14.12	20.59	19.70	18.64	17.08
Total	62.17	74.55	71.49	65.80	62.68

Kale. This important crop has not received much attention from agricultural investigators : we have started several experiments with it which will be developed as the results begin to emerge.

It has great power of utilising added nitrogen. An experiment made at the Midland Agricultural College with marrowstem kale gave marked responses even to 4 cwt. Nitrate of Soda.

	Nitrate of Soda, Cwt.				*Standard*
	0	1	2	4	*Error.*
Kale, tons ..	15.31	18.20	19.06	22.42	0.677

HAY. *Nitrogenous manures.* The average increased production of hay this year has been 6 cwt. for 1 cwt. Sulphate of Ammonia.

SOIL FERTILITY AND MECHANISATION.

The systematic use of large scale machinery on the farm, called for convenience "mechanisation," is usually combined with a reduction in the number of live stock kept, and hence causes certain modifications in the fertility relationships of the soil. Four important groups of problems are being investigated.

(1) Can fertility be sufficiently maintained by artificial fertilisers alone or is it necessary to return the straw to the land in the form of manure? If the straw must be returned, what is the best way of doing it?

(2) Is it possible to produce, by any cultural process, the same good effects on light land as are obtained by sheep folding?

(3) Green manuring.

(4) Fallowing.

The classical experiments at Rothamsted have shown that soil fertility can be kept at a certain moderate level by the use of artificial fertilisers alone without the use of farmyard manure. In general, however, the growth of the crop has not been enough to keep down weeds, and much expense has been entailed in cleaning. A combination of artificial fertilisers with occasional fallows, however, has proved effective in maintaining yields at low expenditure in labour but with a loss of one year in four or five.

The return of the straw to the land can be effected in several ways; three are under investigation:

(1) It may be converted into farmyard manure in the usual way. In our experiments, about 25 per cent. of the nitrogen in farmyard manure is recovered by the plant as against about 50 per cent from artificial fertilisers.

(2) It may be decomposed by the method developed in these laboratories by H. B. Hutchinson and E. H. Richards and put on a commercial basis by the Adco Syndicate; the straw is treated with the necessary nitrogen compound, phosphate and limestone, to encourage the activity of micro-organisms effecting the decomposition.

(3) It may be ploughed under, and the necessary nitrogen and phosphate given in the form of artificial fertilisers. In the autumn a smaller addition is necessary than in the spring, because the soil already contains some nitrate, which if it were not used by the organisms would probably be washed away in the winter.

If this method proves feasible in practice it has the advantage of economy in labour, for the corn could simply be stripped and the straw ploughed under while the soil was still warm.

These problems are being studied in the four-course rotation experiment (p. 129).

Green Manuring.

This affords a simple method of manuring both heavy and light soils and it requires no live stock ; it can be practised on completely mechanised farms. Its advantage in certain conditions has long been recognised, but of late years a number of instances have been recorded where it proved ineffective. The most striking is at Woburn, where, over a series of years, green manuring with tares and with mustard has failed to increase the yield of wheat or of barley. Experiments carried out a few years ago on several other farms with the help of a grant from the Royal Agricultural Society of England also yielded negative results.

There are, however, undoubted successes, and investigations have been made and still are in progress to find the conditions under which green manuring is likely to give useful results. Two of the most important factors are the composition of the plant at the time of ploughing in and the time at which the ploughing is done. If the ratio of carbon to nitrogen in the crop is more than 20, the organisms effecting the decomposition may require more nitrogen then is supplied by the crop, in which case they draw on the soil nitrates that would otherwise either be washed out or taken by the plant. If, however, the ratio is less than 20, the organisms may not need the whole of the nitrogen, they then leave the excess in the soil in the form of nitrate, which as before, is either washed out or taken by the plant. Investigations have shown that at Woburn the tares crop failed to increase the growth of wheat because it was ploughed under in autumn, and rapidly gave rise to nitrate, which was washed out because the wheat plant, being insufficiently developed, could not assimilate it, and in the following spring the wheat suffered from nitrogen starvation. The mustard during its active growth assimilated nitrate and so saved it from loss, but some nitrate escaped assimilation and was washed out because the crop was too small or the soil was bare. Also after the mustard was ploughed in, some of it probably decomposed too slowly to supply useful quantities of nitrogen to the wheat. The value of nitrogen depends on the time when it is given ; when given late to barley it reduced the ear tillers and the number of fertile grains and increased the vegetative tillers. It seems clear that the process of green manuring needs to be clearly adapted to the soil and the crop so as to ensure liberation of nitrate only when the plant is in a position to take it up.

Fallowing.

Since the Broadbalk field was divided into five sections in 1925 to permit of rotational fallowing* it has been possible to accumulate considerable information about the effects produced.

The effect on the weed population is being studied by W. E. Brenchley and K. Warington.

The census of buried weed seeds on Broadbalk field which they began in 1925 is still being continued by the examination of samples taken yearly, in order to determine the rate at which recolonisation occurs after fallowing. The rapidity with which some of the worst seeds reassert themselves is alarmingly great, and indicates the

* See 1930 Report, p. 27, for particulars

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necessity for diligent cultivation immediately the land returns under crop. After a single year under crop the soil may be re-stocked with as many weed seeds of some species (as thyme-leaved sandwort) as were present before fallowing, or even more. After three years in crop the numbers may far exceed the original stock ; black bent and chickweed are notable instances. (Table VIII).

TABLE VIII.

Broadbalk Wheat Plots.

Effect of 2 years' fallowing.

		Buried Weed Seeds Millions per acre*.			
		Before Fallowing (1925)	After 2 years Fallow. (1927)	After 1 year in Crop. (1928)	After 3 years in Crop.† (1930)
Alchemilla arvensis	Lady's Mantle	11.4	3.7	10.0	16.5
Alopecurus agrestis	Black Bent	11.3	0.5	4.8	36.5
Arenaria serpyllifolia	Thyme-leaved Sandwort	0.8	0.75	4.5	3.3
Myosotis arvensis	Forget-me-not	2.1	0.4	0.7	1.4
Papaver spp.	Poppy	82.6	38.0	34.9	34.4
Stellaria media	Chickweed	0.2	0.03	0.5	1.8
Veronica arvensis	Field Speedwell	6.8	1.5	7.3	22.8
,, *hederaefolia*	Ivy-leaved Speedwell	2.0	0.8	1.1	2.4
,, *buxbaumii*	Large Field Speedwell	0.2	0.2	2.0	0.3

Effect of 4 years' fallowing.

		Buried Weed Seeds, Millions per acre*.		
		Before Fallowing (1925)	After† 4 years Fallow. (1929)	After† 1 year in Crop (1930)
Alchemilla arvensis	Lady's Mantle	12.3	1.6	5.3
Alopecurus agrestis	Black Bent	11.3	0.2	3.7
Arenaria serpyllifolia	Thyme-leaved Sandwort	0.9	0.7	0.9
Myosotis arvensis	Forget-me-not	0.6	0.04	0.1
Papaver spp.	Poppy	112.0	23.3	26.9
Stellaria media	Chickweed	0.3	0.4	1.4
Veronica arvensis	Field Speedwell	6.5	0.6	1.6
,, *hederaefolia*	Ivy-leaved Speedwell	1.7	0.2	0.4
,, *buxbaumii*	Large Field Speedwell	0.3	0.3	0.3

Soil improvement due to fallowing is as advantageous to the weeds as to the crop, and those weed seeds which survive the fallow are able to produce very strong plants which form large supplies of seed to restock the soil. If the number of weeds could be kept down for a year or two after fallow, till the soil conditions became more normal, the growth might perhaps be less and the rate of seeding less prolific. Even after a bare fallow lasting for four years, the increase in the buried seeds of some species, such as black bent (*Alopecurus*

* Each figure gives the mean of 28 determinations, the aggregate area examined being 7 square feet. One million per acre corresponds with 160 per 7 square feet.

† Figures incomplete. Will be higher.

agrestis) and lady's mantle (*Alchemilla arvensis*) is very rapid, but others appear to be more easily controlled by cultivation methods.

One point of great practical importance is that fallowing operations may be worse than useless if they are not thorough. After the autumn ploughing the practice is to have the ground untouched till early spring, but during this period a few weeds, as shepherd's purse (*Capsella bursa-pastoria*), thyme-leaved sandwort and large flowered speedwell are able, in favourable seasons, to flower and seed so that there may be more seed present in the soil after fallowing than before. To make fallowing effective, cultivation needs to be frequent, and to be carried out during the winter months as well as during the normal growing season.

TABLE IX.

Ineffectiveness of fallowing, as a means of destroying certain weeds.

Arenaria serpyllifolia.	Millions per acre.
Before fallowing	0.9
After 1 year's fallow	1.0
,, 2 ,, ,,	0.7
,, 3 ,, ,,	1.0
,, 4 ,, ,,	0.7 *

ELEMENTS NEEDED BY PLANTS ONLY IN SMALL QUANTITIES

Plants are made up of some nine or ten elements in rather large amounts ; of these carbon, hydrogen and oxygen come from the air and water, and are not usually under control in this country ; nitrogen, potassium, calcium and phosphorus come from the soil and are regularly controlled by the use of artificial fertilisers ; magnesium, sulphur and iron occur in some of the fertilisers, and are therefore supplied incidentally ; in any case they are usually present in sufficient amount in the soil.

Besides these, however, there are other elements needed only in very small amounts. How many of these there may be is not yet known. The most detailed studies have been with boron, the necessity for which has been demonstrated by K. Warington in these laboratories.

Plants without boron neither grow nor flower normally—special symptoms are produced, including death of the apices and breakdown of conducting tissues. These effects appear much more rapidly in summer than in spring or autumn. The difference is not in the temperature but in the hours of daylight, since plants grown without boron in summer but allowed only 9 hours of daylight are also slow to develop the symptoms, and behave, indeed, like plants grown in spring.

There is some superficial resemblance between the effects of light and of boron. Plants supplied with boron but allowed only a short period of light every day fail to develop flowers just as if they were deprived of boron ; but they will produce flowers when they are given more light, while those without boron will not.

The amount of boron needed by plants is exceedingly small.

* Figures incomplete. Will be higher.

Of all plants yet tested, broad beans seem to require most, but even for them access to 0.2 mgms. and probably less, of boric acid (H_3BO_3) per week per plant during the growing season suffices, while peas and barley require much less. Apparently all plants require some.

These very small amounts are usually, if not invariably present in the soil. No clear case is known where addition of boron has improved plant growth in the field. There are a few possible exceptions which deserve further investigation : *e.g.* a certain tobacco disease in Java may be attributable to boron deficiency.

When the need of the plant is satisfied, further quantities of boron may easily do much harm ; citrus growers in California have suffered loss through the presence of boron in the irrigation water. Manuring with boric acid is certainly not recommended ; indeed, it is strongly to be deprecated.

SOIL PHYSICS

During R. K. Schofield's charge, the work on soil cultivation was continued.

In the laboratory further search was made for easy and rapid methods of soil testing. A new machine, called the Pachimeter, was devised by R. K. Schofield and G. W. Scott Blair to study the process of rolling a plastic cylindrical mass of moist soil or clay between two plates under a gradually increasing load. It was found that the load at which permanent lengthening of the cylinder first occurs is, within limits, a definite and reproducible value which varies considerably with the nature of the soil or clay examined, and this measurement promises to be of value in soil classification and surveying. The method has attracted a good deal of attention outside the sphere of soil investigations, and especially in the flour-milling industry.

R. K. Schofield has developed a new rapid method for determining the " base exchange capacity " of a soil : it consists in measuring the decrease in conductivity of a potassium phosphate solution when a weighed quantity of soil is introduced.

C. G. Hawes, Executive Engineer, Lloyd Barrage and Canals Construction, Sind, spent nine months in the department studying methods of distinguishing soils likely to give trouble under irrigation conditions.

METHODS FOR AGRICULTURAL SOIL SURVEY

In recent years there has been marked development in the number and extent of the soil surveys undertaken in this country and elsewhere, and it has become essential to work out satisfactory methods for field and laboratory examinations. Much progress has already been made in the United States and in Russia. The Russian methods have been studied in Russia during the past few years by several members of the Rothamsted staff. E. W. Russell worked for some months with a soil survey party in South Russia ; G. V. Jacks and H. L. Richardson have worked there for shorter periods ; while E. M. Crowther, H. L. Richardson, and the Director have traversed the country with the leading Russian soil experts to learn their methods from them at first hand.

Somewhat different methods are used in the United States. In order to make a careful study of these, one of their leading soil surveyors, L. L. Lee of the New Jersey Experimental Station, was invited to visited Rothamsted for a year during which time he made two typical surveys: a detailed survey of the Rothamsted farm, showing how the methods are used in making an intensive survey of a small area, and a more general survey of Kent, showing how they deal with a large area in a limited space of time. A number of meetings took place with soil surveyors in this country, out of which emerged agreements as to procedure which will prove of great value for future work. One of the German "Kulturtechniker" Dr. Janert, was also invited here for a year to apply his heat of wetting and other methods to the study of British soils.

GENERAL MICROBIOLOGY

Much of the earlier work of the Station was concerned with the effects of partial sterilisation of soil, and the view was expressed that the increased numbers of bacteria following on the partial sterilisation treatment resulted from the suppression of soil protozoa. This has been confirmed by much subsequent work and regular relationships have been traced between the numbers of bacteria and those of protozoa; when one is high the other is low, and *vice versa*.

The further deduction was made that these higher numbers of bacteria produced a larger amount of ammonia in the soil and therefore increased the total amount of plant food. It now appears that this requires important qualification; the amount of ammonia and carbon dioxide produced does not increase proportionately to the numbers of bacteria, but much less. As the bacterial numbers increase so their individual efficiency decreases. In experiments with cultures of bacteria in artificial media it was shown that additions of the protozoa *Colpidia* reduced the bacterial numbers, and increased the individual efficiency. The relationships between numbers and efficiency could be expressed by a straight line, but the actual line for the protozoa-free cultures differed from that expressing the results for the cultures containing protozoa in a way suggesting that *Colpidium* stimulated ammonia production by the bacteria quite apart from its effect in reducing numbers of bacteria.

This work on the interaction of the various groups of the soil organisms is being continued.

The work on nitrification described in the last Report is being continued.

EFFLUENT FROM SUGAR BEET FACTORIES

The study of the purification of effluents from sugar beet factories has been continued, and useful information has been obtained in regard to the possibility of inoculating filters with particular strains of bacteria.

SOIL BACTERIA

Bacterial Numbers in Field Soils

An essential part of the work of the Bacteriological Department is to form estimates of the numbers of bacteria in the soil. The plating method was used at Rothamsted for many years, and it served the useful purpose of showing which factors increased and which decreased the numbers of bacteria in the soil, though it failed to record many of the groups, so that the results were always low.

A great improvement in the method of counting was made in 1928 by H. G. Thornton and P. H. H. Gray ; direct counts are made from stained films, and the difficult problem of estimating the minute amount of soil involved is overcome by mixing with a weighed quantity of the soil a known volume of a suspension of indigo particles the thickness of which has been determined with a haemocytometer. Bacteria and indigo particles are both counted in the stained films from this mixture, and, from the ratio of bacteria to indigo particles, a simple calculation gives the numbers of bacteria per gram of soil.

The method is not only much more rapid than the older one, but much more complete. The plating method usually gives numbers of the order 10 to 30 millions per gram of soil from our plots ; the new method gives numbers varying from about 1,500 million to 4,000 million per gram of soil. On the Hoosfield barley plots, for example, the numbers varied from 1800 millions per gram in the soil of Plot 1—0 (unmanured since 1856) to 3,600 millions on Plot 4AA (complete artificial fertilisers, including nitrate of soda every year since 1856). Further, the numbers in the different plots varied in much the same way as the yields, so that bacterial counts give some indication of the order of productiveness.

Bacteriological Methods of Assessing Soil Fertility

In recent years several bacteriological methods have been devised for assessing either the general fertility of the soil or else some special deficiency such as lack of lime or of phosphate. One of the simplest and most elegant is that of Winogradsky and J. Ziemiecka, and fortunately we were able to arrange with the authorities of the Pulawy Agricultural Institute, Poland, for Mme. Ziemiecka to work for some months in our laboratories applying the " plaques moulées " method to the soils of the classical plots. The results gave correct indications as to the presence or absence of adequate phosphate and lime supplies on the plots receiving no nitrogenous manure or only the normal dressings, but not on plots to which heavy dressings of nitrogenous manure were given. Further examination showed, however, that Azotobacter was either absent from these soils, or occurred in only small quantities ; when a culture of it was added as part of the test the results came out entirely correctly.

Counts of nitrifying organisms were made from some of the plots, and these showed some relationship with soil fertility.

During the course of her experiments Madame Ziemiecka isolated an organism of considerable interest, whose cells possessed the power of absorbing certain indicators such as Brom Thymol Blue. She also obtained a *Myxobacterium* which attacks cellulose, the first found in our soils.

THE NUMBERS OF FUNGI IN THE ROTHAMSTED SOILS

The quantitative methods worked out in the Mycological Department have been used by Jagjiwan Singh for estimating the numbers of fungi and actinomycetes in the Rothamsted soil. The types of fungi were much the same in the differently manured plots, but the numbers both of types and of individuals were always higher on the more fertile plots. There was no evidence of seasonal fluctuations in numbers, such as have been recorded for bacteria and for protozoa. Barnfield (continuous mangolds, the leaves always ploughed in) contained more fungi but less actinomycetes than Broadbalk (continuous wheat) ; there was also some difference in the proportions of the fungal population. Barnfield contained more *Penicillia* and *Dematia* but less *Fusaria* and *Verticillia* than Broadbalk.

VIRUS DISEASES OF PLANTS

This work is carried out by J. Henderson Smith, with the assistance of J. Caldwell, M. A. Hamilton and F. M. L. Sheffield. It falls into three sections :

1. *The Nature of Virus.* Juices extracted from diseased plants are usually themselves infective and remain so after passage through most porcelain filters. By using graded collodion membranes it has been found possible to determine a limiting porosity (varying with different viruses), above which the filtrate remains infective but below which the virus is held back and the filtrate does not cause disease. Again, when infective material is rubbed on the leaves of certain plants, virus enters through the broken hairs and produces a local lesion at the point of entry. If the material is suitably diluted before rubbing on the leaves, infection occurs in only a few of the many broken hairs and only a few local lesions result. Such experiments show that in infective material virus exists in a particulate state and not generally diffused. The size of these particles has been estimated approximately ; but it is still uncertain whether the virus is itself particulate or merely attached to other particles. Work is in progress to determine which is the true explanation. Nothing has yet been found incompatible with the view that virus is a living organism.

It is frequently asserted that viruses are invisible stages in the life-cycle of visible bacteria, largely because there is a regular association of specific bacteria with certain virus diseases. We have investigated one such case, and find that when the plants are grown aseptically throughout from sterile seed, inoculation with bacterium-free virus produces the typical disease, and the bacteria usually associated with it do not appear. It is also said that intracellular inclusions which are characteristic of virus disease are either colonies of the virus or visible stages of a usually invisible parasite. The development of such inclusions has been watched in individual living cells from their first beginnings to their complete formation, and in the cases investigated they are essentially aggregates, made up by the coalescence of small particles of cytoplasm which has been locally coagulated or precipitated under the influence of the virus.

A cinematograph film has been prepared showing the whole process. The final form of the inclusion varies with the host plant and with the virus.

2. *The behaviour of Virus in, and its effects on, the host plant.* Within the infected plant the virus does not travel in the transpiration or water stream, nor, indeed, does it normally enter the stream. If deliberately introduced into the xylem vessels, it cannot normally escape ; it therefore does not produce the disease, unless and until

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it is artificially liberated. In none of the experiments devised to test the point did virus enter an unbroken cell. Large quantities of virulent juice can be injected into the leaf of a plant through the stomata, but symptoms will not develop unless some of the cells are ruptured. The development of virus in the leaves of an infected plant is followed by considerable alteration in the enzyme content. The mechanism of respiration is also greatly affected. This is being investigated in detail, and the work is still incomplete, but it seems clear that one of the first effects of the entry of virus into the cell is a greatly enhanced respiration rate and a state of general excitation.

3. *The relation of Virus to Insect-vectors.* By the development of a technique for maintaining insects upon solutions apart from the plant, considerable control has been obtained over the conditions determining the infection of the insect. Data have been obtained as to the time required for dyes and other substances taken in by the alimentary canal to reach the salivary glands, information which is necessary for the correct evaluation of the incubation or non-infective period after the insect has fed upon diseased material. By use of this technique it has become possible to investigate such problems as the filterability of viruses which are not transmissible by juice, e.g. leaf-roll of potatoes, and to approach the question why one insect carries and another does not.

A new virus disease has been discovered in *Hyoscyamus*, which is readily transmitted both by needle and by aphis, and has an incubation period in the insect. At the same time, at least two other unrecorded virus diseases were distinguished in commercial crops of this plant. These may prove to be due to viruses already better known in other crops, e.g. potato; and there is reason to believe that one at least of these new diseases is a composite disease caused by the simultaneous action of two different viruses.

BACTERIAL DISEASES OF PLANTS

The angular leaf-spot or " black-arm " disease of cotton is being investigated by R. H. Stoughton in considerable detail, because of its importance in many of the tropical cotton-growing countries of the Empire. The results have proved to be unusually interesting.

The responsible organism, *Bacterium malvacearum*, is of great bacteriological interest, as it possesses a nucleus and forms accessary reproductive bodies never previously described in this group of bacteria. It appears also to pass through a conjugation stage in which two cells join together to form a fusion-body or zygospore, of possibly different potentialities. It also " dissociates " or breaks down into a number of strains, quite unlike in pure culture and having different degrees of virulence. Strongly virulent strains may give rise to almost non-virulent ones, and these again revert to the culturally-unlike virulent form. The possible relation of this production of variants to the life history is now being studied.

The geographical and climatic distribution of the disease indicate that meteorological factors play a large part in determining its severity. Careful study has therefore been made of the separate effects of air temperature, soil temperature and air humidity.

Cotton plants were grown in special chambers in which these three factors are controlled automatically over a wide range so that each can be kept constant or made to vary uniformly as desired. The plants are grown entirely by artificial light, so that experiments at different times of the year are strictly comparable.

Air temperature plays the chief part in the development, as distinct from the spread, of the disease. Black-arm is essentially a high temperature malady, and in the control chambers severe secondary infection of the growing plant by spraying with a virulent culture is only obtained at temperatures above 30°C. The physiological reasons underlying this are under investigation ; they appear to be bound up with the relative rates of growth of the parasite and the plant, and the carbohydrate metabolism of the plant as shown by its sugar content. Fluctuating temperatures, whether soil or air, which resemble more closely natural conditions, give the same result as a constant temperature near the mean of the varying factor.

Soil temperature is less important. It plays, however, some part in determining the amount of disease on the very young seedlings grown from infected seed. The amount of this primary infection is reduced by high soil temperatures, e.g. above 30 C., but not sufficiently to offer any prospect of control by this method.

Air humidity is the chief factor determining the spread of the disease, but it is important only during the short period required for inoculation. Humid conditions are necessary for successful penetration of the tissues by the bacteria on the surface, however they have got there, but once penetration has been effected the external humidity has little direct effect.

Internal infection of seed, which has been suggested as a serious cause of primary infection, was found to be very rare ; external infection is the usual source. The primary infection can be controlled and healthy seedlings raised by complete sterilisation of the outside of the seed, indicating that the organisms are usually carried on the fuzz of the seed coat.

The costly appliances needed for this work were purchased and are maintained out of grants made by the Empire Marketing Board.

FUNGUS DISEASES OF PLANTS

W. B. Brierley continued his study of racial problems in fungi. A number of natural infections of different hosts by *Botrytis cinerea* were intensively analysed and, with few exceptions, two or more races of the parasite were obtained from any single lesion. In certain cases the fungus produced infections which could not be distinguished from each other but the host lesions contained populations consisting of different races or of assortments of the same races in different proportions. This method of intensive analysis was extended to other fungal parasites with similar results, and it seems possible that, in many diseases, infection may be caused by genetically complex populations rather than by single races of specific fungi.

Numerous experiments designed to study the educability of individual races of *Botrytis cinerea* produced no evidence of change lasting beyond the one generation.

M. D. Glynne continued her study of the wart disease of potatoes. Among varieties which, on the basis of field trials, have been officially certified as immune are some which, under the more stringent con-

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ditions of laboratory testing, develop small infections. The development of the parasite has been traced in a number of these varieties and, in some, the increase of the disease seems to be prevented by the development of a necrotic area in the region of infection by which the plant sloughs off the parasite with the dead tissues.

Critical examination of doubtful specimens of wart disease has been continued for the Ministry of Agriculture and the National Institute of Agricultural Botany and reports have been made on seventy-four specimens belonging to thirty-seven varieties.

Investigations into the relation of nutrition to certain fungal diseases of the potato plant by L. M. J. Kramer, at Rothamsted and at Woburn, showed no correlation between manurial treatment and the severity of attack by blight (*Phytophthora infestans*). The distribution of the disease was determined by the direction of the prevailing wind and the presence of infective centres.

Pot culture experiments, however, showed that excessive applications of phosphatic fertilisers increased infection of tubers by pink rot (*Phytophthora erythroseptica*).

A method of assessing the extent of fungal invasion of potato tubers was devised which corrects for the errors due to the size of the tuber. It has been extensively used and is of wide application.

THE INSECT PESTS

Wheat Midges. Observations made by H F. Barnes during the past five years on the incidence of wheat blossom midges on Broadbalk, combined with studies of the records of the Ministry's entomological advisors, have revealed some degree of periodicity in their attack. About every fourth or fifth year they do great damage to wheat, but in the intervening years the damage is insufficient to warrant any expenditure on control measures. The figures for the damage on Broadbalk for the last five years are :

Year.	1927	1928	1929	1930	1931
Percentage of damage to grain	3.2	6.5	7.7	17.6	21.4

Thus 1930 and 1931 were years of great damage on Broadbalk. The Ministry's records show that 1916, 1920 and 1926 were also peak years of damage. H. F. Barnes is following up these remarkable observations. If they lead to forecasting of attack some valuable practical results might be expected to emerge.

Varieties of Plants immune to insect attack. Agricultural pests are not easily controlled by direct methods such as spraying, which is so effective for hops and fruit. Indirect methods, including the use of resistant or immune varieties, are more suitable.

H. F. Barnes has continued his search for varieties of willows immune to gall midge attack ; this year he has concentrated on the midge that attacks the cricket bat willow (*S. coerulea*) which causes serious loss of sets, and has found certain basket willows immune to attack.

M. E. Metcalfe has been doing similar work on clovers and grasses, such as timothy, rye grasses and cocksfoot. All varieties of red clover are as a rule attacked by the red clover seed midge, but the white clovers are not. The extent of damage depends on the time of flowering of the clovers ; possibly it could be avoided by delaying flowering until the flight of midges is over.

H. C. F. Newton is investigating the causes of plant immunity, and has begun a series of amputation experiments to ascertain which organ or organs on the insect enables it to differentiate between the varieties of plants.

The Pigmy Mangold Beetle (*Atomaria linearis*) has of late years been a troublesome pest of mangolds, but its life history could not be worked out because neither the eggs nor the larvae could be found in the soil. This has now been done by H. C. F. Newton, so that further knowledge of the pest can be obtained which may lead to the discovery of suitable remedies.

Other Activities. The department has kept in touch with the problems in the British Empire, and during 1931 has helped by identifying gall midges, on which H. F. Barnes is a recognised specialist, from Trinidad, Brazil, Algiers, Russia, Germany, Sicily, Cyprus, Turkey, Sierra Leone, Uganda, Nigeria, Malay and Formosa.

INSECTICIDES

Pyrethrum. For some years past F. Tattersfield and J. T. Martin have closely studied pyrethrum (*Chrysanthemum cinerariaefolium*), the flowers of which when dried and ground, form one of the most effective and convenient of all insecticides. Its popularity may be gauged from the fact that its production in Japan, the chief source of supply, rose from 279,931 lb. in 1911 to 11,622,906 lb. in 1928 ; its cultivation has also been started in France, Switzerland, Spain and the Argentine. Attempts are being made in conjunction with J. C. F. Fryer, of the Ministry of Agriculture to develop pyrethrum growing in this country ; the results are distinctly promising. A very poor sandy soil gave an excellent sample. The manurial treatments so far tried have not markedly affected either yield or toxic quality of the flowers.

Climatic factors are, however, important. In tropical countries Uganda, Tanganyika and Trinidad, the plant grows but will not produce flowers ; on the uplands of Kenya, however, good crops of flowers of high toxic value were obtained. In temperate conditions the number and the pyrethrin content of the flowers are reduced by reducing the illumination (e.g. by cutting off the hours of daylight) and finally with sufficiently low illumination (1,000 watt lamp only), no flowers are produced.

The toxic properties are due to two closely allied substances called pyrethrin I and II, which are esters of a ketonic alcohol, pyrethrolone, and two acids, one monobasic and the other dibasic. Neither the pyrethrolone nor the acids are toxic, only the combination of the two. The pyrethrin content of the flower heads depends on the plant ; the order of merit of the different plants tested has been much the same in each of the three years of the experiment. There is some evidence that cuttings from high yielding plants will in turn produce high pyrethrin yields, though whether the property is transmissible by breeding is not yet certain.

Hitherto pyrethrum (made up as talc-pyrethrum dust) has suffered from the serious drawback that it is liable to lose its toxicity after a time. F. Tattersfield finds that the cause of the loss is oxidation of the poisonous principle, and this is specially marked in the light ; it is much slower in the dark. The loss is greatly reduced, however, by adding small quantities of certain antioxidants such as pyrocatechol, resorcinol, hydroquinone, pyrogallol and tannic acid ; on the other hand phenol and phloroglucinol were less effective.

Fish-poison Plants. A number of plants are used by the natives of tropical countries for catching fish by poisoning them. Many of these plants have been examined by F. Tattersfield and found to contain one of the most potent insecticides known, rotenone. Derris is the best known of these plants ; its root, which is the most effective part, usually contains some 2 or 3 per cent. of rotenone ; the quantity is variable, however, and in samples received in our laboratory it has ranged from 1 to nearly 6 per cent. Another plant, "cubé," *Lonchocarpus nicou* from Peru, contained as much as 6.4 per cent.

Certain other plants were found also to possess insecticidal properties, among them *Mundulea suberosa*, from India, and *Neorautanenia fisifolia*, from S. Rhodesia, but they seem less effective than the Derris and Haiari groups.

These insecticidal plants have undoubtedly a great future. They are far and away the best and safest insecticides and are very potent both against animal pests and against plant pests. The pyrethrin producers can be grown at home, and the rotenone producers in our tropical empire, notably in Malaya and British Guiana, and their cultivation would open up the possibility of an important new industry. F. Tattersfield has been highly successful in studying these plants, and it is deplorable that the work has had to be curtailed owing to reduction of grants just as it was beginning to yield results. It would have suffered much more but for the public spirited action of Mr. George Monro, who induced his company to make a grant of £100 for three years in order to keep the investigation going in readiness for active development whenever the opportunity arises. The Empire Marketing Board out of its slender resources made a grant of £50 to enable us to examine in detail some of the samples now being grown experimentally in British Guiana.

BEE RESEARCH

An important investigation into the causes of swarming has been begun by D. M. Morland. Young bees are hatched out in an incubator in weekly batches of 1,000 ; they are marked with distinctive marks and introduced into an observation hive ; their subsequent careers are then observed. They all go through a definite course. For the first part of their lives they act as wet nurses to the brood—the young larvae that will shortly become bees. Then, after a time, they pass on to household duties, such as the cleaning and ventilation of the hive. Still later they become food finders, going out foraging for nectar.

All goes well so long as the number of larvae is enough to keep the nurses fully occupied. But in late spring the number of eggs laid is very high, and each egg may in 21 days become a wet nurse seeking larvae to feed. As the number of eggs becomes less the number of larvae falls off, and then the nurse bees, apparently as the only way of using up their superfluous food and energy, start producing queen cells.

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This causes trouble. The queen cells disturb the old queen, and when the next queen emerges, and in some instances even before she comes out, the old queen goes off with many followers. Swarming was induced in the experimental hive by introducing a host of active nurse bees ; a few days before the migrants left home some of them were seen three-quarters of a mile away, preparing an empty hive for occupation. When finally the swarm went off it took with it bees of the different categories—nursemaids, housemaids and food-finders—in approximately the same proportion as in the parent hive.

This work is being actively developed, but it needs more helpers. It is one of the most fascinating branches of social biology.

In addition, a number of investigations are made with questions of purely technical interest, though of great practical importance. Chief among these are the methods of ventilating the hive. Bee-keepers had been divided on this subject ; some had advocated the setting of the combs parallel to the front of the hive ; others preferred to set them at right angles, supposing that this would give better ventilation and freer access to the combs ; this way called the " cold way," in contradistinction to the other or " warm way."

Observations over a number of years have shown that neither arrangement has much effect on the temperature ; the bees manage this for themselves. During summer they completely control the temperature of the brood nest by fanning with their wings and during winter they completely control the temperature of the interior of the cluster by their own body warmth.

Warm air is expelled by the bees during the active season, especially in the process of ripening honey, but in winter the chief loss of heat from a hive occurs through the walls, by conduction. This is so important that special studies have been made to see how to minimise it. An outer cover was made giving a space of 6 or 8 inches all round the brood chamber, this space was filled with planed shavings. This additional protection improved the brood rearing conditions in spring and autumn, greatly reduced the consumption of stores in winter and afforded drier conditions in winter by eliminating condensation.

The omission of the shavings, as in the " W. B. C." hive, reduced the efficiency of the cover ; the temperature in winter was no better than in the single walled hive.

The moisture evaporating from the bees gives rise to important problems in hive construction. It penetrates the wall of the hive, but if the outside of the wall is painted it is held back by the paint forming a water blister. This penetration could not be stopped by coating the inside of the wall either with boiled oil or with the varnish gathered and applied by the bees themselves. If, however, the outside is not painted but only creosoted the moisture escapes. In winter this led to the bees clustering well forward against the warm south side of the hive instead of retiring on their stores in the normal way ; further, on sunny days in winter the bees flew while those in the white painted hives remained quiet. In summer, however, the creosoted hives were unbearably hot to the hand. The bees were quite equal to the emergency, and they kept down the temperature to the proper degree by fanning.

Unpainted zinc was an effective roofing material. Painted white, it remained very wet inside with condensed moisture during winter months, while painted black it became very hot in summer though it was always dry inside.

FUNGUS DISEASES OF CROPS ON EXPERIMENTAL PLOTS AT ROTHAMSTED AND WOBURN, 1931

M. D. Glynne

WHEAT

Mildew (*Erysiphe graminis DC.*) was first observed in June, and was most plentiful in July. It was generally slight, but in Little Hoos Top Dressing experiment at Rothamsted and in the New Rotation experiment on Stackyard field at Woburn the disease was moderate to plentiful.

Whiteheads (Take-all) (*Ophiobolus graminis* Sacc.) was first observed in May. The severity of the attack varied considerably from field to field and from plot to plot. It was more common on wheat grown continuously or in alternate years on the same land than when longer intervals occurred between each wheat crop. On Broadbalk the disease appeared to be rather more plentiful on the badly nourished plots 3—5 than on the others. It was considerably more plentiful at Woburn than at Rothamsted.

The permanent wheat plots on Stackyard Field, Woburn, showed such great differences in the incidence of disease on differently manured plots that a detailed survey was made which will be published later. On plots with a high degree of soil acidity the disease was absent or very much less than on those with a higher pH.

Loose Smut (*Ustilago Tritici*. (Pers.) Jens.) This occurred on several plots of Broadbalk. At Woburn it was found on the Continuous Wheat in Stackyard Field and on the Green Manuring Experiment in Lansome Field. It was also present on the variety Square Heads Master, but not on Yeoman II in the Precision Wheat Experiment on Lansome. Its incidence was slight.

Yellow Rust (*Puccinia glumarum*, (Schm.), Erikss. and Henn.) Was observed as slight in early June but increased as the season advanced. The attack varied from field to field, and from plot to plot, and on the whole was more abundant where the crop was heavy. In Woburn, on the Precision Wheat, it was more abundant on Square Heads Master than on Yeoman II, especially early in the season. It was very plentiful on Winter Wheat Var., Wilhelmina sown in July on Fosters Field, especially in September, when the leaves looked yellow with rust. In October, however, though the older leaves were still badly affected, the younger ones were green and appeared to be growing away from the disease.

Brown Rust (*Puccinia triticina* Erikss). Very plentiful in September on Winter Wheat, var., Wilhelmina sown in July, in Fosters Field. In October the plants appeared to be growing away from the disease, as the young leaves were very much less badly affected than the old ones.

Leaf Spot (*Septoria Tritici* Desm). Was found on all the wheat fields ; its incidence was on the whole slight.

Foot Rot (*Fusarium sp.*). Was found on the underground parts of the wheat plants as a white mycelium. Its incidence was very

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slight at Rothamsted, except on Hoos Field Wheat after Fallow, where it was present, though not plentiful.

At Woburn it was very slight on the Continuous Wheat on Stackyard, while on the Green Crops as Manures in the same field it was more plentiful, though still slight. It contrasted with Whiteheads, which was very plentiful on some plots of Continuous Wheat and very slight on the Green Crops as Manures.

OATS

MILDEW (*Erysiphe graminis, DC.*). Was found much more abundantly on the spring-sown than on the winter oats. The attack was especially heavy on the dark green, well-nourished plants. It was found fairly plentifully on Great Harpenden, Pastures and Broadbalk spring oats, and was present but not plentiful on the winter oats on Great Harpenden and Little Hoos fields.

LOOSE SMUT (*Ustilago Avenae* (Pers.), Jens.. Was found in the winter oats from June onwards. It was scattered through the crops and was fairly plentiful in Great Harpenden, in Little Hoos, and at Woburn in Lansome Field. It was not found on the spring oats.

CROWN RUST (*Puccinia Lolii* Niels). Was slight early in the season, and by August was fairly plentiful on the spring oats. It was also found in September and October fairly commonly on oats sown in Fosters Field in July.

LEAF SPOT (*Helminthosporium Avenae* (Bri. and Cav.), Eid.) Was found on both spring and winter oats at Rothamsted and Woburn, varying in quantity from slight to moderate. In no case did it appear to do much damage.

BARLEY

MILDEW (*Erysiphe graminis, DC.*). Was found on most of the barley, in greatest quantity on the plots receiving heavy application of nitrogenous manure.

WHITEHEADS (TAKE-ALL) (*Ophiobolus graminis*, Sacc.). Was observed on the Continuous barley in Stackyard Field at Woburn.

NET BLOTCH (*Pyrenophora teres* (Died.) Drechsl.). Was present in all the barley crops. It varied from slight to very plentiful on different fields at Rothamsted and Woburn.

BROWN RUST (*Puccinia anomala* Rostr.). Was generally fairly common. It was very heavy in September on barley sown in July in Fosters Field.

LEAF STRIPE (*Helminthosporium gramineum* Rabenh.). Was found on most of the barley crops at Rothamsted and Woburn, killing occasional plants. The loss due to the disease appeared to be slight.

While *H. gramineum* did not appear to cause much loss in the field, it did serious damage in many pot experiments. For work of this kind disinfection of seed is strongly recommended.

LEAF BLOTCH (*Rhynchosporium Secalis* (Oud.) Davis). Was found in most, but not all the barley fields. None was found on Long Hoos, Rotation ; it was most common on the Continuous barley in Hoos. At Woburn it was moderate on the Continuous barley in Stackyard and in the Rotation Cake v. Corn in Lansome Field. On most other barley plots it was slight.

RYE

ERGOT (*Claviceps purpurea* (Fr.) Tul.). A little was found in August on the commercial rye grown for seed in Great Harpenden Field.

BROWN RUST (*Puccinia secalina*, Grove). Was present but not very plentiful except on the rye sown in July in Fosters Field, where the attack was moderate.

LEAF BLOTCH (*Rhynchosporium Secalis* (Oud.) Davis). Was present in small quantity on Little Hoos and Great Harpenden Field at Rothamsted. On Butt Furlong Field at Woburn the attack was unusually severe.

RYE GRASS

ERGOT (*Claviceps purpurea* (Fr.) Tul.). Was found occasionally on rye grass growing at the edge of Fosters Field.

CROWN RUST (*Puccinia Lolii*. Niels). Was common in September on rye grass in the forage plots on Fosters Field.

GRASS PLOTS

CHOKE (*Epichloe typhina* (Fr.) Tul.). A detailed eye estimation of the amount of this disease was made on all plots on June 23rd, 1931, and checked on the following day. *Epichloe typhina* was found generally on Agrostis and very occasionally on *Dactylis glomerata*. It varied considerably from plot to plot, as has been observed for many years. Liming appeared to reduce the disease, and ammonium sulphate even after it had been discontinued for many years, appeared to increase the disease except in the limed parts. Plots 11-1 and 11-2, which receive treble ammonium salts, had little disease, but there was very little Agrostis in these plots except at the edges and these plants were considerably affected.

A potash deficiency has long been regarded as a predisposing cause for this disease. A careful comparison of comparable plots with and without potash 5-2 and 5-1, 7 and 8, 9 and 10, showed similar amounts of disease in the individuals of each pair of plots except in 9 and 10. Plot 10, which lacks potash, had more *Agrostis* and more *Epichloe* than 9, but the proportion of *Epichloe* to *Agrostis* appeared similar in each plot. This observation should be repeated over a number of years.

The distribution of the disease must necessarily be partly depedent on that of *Agrostis*, and this varies very much with manurial treatment. There is, however, some evidence which suggests that the distribution of Choke varies on plots in which the amount of *Agrostis* is similar. In order to assess the parts played by the distribution of *Agrostis*, the direct effect of manurial treatment and other factors, on the incidence of the disease considerably more data are needed.

BROAD BEAN

(On Great Knott Field, Rothamsted)

CHOCOLATE SPOT (*probably Bacillus Lathyri* Manns and Taub.). Very common.

RUST (*Uromyces Fabae* (Pers.) de Bary). Very common.

GREY MOULD (*Botrytis cinerea*, Pers.). Very common, occasional plants apparently killed by it.

SWEDE

FINGER-AND-TOE (*Plasmodiophora Brassicae* Woron.). Was found on Barnfield, but was not common.

MILDEW (*Erysiphe Polygoni*, DC.). Fairly common.

MANGOLD

RUST (*Uromyces Betae* (Pers.) Tul.). Was found fairly frequently on Barnfield in October.

BLACK LEG (*Phoma Betae* (Oud.) Frank). Was found on Barnfield on young plants in June, in moderate quantity. Affected roots were found but were not common at harvest.

LEAF SCORCH (*possibly non-parasitic*). Was common on plots in Barnfield in October. It was on the whole more plentiful in plots which received nitrogen as manure than in those which did not.

SUGAR BEET

CROWN GALL (*Bacterium tumefaciens* E.F. Sm. and Towns). Was found on a few roots at Rothamsted. It was uncommon, but occasionally well developed.

RUST (*Uromyces Betae* (Pers.) Tul.). Was found occasionally in the sugar beet at Rothamsted. The attack was slight.

LEAF SCORCH (*possibly non-parasitic*). Was common both at Rothamsted and Woburn. At Rothamsted, on Rotation II on Long Hoos, it was fairly evenly distributed, and was moderate to plentiful on every plot. The difference in manurial treatment did not appear to affect the incidence of the disease.

At Woburn, on the Manurial and Cultivation Experiments on Butt Furlong Field, it varied considerably from plot to plot. Counts were therefore made of the number of plants showing " scorch " on the micro-plots and on the plots in four blocks of the main experiment.

There was some indication on the main experiment that late application of manure and the addition of sulphate increased the disease and rotary tillage reduced it. On the micro-plots, however, the addition of sulphate did not appear to increase the disease, which was on an average greatest on the unmanured plot.

REPORT ON INSECT PESTS OF THE ROTHAMSTED FARM, 1930-1931

By H. C. F. NEWTON

GENERAL. One of the most notable features on the Rothamsted farm this year was the almost complete absence of damage to the cruciferous crops by Flea-beetles (*Phyllotreta* spp.), although last year two, and in some parts of the fields three, sowings had to be made to get a plant.

Insect fluctuations and their causes are receiving an increasing amount of attention by entomologists. Very little is known about flea-beetle attacks, beyond the broad generalisation that a dry hot spell favours attack. Wet weather may be disastrous, in spite of general opinion to the contrary, provided the temperature be not too low. The attack, however, is not determined only by the weather prevailing at the time, but also by the character of the winter, for the damage is done by beetles that developed during the previous summer and survived the winter as adults.

Very little is known about the parasitism of the *Phyllotreta* spp. One of them, *P. nemorum*, passes through its developmental stages above ground and can be heavily parasitised ; the other species are all underground during development, and as far as is known suffer but little parasitisation ; and as these usually far outnumber *P. nemorum*, it appears unlikely that parasitisation can be an important factor in causing the enormous fluctuations in numbers recently witnessed on the farm.

FRIT FLY (*Oscinella* (*Oscinis*) *frit Linn.*). This year an unusual and widespread attack on the winter cereals by "frit" took place during the months November-January. The maximum emergence of the last flight occurs about the months of August-September, but the cereals attacked were not sown till the middle of October, and of course grew up much later. There is thus a period of some weeks between the time when the flies are ovipositing and when the cereals could become infected. It is probable that the volunteer corn, which came up plentifully after the wet harvesting conditions, maintained the frit larvae in the interval, the young corn being infected from this source. The actual dates are as follows for Broadbalk, 1930:

Cutting wheat . . .	August 18th
Cultivation	August 30th
Ploughing operations . .	October 3rd—14th
Wheat drilled . . .	October 16th*

There was therefore a period of nearly six weeks during which ample opportunity for infestation of volunteer corn occurred ; between final ploughing and seeding only a very short interval.

The spring attack of Frit fly was below normal.

WIREWORM (*Agriotes spp.*). Damage due to this pest was unusually bad on the classical barley plots, and is dealt with more fully in a later paragraph.

BROADBALK

WHEAT

THE FRIT FLY (*Oscinella* (*Oscinis*) *frit* Linn. An examination of brown discoloured shoots observed at the end of November revealed the presence of Frit fly larvae. The attack was spread generally over the field and was in places severe. A number of observations were made to discover (*a*) the percentage of attack ; (*b*) the number of attacked plants that recovered ; and (*c*) the spread of the infestation during the period under observation.

A number of random square yards were pegged out, and the number of dead, attacked but living, and unattacked plants were counted at intervals.

The counts on November 22nd and mid-December were, when expressed as numbers of attacked plants per acre :

* For the present season the dates are as follows: 1931. Cutting, August 18th; ploughing operations begun August 29th and continued till September 15th; cultivations, September 21st, September 26th and October 10th—12th; seeding, October 13th. A search for frit-infested plants during the last month (November-December, 1931) has been almost entirely fruitless. In the absence of relevant data concerning the numbers of the last flight of frit in the two years it is not claimed that the difference in the cultural methods is wholly responsible for the difference in attack, but it is certainly suggestive. The matter could be simply settled by keeping an area of the field free from volunteer corn.

	November 22nd.	Mid December
Plot 2	22,448	96,800
,, 3	10,164	48,400
,, 5	4,840	34,848
,, 6	10,300	61,952
,, 7	14,036	—
,, 8	8,712	—
,, 13	—	40,072

The total number of plants per acre was about a million.

The worst attack encountered was in Plot 2 (farmyard manure), and affects just under 10 per cent. of the total plant population.

There is no correlation of attacks with manurial treatment, but the highest infestation was on an area in the Farmyard Manure Plot, 38 plants to the square yard, or nearly 15 per cent. Seventy per cent. of the plants marked as " dead " had not recovered up to the beginning of January. Whether the plant dies or not depends on how far the grub eats out the central shoot. In wet weather the plant frequently rots and is invaded by secondary parasites, e.g. mites and nematodes which complete the disintegrating process. Plants attacked just after germination and during the next month or so rarely recover ; after January the plants can resist the attack.

Wheat Bulb Fly (*Hylemyia coarctata* Fall.) This fly was present, but did no appreciable damage. Another dipterous larvae causing similar damage was also present, and is being investigated. This fly would appear to occur rather later than the bulb fly, as larvae not fully developed were found as late as the middle of May.

Leaf Miner (*Agromyza sp.*). This fly was much less plentiful than last year and damage was small. Most of the mines were inhabited by one larvae, but many with 2, 3 and sometimes 4, were found. Occasionally also, pupation takes place within the leaf instead of in the ground. Material has been collected to find out if more than one species is present, and to see what parasites—if any —emerge.

Midges (*Contarinia tritici* Kirby, *Sitodiplosis mosellana* Géhin.). The midge attack was the worst observed during the last five years. Parasitism was very heavy, in some cases the ears being at times almost black with ovipositing parasites.

The Wheat-stem Borer (*Cephus pigmæus* Linn.). This was again present, but damage was estimated *nil*.

Pheasants. A good deal of injury was caused by pheasants in the early winter.

Timothy Grass

The ears of the Timothy grass in the borders around Broadbalk were much attacked by the Timothy fly (*Amaurosoma* sp.).

GREAT HOOS FIELD

Classical Barley Plots

Wireworm (*Agriotes* spp.). The most notable feature of the year was an attack by wireworm. It was first observed on May 6th and by May 13th the rows of barley on some of the plots looked as if a fire had swept across them. The attack was most noticeable on the unmanured or incompletely manured plots, and on the worst of these, 6-1, 50 per cent. of the plants showed signs of attack and many were killed. On the completely manured plots the plants were better able to keep pace with the damage, but even here many gaps were made. By the end of June the surviving plants had outgrown the attack.

The relative damage on the different plots was as follows: (1) being the most damaged; (4) the least; in each category the plots are arranged in the order of the damage done:

1. 6-1 (most damage), 4, 3, 6-2, 3A, 1.
2. 7-1, 7-2, 4A, 1A, 1AA.
3. 2, 4AA, 3AA, 1AA.
4. 2AA, 2A, Rape Cake Plots (least damage).

The order in which the plots recovered was as follows, (1) being the quickest and (4) the slowest:

1. 7-2 (recovery quickest) Rape Cake Plots, 4A.
2. 2AA, 4AA, 2A, 3AA, 1AA.
3. 7-1, 4, 3, 2, 1.
4. 6-1 (recovery slowest).

This order corresponds fairly well with that of the average yields.

THE GOUT FLY (*Chlorops taeniopus* Meig.) was present as usual, but the attack was less than last year.

THRIPS. Frequently damaged the young ears, but not seriously.

FOUR COURSE ROTATION EXPERIMENT

WHEAT. *Cephus pigmæus* present.

Practically no leaf miner (*Agromyza* sp.).

SWEDES. This year there was no loss from flea-beetles (*Phyllotreta* spp.). A good deal of leaf damage to young plants was, however, caused by pigeons, June-July. An attack of mildew was encouraged by the late singling of the plants.

SEEDS AND BARLEY. No significant attacks.

ALTERNATE WHEAT EXPERIMENT

Early attack by Frit fly; wheat bulb fly (*Hylemyia coarctata* Fall), wheat midge and *Cephus pigmæus* all present. Leaf miner attack slight.

KALE

No flea-beetle attack.

SIX COURSE ROTATION

WHEAT. As expected, the wheat after fallow was attacked by wheat bulb fly during March and April. However, the wheat seeding had been so thick and so much early tillering had taken place before the attack began that no loss resulted. The number of tillers in a linear yard varied from 280 to 120, figures far in excess of those obtaining on Broadbalk. The average number of tillers attacked per linear yard was fifteen.

CHARLOCK PLOT. Larvae of *Chortophila brassicae* Bché occurred on the Charlock roots. This insect may be a serious pest of cultivated Cruciferae.

SUGAR BEET. *Atomaria linearis* Stephens, the Pigmy mangold beetle, was present but caused no loss of final " plant." The loss that occurred was probably due to hares. Only two larvae of *Pegomyia hyocyami* were seen at the end of June. Numbers of the Spotted Snake Millipede, *Blaniulus guttulatus* Bosc. were found usually in association with *Atomaria* ; the wounds caused by the one apparently attract the other.

BARLEY. There was slight wireworm attack in April and some damage by wheat bulb flies which must have been very late specimens. Frit and Gout fly attacks were insignificant. A few leaf miners were found similar to the *Agromyza* on wheat.

CLOVER. POTATOES. No significant attack.

FORAGE MIXTURES. Slight attack by wireworm (March-April) after bastard fallow. Wheat bulb fly killed many tillers during the same period ; in the worst cases as many as four out of six tillers were attacked.

No damage was observed on the Rye plots, nor the Linseed and Kale that followed.

LITTLE HOOS

FORAGE CROP EXPERIMENTS. Attack by the pea and bean weevils (*Sitona* spp.) occurred, but was much less serious than last year, when the crop was spring-sown and so less able to withstand damage. An autumn attack by Frit fly occurred.

WHEAT EXPERIMENTS. The autumn early winter attack by Frit fly was general.

GREAT HARPENDEN

SPRING OATS. A rather bad attack by wireworm occurred generally during April, and this, together with the rooks, depleted the plant. Spring Frit fly attack was small, but there was occasional damage by a lepidopterous larva, probably *Apamea secalis* Bjerk.

WINTER OATS. A slight attack of wireworm occurred during the spring following the early winter Frit fly attack.

WHEAT VARIETY TRIALS AND RYE PLOTS. In early winter there was an attack of Frit fly generally. Some plants when about 1 foot high had the central shoot killed by *Apamea secalis* Bjerk.

MICRO SUGAR BEET PLOTS. *Atomaria linearis* Stephens was the chief pest here, but the sugar beet had been " dibbled " in, some 5 or 6 seeds to a hole, so that though some plants were destroyed the final stand was not affected. Observations made on the life history of this beetle are being published (*Ann. Appl. Biol.*, Feb., 1932). Surrounding dock plants were much eaten by *Plectroscelis concinna* Marsh, but no damage to beet plants was noticed.

BARNFIELD

Atomaria attacked the mangolds in early May, but the numbers were insufficient to account for the failure of the first sowing, which appeared to be due in part to cultural conditions. Only one *Plectroscelis concinna* was seen, and there was no evidence of attack by this beetle.

The second sowing did not appear to suffer from attack except for a strip along the west side of Plots 1C, 1AC and 1A, where the mangolds were taken but not the swedes. Pigeons probably did much of the damage, but earwigs were also plentiful, obtaining shelter from the grass banks at the side and perhaps from the chicken pens. Three earwigs captured from the plants at night were kept in the laboratory confined with 2 swede and 3 mangold plants. Within 5 days the plants were destroyed but no preference was shown.

WOBURN

An attack on the micro-plots of sugar beet was the only thing of interest this year. Only a few plants were lost, the stems being eaten off a short distance above ground level with a short length of the central strand left. Mammals or birds are suspected. A *Harpalus* was collected by spreading sacking at night, but no damage could be ascribed to this insect.

FIELD PLOT TECHNIQUE

The Statistical Department has been largely concerned with the methods of the interpretation of field and laboratory experiments, and with the principles of their design. The principles which govern the dependence of interpretation on design have been made clear in previous years. Many voluntary workers, however, are anxious to illustrate particular aspects of these principles and to explore further the practical bearing of the observations made in uniformity trials and in explicit experimentation.

During the year three workers (F. R. Immer, S. H. Justensen and R. J. Kalamkar) have taken up the question of the most efficient use of land in experiments in which an edge row must be discarded. In such cases the narrower the strip used as a plot, the larger the proportion of the crop rejected from the experimental data. On the other hand, it has been widely verified that, for the same area harvested, subdivision into numerous small plots generally leads to a considerable increase in precision. Using independent data relating in two cases to potatoes and in one to sugar beet, each enquiry showed that the best use of a given area can be made by using 4-row plots, where half the total area is discarded. Consequently where the precision of the experiments is chiefly restricted by the experimental area available, this width of plot may be expected to give the best results.

The efficiency of the sampling method, both in its application to yield trials and to the progress and growth of crops, largely depends on the choice of the sampling unit, or set of drill lengths fixed by a single act of randomisation. Experience in previous years had thrown doubt upon whether the form of sampling unit originally chosen for crop weather observations was the best possible: (1) because the 4 quarter metres of which it was composed were all taken from the same drill row, and as had been first shown by Clapham, lengths from the same drill row were somewhat highly correlated; (2) because it was doubtful if any additional precision was gained by spreading the sampling unit over a length of 10 feet, when probably there was a real competition between the growth of parallel adjacent rows. By harvesting a small area completely in $\frac{1}{2}$-metre lengths, Kalamkar was able to test experimentally the efficiency of different forms of sampling unit, with the result that a unit of four parallel lengths on adjacent rows was found to be actually the most efficient. Since this form of unit is very convenient to take in the field, and in the crop weather observations can be used to simplify the whole sampling procedure, its use in future is to be recommended.

As the existence of an accurate theory of small samples has come to be known, mathematical statisticians on both sides of the Atlantic have devoted much work to investigations by experimental sampling. Much of this work has been aimed at solving (practically) somewhat abstract problems of distribution, which presented analytical difficulties to the mathematician. Rightly approached, however, the subject has a practical and scientific interest, for the experimenter in designing his experiments will want to know whether the analysis of variance, or one of the tests which are particular cases of this analysis, will, without additional precautions, be sufficiently applicable to his material, even if it exhibits anomalies of the third degree, such as skewness, correlation of mean with variance, etc. An extensive sampling experiment has recently been carried out by T. Eden, to test whether the analysis of variance, applied to a randomised blocks *schema*, on such skew material, would in fact indicate the true limits of significance. The distribution of 1,000 tests of significance was found to be in complete conformity with theoretical expectation for normal data.

The analysis of variance has not, however, always been rightly applied. The great simplicity of the arithmetical processes, when applied to experiments designed to secure this simplicity, has sometimes led to a neglect of the fact that any interactions which, as is often advantageous, have been confounded with components of soil heterogeneity, or which, as is usually less satisfactory, are between non-orthogonal sets of treatments, as in many of the older types of experiment, require special care to obtain the true estimate of error. Through neglect of this precaution the interpretation to be placed on two of our previous experiments in 1929 and 1930 have been revised in the current report (p. 150 ; p. 156). Although no important conclusions, but only the significance of certain manurial interactions, are affected, the point is one which deserves attention, as it is very liable to give trouble to inexperienced computers, and should especially be considered in experimental design.

An increasingly important aspect of the application of the principles of experimental design, concerns the design of co-ordinated experiments carried out at a number of centres. During the year two workers from Canada have been working on these problems, and a report with recommendations has been made by J. W. Hopkins to the National Research Council of the Dominion, on their co-operative experiments on the influence of seed rate on the yield of varieties of oats. Professor Summerby also was engaged in the design of comprehensive manurial experiments on fields under rotation.

In the field of Agricultural Meteorology, A. L. Murray, of Dublin, has taken up the question of the interpretation of the heavy loss in wheat yield from Broadbalk, ascribable to winter rain ; finding, contrary to expectation, that this loss is not to be avoided by using spring in place of autumn dressings of nitrogeneous fertilisers. The spring dressed plots show, however, an advantage in years with a wet summer. The classical experiment with mangolds, on Barnfield, has been analysed by R. J. Kalamkar, in connection with the amount and distribution of the rainfall. The yields from these plots are, however, so variable that it would be unsafe as yet to interpret the data, until the influence of varying root number has been separately assessed.

The year has seen considerable progress in theory, especially in regard to the analysis of covariance, as well as in the practice of its various applications.

THE ACCURACY OF THE FIELD EXPERIMENTS

The standard errors per plot of experiments carried out in 1931 are given in Tables X, XI and XII together with an average of those obtained in previous years. It will be seen that these errors are of the same magnitude as in previous years, and that there is little difference in the accuracy obtained at Rothamsted and the outside centres.

TABLE X.

STANDARD ERRORS PER PLOT, 1931.

Rothamsted.

Weight per acre.

	Potatoes.	*Sugar Beet*		*Barley.*		*Wheat.*	
	tons.	Roots. tons.	Tops. tons.	Grain. cwt.	Straw. cwt.	Grain. cwt.	Straw. cwt.
Latin Squares—							
Average 1925-1930 ..	0.4	0.6	0.7	1.3	1.9	—	—
1931	—	—	—	2.0	2.1	1.5	3.1
Randomised Blocks—							
Average 1925-1930 ..	0.7	0.3†	1.2†	1.5	1.9	2.9	4.3
1931	1.2	0.5	1.0	—	—	1.8 1.4	4.2 3.2

†Single figure.

	Oats.		*Forage.*			*Hay.*
	Grain. cwt.	Straw. cwt.	Hay. cwt.	Grain. cwt.	Straw. cwt.	cwt.
Latin Squares—						
Average 1925-1930	—	—	—	—	—	—
1931	—	—	4.2	2.4	3.6	3.1
Randomised Blocks—						
Average 1925-1930	—	—	—	—	—	—
1931	2.4	2.6	1.4	—	—	—

Per cent of Yield.

	Potatoes.	*Sugar Beet.*		*Barley.*		*Wheat.*	
		Roots.	Tops.	Grain.	Straw.	Grain.	Straw.
Latin Squares—							
Average 1925-1930	4.4	5.7	5.6	5.6	7.4	—	—
1931 ..	—	—	—	12.4	9.4	8.3	8.7
Randomised Blocks							
Average 1925–1930	8.4	10.2*	10.9*	9.1	7.2	14.0	10.8
1931 ..	10.0	4.1	6.4	—	—	8.3 8.9	9.5 8.2

*Single figure.

	Oats.		Forage.			Hay.
	Grain.	Straw.	Hay.	Grain.	Straw.	
Latin Squares—						
Average 1925-1930	—	—	—	—	—	—
1931	—	—	8.2	12.2	7.8	7.9
Randomised Blocks—						
Average 1925–1930	—	—	—	—	—	—
1931	12.7	10.2	16.1	—	—	—

TABLE XI.

Woburn.

Weight per acre.

	Potatoes.	*Sugar Beet.*	
		Roots.	Tops.
	tons.	tons.	tons.
Latin Squares—			
Average 1926-1930	0.5	1.3	1.1
1931	—	1.0	1.2
Randomised Blocks—			
Average 1926-1930	0.7	1.0	1.5
1931	—	1.3	2.6

Per cent. of Yield.

	Potatoes.	*Sugar Beet.*	
		Roots.	Tops.
Latin Squares—			
Average 1926–1930	5.1	9.1	11.0
1931	—	8.4	7.3
Randomised Blocks—			
Average 1926–1930	8.7	12.5	19.1
1931	—	11.5	20.2

TABLE XII.

Average of Outside Centres.

Weight per acre.

	Potatoes.	*Sugar Beet.*		*Swedes.*		*Barley.*		Hay.
		Roots.	Tops.	Roots.	Tops.	Grain.	Straw.	
	tons.	tons.	tons.	tons.	tons.	cwt.	cwt.	cwt.
Latin Squares—								
Average 1927-1930	0.6	0.6	0.8	—	—	1.5	1.4	2.1
1931 ..	0.6	0.6	1.1	1.7	0.2	—	—	3.6
Randomised Blocks								
Average 1927-1930	1.0	0.8	1.3	—	—	—	—	—
1931 ..	0.8	0.7	2.0	—	—	—	—	4.9

Per cent. of Yield.

	Potatoes.	Sugar Beet. Roots.	Sugar Beet. Tops.	Swedes. Roots.	Swedes. Tops.	Barley. Grain.	Barley. Straw	Hay
Latin Squares—								
Average 1927–1930	5.2	6.4	6.7	—	—	7.8	8.3	8.5
1931 ..	6.6	5.3	8.4	5.6	5.6	—	—	7.7
RandomisedBlocks—								
Average 1927–1930	9.0	7.4	8.2	—	—	—	—	—
1931 ..	10.2	5.8	10.3	—	—	—	—	10.9

FARM DIRECTOR'S REPORT, 1931

Weather. The general character of the weather is shown by the graph of deviations from average values (p. 62). The features of the year October, 1930—September, 1931 were the wet November and December, the mild winter and the cool, moist summer with a wet harvest. The mean temperatures for June, October and November were respectively 1°F., 2.1°F. and 0.3°F. above the 52 year average, but for all the other months it was under the average, the total deficit for the year being 7.1°F. The only really hot weather occurred between June 20th and July 10th.

There was very little frost apart from a fortnight of quite sharp weather at the end of February and beginning of March. This, along with occasional night frosts during the winter, brought the ploughed land to a good powdery tilth by the spring.

Every month from April to September experienced fewer hours of sunshine than the 38 year mean, the deficit totalling altogether 191.6 hours. October had 28 hours and March 38.7 hours above the mean.

5.1 inches of rain in November made the autumn very wet, but luckily this did not affect any of the farm work. July and August together had 2.1 inches rainfall above the 78 years average, but it was not the amount that made the bad harvest so much as the numerous small showers. The total for the year was 29.9 inches, being 1.15 inches above the mean.

Although the past season was wet and cool, yet October, 1930, and March, 1931, were unusually dry. In October, only 1.24 inches fell, against the average of 3.11 inches, and the drainage through 60 inches of bare soil was 0.211 inches as against the average of 1.63 inches for that month. In March the total rainfall was 0.09 inches, and measurable rain fell on two days only. The rainfall was the lowest shown in our 78 years records for March, except for March, 1929 (0.065 ins.), the lowest recorded figure for any month being 0.063 ins. in December, 1864.

Cropping, 1930-1932. (For dates, yield and other information, see pp. 109-114.)

Rye was sown in Long Hoos, Sections I, II and III, in September, 1930. This was fed off to sheep in March, 1931, and again in May. Sections I and III (old division) had previously been dunged just before sowing at the rate of 14 tons per acre. Section II had carried mustard folded off with sheep in August, 1930

Dung was carted out to Little Hoos in September, 1930, at the same rate ; this was the first application of dung since the termination in 1921 of the old experiments on residual values. Several good crops had been grown without dung. Forage and wheat were later sown in this field.

Beans were sown in Great Knott after wheat, on October 2nd, and proved successful, apart from some thin places due to damage by pigeons. Before harvest the plants were 6 feet high in many places. The lower portion of this field is still rather infertile, however, and the crop was distinctly lighter there.

All of the 1930 sugar beet and potatoes were out of the way before October, thus enabling the following crops to be sown early. Broadbalk was sown on October 16th. All the sowing was completed under favourable conditions, although rather later than in 1929 ; the ground was fairly moist, and not dusty as it had been for the preceding crops.

The kale in Pastures was used between the middle of December and the end of February, 1931 ; some was carted off to stock, the rest folded.

This folding caused some puddling ; nevertheless, the field after ploughing worked down to quite a favourable tilth. On part of the land Marvellous oats were sown ; the crop, however, was disappointing and much inferior to the mixture of barley with beans. Mayweed—usually, like iron grass (*Polygonium aviculare*), bad in this field—spread rapidly where the plant was thin. Another part of the land carried the 1931 experimental potatoes grown without dung ; the yields were amongst the heaviest obtained here. The old kale stems caused no difficulty in ploughing or sowing corn, but somewhat hindered the preparation of the potato ground.

Part of the Great Harpenden seeds ley was ploughed up in September and sown with Grey winter oats ; on the remainder sheep were fed during the winter, the land was ploughed in January, with narrow, well set-up furrows, and crumbled to an ideal tilth for spring oats after some frosts. Just after sowing, a sharp spell of frost occurred ; during this period crows attacked the seed, yet the crop was considerably heavier than the winter oats. Wireworm and crows both affected the spring oat experiment carried out on this area.*

One year seeds in Fosters yielded heavily, estimated at over 2 tons hay per acre. The crop, however, was used for stack silage because of the very showery weather. To it was added the produce from our rotation and forage experiments, making a total of about 100 tons of green matter. The final product was sweet, dark brown silage, much relished by stock. The waste round the outsides was smaller than anticipated ; it was roughly estimated at about 10 per cent. The outside material was carted to out-wintered cattle and the small amount they did not eat was tramped into the ground as

* The mean yields of the spring varieties were in cwt. per acre.

	Grain.	Straw.
Marvellous	19.6	24.6
Golden Rain II.	18.7	27.0
Victory	17.4	27.5

It is doubtful whether any of these differences are significant as the plots were not adequately replicated or randomised (p. 144) manure. Analyses showed, however, that in spite of the good appearance, the material contained much less protein than is usually found in farm crops.

Per cent. in sample as received.

	Protein	Fat	Soluble Carbo-hydrates	Fibre	Ash	Water
Silage from one year's seeds mixture	1.22	1.24	23.0	13.9	3.95	56.7
Silage from general forage mixture	1.22	0.96	16.2	10.7	2.52	68.4
Per cent. in Dry Matter						
Silage from one year's seeds mixture	2.82	2.86	53.1	32.1	9.12	—
Silage from general forage mixture	3.87	3.04	51.3	33.8	7.99	—

Oats and wheat (cut green) contain 6 to 7 per cent. of protein in the dry matter, while leguminous crops contain 17 to 20 per cent.

All the oats in Great Harpenden, winter and spring, were undersown in April, 1931, with 20 lb. Western Wolths Ryegrass and 5 lb. trefoil per acre. This is to be utilised for feeding sheep on during the winter, then it will be dunged and sown with kale.

Laid corn was a less serious problem than in the previous harvest The winter oats were worst, but the power-binder proved of great value in dealing with them. The Little Hoos wheat experiments were badly laid and had to be scythed, while several of the Broadbalk plots were also bad.

The weather seriously hindered the harvest, particularly from the plots. Threshing took a long time, and much of the produce had to be carted into the shelter of the Dutch Barn. By the end of harvest we were a full fortnight later with our general farm work than in previous years. Luckily a very fine spell of weather during October and part of November allowed us to catch up again.

After the ewes and lambs had used the Long Hoos rye (p. 57) it was ploughed up. Sections II and III were sown on May 7th, 1931, with linseed, which yielded 10 cwt. grain per acre. It is difficult to cut with the horse binder, but easy to manage with the power-binder. Section I was sown with kale on June 13th. It came well and did not suffer from the flea-beetle. Despite this and the excellent growing season, the final yield of 16-18 tons per acre was disappointing considering the autumn dung, manuring by sheep, and 2 cwt. sulphate of ammonia per acre ; in 1930 the yield had been 4 or 5 tons per acre higher.

Barnfield mangolds were sown on April 15th-17th. The seed went in deeply on a dusty tilth and germination was slow and uneven. They were therefore re-sown on May 26th, and gave a splendid plant and a splendid crop. A few swedes sown as a safeguard with the mangolds developed even better ; their superior size compared with neighbouring mangolds was striking. In the dry autumn the crop was carted in ideal conditions, the land being much less cut up with the carting than usual. It was all ploughed, after applying dung to the proper plots, in this good condition. For two years now we have tried two different spacings on each of the plots. It was hoped that with narrower drills the foliage would more quickly

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grow over and check weeds ; instead, the low yielding plots where this effect was most desired, gave smaller plants than with wide spacing, thus defeating the object of the narrower drills.

In Agdell the wheat on the fallow half was very poor. On Plot 1C and on the top half of 3M the germination was very poor indeed. The seedlings appeared to be drowned by the rain before they were properly established.

Two observations in the Hoos Field Rotation were noteworthy. After the hay crop, the residual effect of all the manures, including dung and straw plus artificials on the following wheat was very slight. After the swede crop, however, the residual effect of straw plus artificials, which had greatly increased the yield of swede tops, was obviously greater than the direct effect of straw plus artificials applied direct to the barley, despite the very heavy dressing of nitrogen given ; the one plot was laid, the other was not to any extent.

On the other hand the direct effect of straw plus artificials on the hay crop was greater than the residual effect, and indeed exceeded the effect of any other treatment.

The forage experiment in Little Hoos gave high yields. The best plots could not well have been heavier, being about 6 feet high and almost lodging when cut green. The wheat mixtures seemed superior to the oats, the oats growing very slowly in the early summer; it was therefore surprising to find that the oat mixtures were the heavier after all. The half plots left till harvest were very badly laid and suffered from birds.

In July another forage experiment was started. Its aim was to explore the possibilities of producing early and later green crops so as to extend the operating season of a machine for drying green crops, which would deal chiefly with lucerne and grass in the main part of the season. The weather between July and November was more than usually favourable to growth, nevertheless the maximum autumn yield was only 7 tons of green matter per acre, no more than the much cheaper temporary grass growing nearby which, however, would have been more difficult to cut at that time of year. The experiment is continuing to the late spring of 1932.

Control of Black bent (*Alopecurus agrestis*), at present the worst weed on the arable land at Rothamsted. It is much worse in autumn sown crops—cereals and beans—than in those sown in spring. Several methods of reduction are being tried :

(1) Rye is grown as the winter cereal ; this is folded by sheep in spring and then ploughed under in April or May ; the *Alopecurus* seed can thus germinate, but the resulting plants can produce no fresh seed. Rye, however, has some drawbacks. It is more costly than certain other spring foods, and in 1931 it appeared to handicap the succeeding kale crop. This is being followed up experimentally.

(2) Spring oats are grown instead of winter oats. If this proved successful the sheep feed would be supplied by cheap one-year seeds mixtures or rape kale instead of green rye.

Grass. This was a most favourable season for grassland. Pastures continued green and in active growth throughout, although the start was slow, and for a fortnight at the beginning of July growth almost ceased. Sawyers I and III received 1 cwt. per acre nitrate of soda early in February to encourage an early spring bite ; the result, however, was very disappointing, there being very little early growth at all. Later on, however, this field provided excellent keep for the ewes and lambs. It was then shut up for only 6 weeks and gave a 30 cwt. crop of hay. Despite the nitrate and the haymaking, the Wild White clover formed a thick carpet in the aftermath.

All the other grass showed steady improvement under the favourable conditions and gave a splendid aftermath for the lambs and for flushing the ewes.

Live Stock. The chief development has been with sheep. Three investigations have been started :

(1) A study of the suitability of half-bred ewes, bred at Rothamsted by using a Scotch half-bred ram on the best of our commercial Scotch half-bred ewes. An attempt will be made to breed from some of the ewe-lambs.

(2) Comparison of a first-cross between a Cheviot ewe and a Dorset Horn ram with the Scotch half-bred. Six ewe hoggs of this Dorset Horn cross have been purchased from the Earl of Elgin ; these are, as far as is known, the only ones at present in the country. If they are as satisfactory as the half-bred, and in addition can take the ram over a wider period of time, they may become attractive commercially. The Dorset Horn is also being tried on the Scotch half-bred ewe, although this is a second cross.

(3) Examination of the possibilities of breeding from ewe lambs. Many farmers do this successfully, but the average type of ewe lamb which we have purchased during the past two years has been too young and small, and the result has been unsatisfactory. We are now trying bigger and more expensive half-bred ewe lambs at Woburn with results which, at present, are more promising.

In October, 1930, the flock consisted of 98 half-bred ewes, 97 gimmers and ewe lambs and 300 lambs. All the ewes were put to the Suffolk ram. Lambing began on March 10th and extended till April 14th ; the number of lambs on May 30th was 187, consisting of 2 triplets, 62 doubles and 57 singles.

Cattle. In October, 1930, the stock consisted of four in-calf Shorthorn heifers and 23 cross-bred Angus stores. During the year polled black calves were purchased locally from dairy farmers (Polled Angus bull and Shorthorn cow), and two more heifers ; there were born also six calves. The four heifers during their lactation period reared 35 calves between them.

This method gives us well-reared animals in sufficient number to stock our grass land adequately, and at less cost than the purchase of store cattle in spring. It is capable of considerable development, and we hope that the services of a recorder may become available so as to help in working out the various problems connected therewith.

Pigs. In October, 1930, the herd consisted of 21 Wessex Saddleback sows, one large white boar and one Wessex boar ; no fresh sows have been purchased, but 8 have been brought into the herd from our own litters. By far the greatest number of the pigs have been crosses, sold as stores soon after weaning (some 12 weeks old) or for pork when about five months old and weighing from 80 to 110 lb. dead weight.

Buildings. The building developments outlined in the previous Report have now been completed, although the equipment, both mechanical and electrical, is not yet complete, through lack of funds.

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https://doi.org/10.23637/ERADOC-1-65

Implements. The following firms have lent us implements in addition to those mentioned in the 1930 Report:

Austin Motor Co. (tractor).

Miller Wheels, Ltd. (Patent Tractor Wheels).

R. A. Lister & Co. (power-driven sheep-shearing machine).

We have also been indebted to Messrs. Massey-Harris, Ltd., for the loan for a few weeks of a four-wheel-drive tractor, tractor-plough and cultivator.

Staff. C. Frith left us in July, 1931, and went as assistant to a farmer in Cambridgeshire, who is adapting his system to mechanisation. J. R. Moffat came in December, 1931, as voluntary assistant, and is occupied with our sheep investigations and with our various farm records.

METEOROLOGICAL OBSERVATIONS

Meteorological observations have been systematically made at Rothamsted for many years; these records are being used in the Statistical Department in interpreting crop records. The Station has co-operated in the Agricultural Meteorological Scheme since its inauguration by the Ministry of Agriculture in 1926, and possesses all the equipment required of a Crop-Weather Station. The observations taken under this scheme include:

OBSERVATIONS TAKEN ONCE DAILY: 9 a.m. G.M.T.

Temperatures—maximum and minimum (screen), solar maximum, grass minimum.

Rain (inches) and *Sunshine* (hours and minutes by Campbell-Stokes recorder) during the previous 24 hours.

OBSERVATIONS TAKEN THRICE DAILY: 9 a.m., 3 p.m., and 9 p.m. G.M.T.

Temperatures—wet and dry bulb (screen), 4 inches and 8 inches under bare soil.

Wind—direction and force (continuously recording anemobiagraph).

Weather—(Beaufort letters).

Visibility.

These, together with notes and observations of crop growth are used in drawing up the weekly statement for the purpose of the Crop Weather Report of the Ministry of Agriculture.

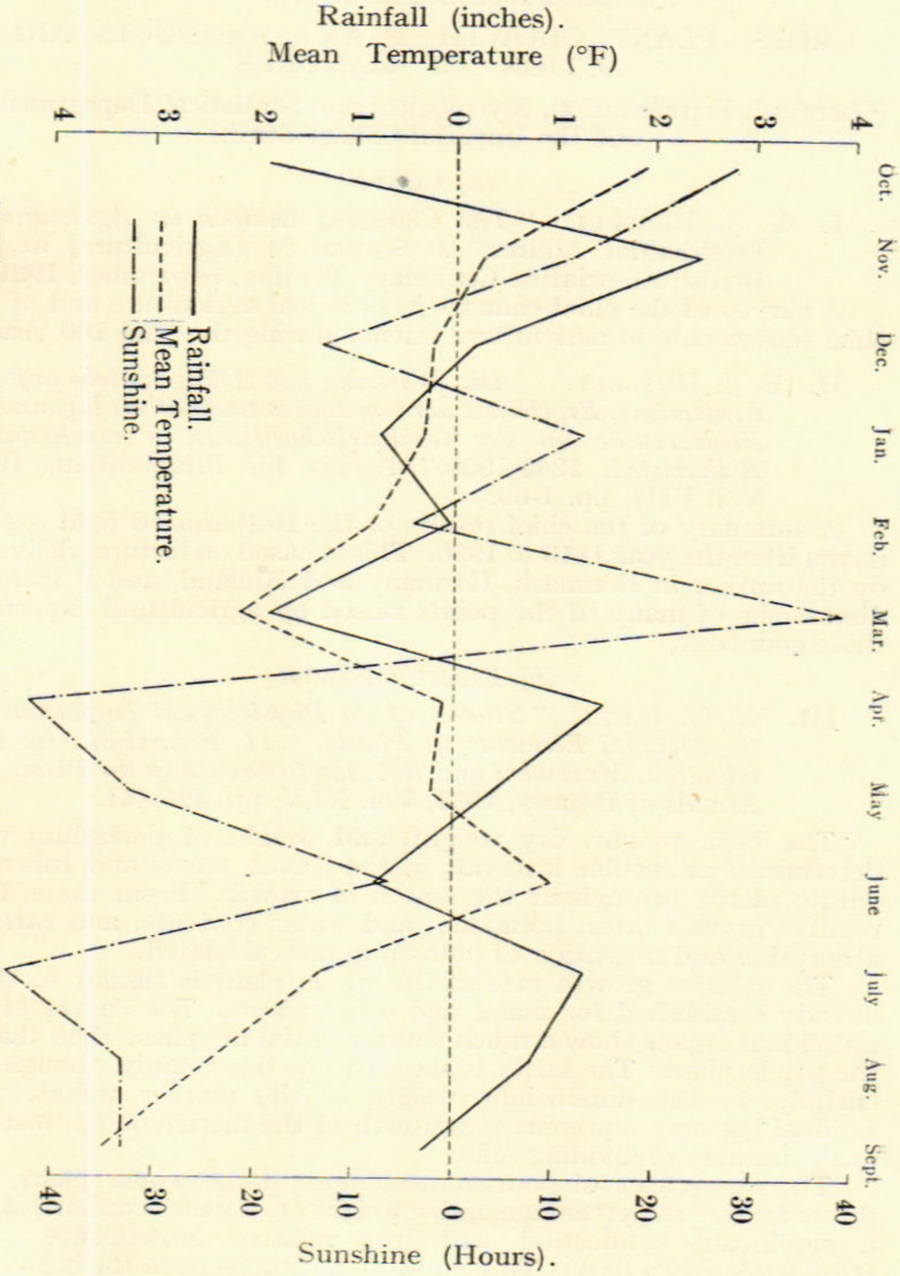
Additional data are collected under the following heads:

RADIATION.—A Callendar Radiation Recorder (on loan from the Imperial College of Science) gives a continuous record of the radiant energy falling on a receiver situated on the roof of the laboratory. The records are compared with those for South Kensington, and are also used in plant physiological studies in the Station.

RAINFALL AND DRAINAGE.—The rain falling on one thousandth of an acre is collected in the big gauge erected by Lawes in 1871. Samples of the water are analysed in order to ascertain its nutrient value.

EVAPORATION.—The amount of water that evaporates in 24 hours from a porous porcelain candle dipping into a bottle of water is measured daily by the loss in weight. This measurement has been found to give a good general indication of the "drying power" of the atmosphere during rainless periods which, being controlled by wind, radiation, and humidity, is difficult to complete from standard data.

SOIL TEMPERATURE.—Soil temperature records are taken under grass as well as bare soil. These are a continuation of experiments which have been carried out for some years past and which have for their object the determination of the best times for making single temperature measurement for use in calculating averages.



Deviation from average monthly values of sunshine, mean air temperature, and rainfall. Season 1930-31.

SCIENTIFIC PAPERS

Published 1931 and in the Press

CROPS, PLANT GROWTH, PLANT PRODUCTS AND ACTION OF MANURES

(Chemical, Fermentation, Mycological and Statistical Departments ; and the Imperial College Staff.)

(*a*) CROPS

I. E. J. RUSSELL. "*The Changing Outlook in Agriculture.*" Presidential Address to Section M (Agriculture) at the British Association Centenary Meeting, September, 1931.

A survey of the chief changes in practical agriculture and of the chief movements in agricultural science during the past 100 years.

II. E. J. RUSSELL. "*Die Wirkung von Düngemitteln auf den Ernteertrag. Ergebnisse der von Lawes und Gilbert begonnenen Feldversuche an der landwirtschaftlichen Versuchsstation Rothamsted*, 1843-1930." Archiv für Pflanzenbau, 1931, Vol. VIII, pp. 1-69.

A summary of the chief results of the Rothamsted field experiments from the year 1843 to 1930. This is based on lectures delivered by the author in Denmark, Germany and Holland, and it includes discussions of many of the points raised by agricultural experts in those countries.

(*b*) PLANT GROWTH

III. W. O. JAMES, "*Studies of the Physiological Importance of the Mineral Elements in Plants. II. Potassium: its Distribution, Movement and Relation to Growth in the Potato.*" Annals of Botany, 1931, Vol. XLV, pp. 425-441.

The fresh weight, dry weight, and weight of potassium were determined at regular intervals in the leaves, stems and tubers of potato plants throughout the season of growth. From these data, relative growth rates, potassium and water contents, and rates of absorption and migration of potassium are calculated.

The relative growth rate of the whole plant is similar to those already established for maize and other plants. The curves of the individual organs show a much shorter initial lag phase than that of the whole plant. The latter is shown to be due mainly, though not entirely, to the diminishing weight of the mother tubers. The residual lag may represent the growth of the meristem, i.e. increase in the number of dividing cells.

The time curve of potassium content of the whole plant (expressed either as percentage of dry weight or of water content) shows a significant connection with the relative growth-rate curve (r=0.9448, P=> 0.01). This connection disappears in the individual organs owing to the comparatively short periods of rising relative growth rate. In later phases growth rate declines more rapidly than potassium content, but less rapidly than potassium absorption, suggesting a heaping up of potassium in non-meristematic regions.

There is a significant positive correlation ($P > 0.01$) between potassium and water contents through the growth period and a definite connection in spatial distribution. It is suggested that the mechanism of the relation is complex, involving at least solution tension, osmotic pressure, and adsorption forces. The result is a tendency to establish an equilibrium between potassium and water at somewhere between 1 and 0.5 per cent. potassium, in the active parts of the plant, and somewhat lower in the mature tubers.

It is shown that potassium ions may move from one organ to another either with or against the average concentration gradient between them. The movements contrary to such gradients are always in the normal direction of the transpiration stream, while those with the gradients are against the stream.

These movements, together with the heaping up and final removal of potassium from the leaves, suggest that a continuous circulation of the element goes on. The upward movement probably depends mainly on mass movement in the transpiration stream, while the downward movement is due to some different mechanism, dependent upon concentration gradients, but faster than diffusion.

IV. F. G. Gregory, and F. Crowther. "*A Physiological Study of Varietal Differences in Plants. II. Further Evidence for the Differential Response in Yield of Barley Varieties to Manurial Deficiencies.*" Annals of Botany, 1931, Vol. XLV, pp. 579-592.

Further evidence is presented for the existence of a differential response of varieties of barley to various types of manuring.

Three varieties were grown, namely, the hybrid Plumage Archer and the parent forms Plumage and English Archer. Four types of manuring were used: fully manured controls, and deficiency in nitrogen, in phosphorus, and in potassium. Forty-two replicates of each variety for each manuring were used, giving 504 cultures in all.

Each set of replicates was sampled fortnightly throughout the period of vegetative growth, each harvest representing a random sample of six pots.

The resulting data were treated by the analysis of variance method, and values for differential response of significance far greater than 100 to 1 are obtained for each part of the plant.

The behaviour of the varieties is compared with the previous results of 1927, and a large measure of agreement is found, showing that with some certainty the varieties studied may be characterised by their manurial efficiencies.

The hybrid form appears to inherit specific manurial efficiency from both parents.

V. "Alumnus." "*A Comparison of the Effect of Rainfall on Spring and Autumn-dressed Wheat at Rothamsted Experimental Station, Harpenden.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 101-114.

During the first twenty-four years of the Broadbalk wheat experiment the nitrogenous manures were applied wholly in the autumn. This paper describes an enquiry into the possibility that the large average loss of yield ascribable to winter rain on Broadbalk had been due especially to this early period. It is found that the curves of loss due to rainfall would in fact be scarcely changed had the manurial treatments been applied always as they are now.

An additional fact which attracted notice and was verified by further data is that the advantage of spring-dressed over autumn-dressed plots, though little influenced by winter rain, is considerably affected by summer rain. In fact, it appears that before a dry summer the autumn dressing is the more advantageous.

VI. J. O. IRWIN. "*On the Influence of Soil Temperature on the Germination Interval of Crops.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 241-250.

The data collected under the Agricultural Meteorological Scheme of the Ministry of Agriculture have provided information for a number of years in a number of places on the dates of sowing and appearance above ground of wheat, winter oats, spring oats, spring barley, turnips and swedes.

The present paper summarises these data, and determines the correlations and regressions of germination interval on soil temperature.

For all the cereal crops the correlations are significant, and, except for spring barley, high. The results for the winter-sown cereals are different from the spring-sown and we may summarise them by saying that the "germination interval" for winter wheat and oats is shortened by from 1.5 to 2 days for each increase of a degree F. in 4 in. or 8 in. soil temperature ; for spring cereals the corresponding shortening is about a day.

VII. J. O. IRWIN. "*Precision Records in Horticulture.*" Journal of Pomology, 1931, Vol. IX, pp. 149-194.

The present study is based on observations made on apple trees planted in connection with the Ministry of Agriculture's Horticultural —Meteorological Scheme. This scheme had as its object the study of the relation between weather and the growth of horticultural crops.

A meteorological station, where one did not already exist, was set up in every station participating in the scheme and observations on apples, plums, black currants and peas were made in each place. The observations were started in 1925 and are still continuing. It was laid down that the varieties used were to be the same in each place, and a standardised programme of observations was drawn up.

In order to determine whether phenological phenomena in horticulture are capable of precise and objective measurement by the sampling method, an experimental trial was made at East Malling in the spring of 1930.

(*c*) PLANT PRODUCTS

VIII. L. R. BISHOP. "*The Practical Application of the Results of Research to the Production of Malt and Wort.*" Journal of the Institute of Brewing, 1931, Vol. XXXVII, pp. 345-359.

A study of results partly obtained by Miss E. M. Thomas under the late Professor Schryver. It is shown that about 35 per cent. of the nitrogen in the barley becomes "permanently soluble nitrogen" in the wort from the resulting malt. For six rowed barleys the figure is 29 per cent. Differences from this figure reveal differences in modification. The highest value is obtained at a mashing temperature of 50°C, and declines on each side of this temperature. Ammonia, amide and amino nitrogen increase slightly with increase in barley nitrogen content but, in this case and with change in mashing temperature, the main changes are due to changes in "peptide" and "undetermined" nitrogen.

The simultaneous studies of the carbohydrates showed that, other factors being constant, maltose production has a sharply marked optimum at 60°C., while the dextrinous substances in wort increase slowly to an optimum above 70°C.

IX. F. E. Day. "*Laboratory Brews with the New Hops.*" Journal of the Institute of Brewing, 1931, Vol. XXXVII, pp. 202-205.

The author's laboratory method for small scale brewing was improved in details and shown to be of value in investigations involving questions of flavour. It was successfully applied in the examination of small quantities of hops under more controlled conditions than are possible in large scale trials.

X. A. G. Norman, "*Studies on the Gums. II. Tragacanthin—the Soluble Constituent of Gum Tragacanth.*" Biochemical Journal, 1931, Vol. XXV, pp. 200-204.

Tragacanthin, the soluble constituent in gum tragacanth, may be separated by ordinary filtration in extreme dilution. Uronic acid units are found to be present and to constitute about one-half of the molecule. Arabinose was the only sugar found ; no galactose could be detected. Hydrolysis products were prepared, the analytical figures for which give rise to the suggestion that a portion of the arabinose is united to the uronic acid to form a resistant nucleus, and the residue attached by glucosidic linkage, and therefore easily removable.

XI. H. L. Richardson. "*The Use of Hydrogen Peroxide for Estimating Humification.*" Soil Science, 1931, Vol. XXXII, pp. 167-171.

Six per cent. hydrogen peroxide, as used for measuring "degree of humification," was found to exercise a considerable action on a wide range of unhumified plant materials, and this action was increased by the presence of soil. Consequently, the method may be useful for following progressive stages in the decomposition of a single material, but it can give only approximate results and should not be used for comparing materials of different origin.

(*d*) Action of Manures

XII. T. J. Mirchandani. "*The Effect of Summer Green Manures on the Ammonia and Nitrate Contents of Soil Cropped for Winter Wheat.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 458-468.

At the Woburn Experimental Station it was found that winter wheat after summer tares was poorer than that after summer mustard in the early years of continued experiments both when the green crops were ploughed in directly and when they were folded off by sheep. Further, after a few rotations the wheat yields in all cases sank to a very low level. Systematic soil analyses throughout two seasons showed very low contents of nitrate and ammonia, and small scale plot experiments within the main wheat plots gave very large responses to nitrate of soda. It is concluded that the low fertility of these plots is caused by an acute shortage of available nitrogen in late spring and early summer when the wheat has a high nitrogen requirement.

XIII. E. M. Crowther and T. J. Mirchandani. "*Winter Leaching and the Manurial Value of Green Manures and Crop Residues for Winter Wheat.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 493-525.

It is suggested that the striking failure of winter wheat grown in rotation with two summer crops of tares or mustard on the sandy soil of the Woburn Experimental Station is due to the production of nitrate and ammonia from the green manures at times when the wheat is unable to use them efficiently and the consequent loss of nitrate in the drainage. Owing to the low C/N ratio in tares, the nitrogen nitrifies very rapidly and the loss by leaching is very great. Mustard, on the other hand, reduces the winter loss, but the nitrogen present in the mustard and that absorbed in the decomposition of the excess carbon compounds are liberated too slowly to be utilised efficiently by the wheat and much of the nitrate subsequently produced is also lost by leaching.

Nitrification experiments in the laboratory and pot experiments on wheat showed that nitrogen was made available more rapidly and more completely from materials with 13C/1N (tares, mustard+ blood, straw + blood) than from those with 26C/1N (tares + straw mustard, straw + blood). The yields in unleached pots were much higher with materials with 13C/1N, but in pots leached systematically during the winter the two types of organic matter were equally effective. The reduction of crop by leaching was closely correlated with, but not proportional to, the extent of early nitrate formation as measured by the amount of nitrate leached from the pots. It is suggested that early nitrate formation reduces the yield not only by increasing the removal of nitrate by leaching, but also by increasing the amount converted by the soil micro-organisms into forms which become available again only very slowly.

Tares material formed nitrates and mustard material removed it more rapidly and completely than equivalent mixtures. The less intimate association of the proteins and cellulosic substances in the mixtures appears to be sufficient explanation of these differences. There was no evidence of specific toxins or stimulants in mustard or tares. The bearing of these results on crop rotations and green manuring on light soils is discussed.

XIV. E. M. Crowther and R. G. Warren. "*Report on Laboratory and Pot Culture Work and Discussion of the Yields and Composition of the Experimental Crops from the Field Experiments on Phosphatic Fertilisers.*" Appendix to Ninth Interim Report of Permanent Committee on Basic Slag, 1931, Ministry of Agriculture, pp. 7-31.

An account is given of a series of phosphatic fertiliser trials on grassland both for hay and with repeated mowing in partial imitation of grazing conditions. The herbage in all cases was analysed for nitrogen and phosphoric acid so as to assess improvement in feeding value and the recovery of the added phosphoric acid. Pot experiments on some of the more recent types of low soluble slags gave results only very slightly superior to those of the older types.

XV. E. M. Crowther and H. L. Richardson. "*Studies on Calcium Cyanamide. I. The Decomposition of Calcium Cyanamide in the Soil and its Effects on Germination, Nitrification and Soil Reaction.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 300-324.

These studies were undertaken as an investigation of the modern standardised form of Calcium Cyanamide. Its rates of decomposition by various powdered minerals and in a number of soils were compared. In different soils the rate varied considerably, but given thorough mixing, most of the cyanamide was converted to urea or ammonia within a few days. The rate of disappearance in a soil was found to follow a logarithmic law, being proportional to the concentration of cyanamide in the soil solution.

The toxicity to germinating seeds was examined in laboratory experiments, and was found to be caused by the cyanamide itself, not by impurities or products of decomposition of the fertiliser. It fell off rapidly as the interval between applying Calcium Cyanamide and sowing the seeds increased, in accordance with the rapid disappearance of the cyanamide.

Ammonification and nitrification were studied in pot and field experiments; within a few days the soil ammonia content was practically the same whether nitrogen was added as sulphate of ammonia or as Calcium Cyanamide, but the final stage of nitrification was often slower with the latter. The extent of the retardation depended on the type of soil and on environmental conditions, showing a reduction with improved aeration in the pot experiments, and being very slight in the field experiments.

The effect of Calcium Cyanamide on soil reaction was consistently good as compared with the acidifying action of sulphate of ammonia, and it was shown that the use of Calcium Cyanamide was equivalent to the addition of its own weight of quicklime with a corresponding dressing of sulphate of ammonia.

XVI. B. K. Mukerji. "*Studies on Calcium Cyanamide. II. Microbiological Aspects of Nitrification in Soils under Varied Environmental Conditions.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 335-347.

Extensive series of bacterial counts and determinations of CO_2 production showed that under laboratory conditions both of these were increased by the addition of Calcium Cyanamide to soil. Bacterial numbers were also increased in pot experiments. The ammonification and nitrification of Calcium Cyanamide in soil were studied in the laboratory, and the degree of aeration was found to influence considerably the rates of disappearance of urea, and of production and disappearance of ammonia, as well as the rate of nitrification. In solution cultures Calcium Cyanamide was more toxic than dicyanodiamide to nitrifying organisms, although in soils the toxic action of the former is relatively less because of its much more rapid disappearance.

XVII. H. L. RICHARDSON. "*Studies on Calcium Cyanamide. III. Storage and Mixing with Superphosphate.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 348-357.

There was no appreciable loss of nitrogen from Calcium Cyanamide during storage under good farm conditions for two years, and only slight changes in the forms of the nitrogen present. Less than 1 per cent. was converted to dicyanodiamide after one year. Mixing Calcium Cyanamide and superphosphate caused changes that varied greatly with the conditions ; in a farm mixture spread in a thin layer after mixing, one-sixth of the nitrogen was changed to dicyanodiamide within a day, and one quarter in a month. In a series of laboratory mixtures the proportion of nitrogen converted to dicyanodiamide varied regularly with the composition, a maximum of 50 per cent. being reached in the mixture containing 20 per cent. of Calcium Cyanamide.

Both this paper and the first in the series contain appendices describing the special analytical methods used in the investigations.

STATISTICAL METHODS AND RESULTS

(Statistical Department)

(*a*) MATHEMATICAL THEORY

XVIII. R. A. FISHER. "*The Moments of the Distribution for Normal Samples of Measures of Departure from Normality.*" Proceedings of the Royal Society of London, A, 1930, Vol. CXXX, pp. 16-28.

Two methods are given for discussing the distribution of the ratios of the symmetric functions k_3, k_4 . . . . obtained from samples from a normal distribution to the powers of k_2 of the same degree.

The first method consists in the development of recurrence relations expressing the ratios from a sample of n in terms of the corresponding ratios from a sample of n—1 observations, and of a parameter distributed independently in a known distribution. Theoretically, all the properties of the general distribution could be obtained from these relations in conjunction with a study of samples of 3, 4, 5 . . . observations.

The relations are used to derive the exact values of the first three even moments of the simplest ratio γ, and of the simpler non-vanishing moments of the simultaneous distribution of all the ratios. It is observed that these moments are very simply related to the corresponding moments of the distribution of k_3, k_4 . . . given in a previous paper.

The second method is an application of the method of symbolical operators developed by the author, which confirms the generality of the relationship found. The moments of the one distribution may thus be inferred directly from that of the other for which the combinatorial procedure is available.

XIX. J. Wishart. "*The Mean and Second Moment Coefficient of the Multiple Correlation Coefficient, in Samples from a Normal Population.*" Biometrika, 1931, Vol. XXII, pp. 353-361.

The exact distribution of the multiple correlation coefficient was given in the Proceedings of the Royal Society, A (Vol. CXXI, pp. 654-673) in 1928. From this any required property of the distribution may be directly obtained. In the present paper the mean and variance of R^2 for $n_2=2$, 4, and 6 are calculated, and the general formula inferred. It is pointed out that the moments of R itself do not seem to be capable of simplification.

XX. J. Wishart. "*Notes on Frequency Constants.*" Journal of the Institute of Actuaries, 1931, Vol. LXII, pp. 174-177.

A note on the notation and use of statistics derived from sums of powers of the observations, with especial reference to previous discussions by Lidstone and Steffenson on the moments of Pearson and the semi-invariants of Thiele.

XXI. R. A. Fisher and J. Wishart. "*The Derivation of the Pattern Formulae of Two-way Partitions from those of Simpler Patterns.*" Proceedings of the London Mathematical Society, 1931, Series 2, Vol. XXXIII, pp. 195-208.

A method is developed of calculating the function of n to be associated with any two-way partition in the evaluation of the cumulants of the sampling distribution of the appropriate moment statistics k, by expanding it in terms of the functions of partitions having simpler patterns. When columns of two or three entries occur the simplification is extremely rapid. The method is, however, generalised for all cases.

A proof is given of the vanishing of the functions corresponding to all patterns in which the rows may be divided into two groups having only a single column in common.

XXII. J. Wishart. "*The Analysis of Variance Illustrated in its Application to a Complex Agricultural Experiment on Sugar Beet.*" Archiv für Pflanzenbau, 1931, Vol. V, pp. 561-584.

A description is given of a complex experiment on the manuring of two varieties of sugar beet, carried out at Rothamsted in 1929. The special experiment described is of a complex type, but is treated by determining a number of standard errors appropriate to special comparisons. While there is less certainty in such a case as to the genuine validity of these errors in their appropriateness for all the comparisons possible, the great advantage in precision to be obtained by combining diverse enquiries in large and complex experiments seems at this early stage to outweigh the convenience of simply demonstrable estimates of error.

XXIII. J. O. Irwin, "*Mathematical Theorems involved in the Analysis of Variance.*" Journal of the Royal Statistical Society, 1931, Vol. XCIV, pp. 284-300.

In this paper proofs are given of the essential theorems involved in the " analysis of variance " method which R. A. Fisher has invented. An endeavour has been made to treat them in an elementary manner, so as to make them available in one place for the mathematical-statistical student of average ability, or any others interested in the subject. For this reason somewhat full proofs have been given and points dealt with in detail which will appear obvious to the highly trained mathematical statistician.

(b) Genetics

XXIV. R. A. Fisher. "*The Evolution of Dominance.*" Biological Reviews, 1931, Vol. VI, pp. 345-368.

The theory that the genetical phenomenon of dominance is itself a product of the evolutionary process rather than a necessary consequence of the biochemical organisation of the nucleus, was first put forward in 1928, in connection with the facts which are now known about mutations in species bred in large numbers for genetical purposes such as *Drosophila* and *Gammarus*. Since this publication very numerous groups of genetical facts have been brought to the attention of the author respecting the domesticated species, and species showing polymorphism in nature, which strongly confirm and amplify the original proposition, and in conjunction with it, throw much light upon the genetic situations in these forms. This paper draws together the evidence from various fields, and indicates the special cases in which the theory may be tested by further experiment.

XXV. R. A. Fisher, F. R. Immer and Olof Tedin. "*The Genetical Interpretation of Statistics of the Third Degree in the Study of Quantitative Inheritance.*" Genetics, 1932, Vol. XVII, pp. 107-124.

A genetical interpretation is given for various second and third moment statistics which are of use in studying quantitative inheritance.

Published data taken from lettuce and maize, and unpublished data from barley crosses are used to illustrate how the problem may be attacked. The special needs of data adequate for this purpose are illustrated, and certain possible precautions in planning the experiments are pointed out.

A study of the skewness of seven distributions for strains of mice selected for high and low tailring number indicated that the theoretical negative association between the statistics k_1 and k_2 in selected strains could probably be evaluated.

Formulae are given by which the effect of the dominance bias in the heterozygote in relation to the measurable characters of the homozygotes in F_2 or F_3 distributions or various types of crosses may be calculated.

The two common sources of bias (metrical and dominance) are discussed and data from a barley cross used to illustrate the results obtained when the former is of major importance.

Since the combined effect of the dominance and metrical biases may be obtained experimentally in many different ways, an empirical test of the consistency of the genetical interpretations is available, as well as an opportunity of evaluating and eliminating the metrical bias.

Standard errors are given for the different statistics used.

THE SOIL

(Chemical and Physical Departments)

(*a*) Soil Classification

XXVI (A). E. J. Russell. "*Principles and Methods of Soil Utilisation with Illustrations from the British Empire.*" Proceedings of Second International Soil Congress, Russia, 1930.

XXVI (B). E. J. Russell. "*The Soil Resources of the Empire.*" Proceedings of a Conference on Soil Science Problems held at the Rothamsted Experimental Station, September 16th-18th, 1930. Imperial Bureau of Soil Science Technical Communication No. 17, 1931, pp. 23-28.

These two papers contain accounts of the methods by which the soils of the most important types in the Empire have been brought into cultivation and in many instances made to increase in productiveness.

A survey of the soil resources of the Empire is urgently needed in view of the important social and economic problems involved in further development and land settlement. Much progress has been made in mapping the soils of Australia, and material is being assembled in other parts of the Empire on which a preliminary survey could be based.

XXVII. E. M. Crowther. "*Soils and Climate.*" Ministry of Agriculture, Report on Agricultural Meteorological Conference, 1931, pp. 5-11.

Earlier work (*cf.* Report 1930, XXXI, p. 82) is briefly reviewed and supplemented by an analysis of the distribution of soil types in European U.S.S.R. in relation to climatic factors as measured by the mean annual rainfall and temperature. It was found that for points distributed at distances of about 70 miles over the area between 65° N. and 45° N. and 28° E. and 58° E. the soil type, as shown on Prassolov's map on the scale of 1 to 2,500,000, the values for an arbitrary index of climate (R—30 cms. $\div$ T + 4° C) fell within the following limits for 290 out of 318 points: Brown soils and alkali soils, negative; chestnut soils, 0 to 0.5; southern Chernozem, 0.5 to 1.0; ordinary Chernozen, 0.75 to 2.0; thick and Azov Chernozems, 1.0 to 3.0; degraded and leached Chernozems, 2.0 to 4.0; strongly degraded soils (secondarily podsolised), 2.0 to 4.0; podsolised, peaty podsolised, gley podsolised and bog soils, greater than 3.0. For the areas covered by seven of these soil types there were significant regressions of rainfall on temperature. The degraded Chernozems and the secondarily podsolised soils fell into the same climatic band and the distinction between these soils may therefore depend on the interval since the forest invaded the steppe. The graphs illustrating the above groupings and the form of the empirical relationship chosen show quite clearly that Lang's "Regenfaktor" (R$\div$T) fails completely to group climates in accordance with soils. The factor (3 cms. per °C) used to separate highly leached soils from all others agrees closely with that derived from American and other data in the earlier paper.

(*b*) Mechanical Analysis

XXVIII. Erik Troell. "*The Use of Sodium Hypobromite for the Oxidation of Organic Matter in the Mechanical Analysis of Soils.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 476-483.

Freshly prepared solutions of sodium hypobromite may be used with advantage instead of boiling hydrogen peroxide in mechanical analysis by the pipette method. Soils containing manganese dioxide or large amounts of organic matter may be treated rapidly ; changes in the clay are minimised ; the reagents are cheaper and more stable, and the method allows further simplifications in technique.

(*c*) Physical Properties

XXIX. R. K. Schofield and G. W. Scott Blair. "*The Influence of the Proximity of a Solid Wall on the Consistency of Viscous and Plastic Materials. III.*" Journal of Physical Chemistry, 1931, Vol. XXXV, pp. 1212-1215.

In earlier work evidence was obtained that when clay pastes are forced through narrow tubes, the consistency of the material near the wall differs from that of the bulk of the material. A construction was developed for obtaining plastic constants referring to the paste in the central part of the tube, by assuming that the modified layer was of small thickness compared with the tube radius. A simpler and more complete treatment is now given which indicates that although the thickness of the modified layer may be appreciable, the original construction proposed still gives a close approximation to the true values of the material in bulk. The treatment has now been carried up to the limit of the present accuracy of the experimental methods.

XXX. R. K. Schofield and G. W. Scott Blair. "*Depth and Rigidity of Sediment in Flocculated Clay Suspensions.*" Transactions of the Faraday Society, 1931, Vol. XXVII, pp. 629-632.

An extension of experimental work on the phenomena of rigidity in weak clay suspensions, (Schofield and Keen, '*Nature*,' 1929, 123, 492) with reference to the rigidity and volume of the sediment.

The strength of the rigid structure depends on the exchangeable ions and the added salt, but the relationship is not at present understood. The volume of the sediment after flocculation of the clay with varying quantities of different ions seemed to depend only on the nature and concentration of the clay, suggesting that the measurement might be of use in soil investigations.

XXXI. Ashutosh Sen and C. H. Wright. "*The Electrical Conductivity of Aqueous Soil Suspensions as a Measure of Soil Fertility.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 1-13.

The increase, on standing, in the electrical conductivity of an aqueous extract of soil over its initial value serves as a qualitative measure of soil fertility (Atkins. Journal of Agricultural Science, 1924, 14, 198). Measurements were therefore made on old soil samples from the Rothamsted classical plots which have been taken and carefully preserved in sealed bottles at intervals since the early days of the field experiments. The increase in conductivity is highly correlated with the recorded crop yield of the season in which the given soil sample was taken. The correlation is shown to be an expression of the progressive decline in the fertility of the soil over the period of the experiment.

XXXII. ASHUTOSH SEN. "*The Measurement of Electrical Conductivity of Aqueous Soil Suspension and its Use in Soil Fertility Studies.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 212-234.

The effects of season, cropping, manuring, and cultivation on the change in the electrical conductivity of aqueous extracts of soil, were studied, in view of the possible use of this measurement as an index of soil fertility.

There is practically no change in the measurements for unmanured plots of low yield.

The addition of easily decomposible organic material causes, in general, a marked increase in the measurement.

Continued fallowing has little effect.

For soil under permanent grass there are marked seasonal variations, and where comparisons are being made the soil samples should be taken at the same season and under comparable meteorological conditions, while for arable soils the most suitable time is after the soil is prepared for the crop, but before manures are sown.

(*d*) PHYSICAL CHEMISTRY

XXXIII. J. K. BASU. "*Studies on Soil Reaction VII. An Electrodialysis Apparatus for the Determination of Replaceable Bases in Soils.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 484-492.

A six-unit apparatus of two compartment cells is described and it is shown that the technique may be modified to exclude the kations from soluble salts from either the total bases as determined by direct titrations of the dialysate or from the individual bases as determined by analysis.

XXXIV. E. M. CROWTHER AND J. K. BASU. "*Studies on Soil Reaction VIII. The Influence of Fertilisers and Lime on the Replaceable Bases of a Light Acid Soil after Fifty Years of Continuous Cropping with Barley and Wheat.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 689-715.

At the completion of a 50-year cycle of continuous cropping with both wheat and barley on a light sandy soil at the Woburn Experimental Station, soil samples from all of the plots were analysed for replaceable bases.

The soil had little or no calcium carbonate originally and comparison with early soil samples showed that the unmanured plots lost about half of their replaceable calcium in the 50 years. The loss of calcium was much greater on plots with ammonium sulphate and the crops failed completely in about 20 years. Plots with sodium nitrate or farmyard manure retained considerably more calcium than the unmanured plots.

The effect of superphosphate was so slight that for practical purposes it may be regarded as without effect on the replaceable bases.

The final replaceable calcium was reduced at the rate of 0.8 mol. CaO per mol. of ammonium sulphate added throughout the experiment, and increased at the rate of 0.5 mol. for the equivalent amount of sodium nitrate. The relatively low value for the ammonium sulphate effect is due to the low base content of the very acid soils and the low calcium bicarbonate content of the water. To increase the replaceable calcium of the ammonium sulphate plots to that of the sodium nitrate plots required 2.8 mol. of CaO per mol. of ammonium sulphate when the lime was applied at intervals of about 10 years. A rule is proposed for calculating the effects of various nitrogenous fertilisers on the lime content of the soil.

Most of the added lime was recovered many years later when the original lime content was low, but added lime was rapidly lost by leaching from soils of relatively high replaceable calcium content.

A new method was devised determining the " degree of unsaturation " or " exchangeable hydrogen " of soils. A mixture of soil and calcium carbonate is extracted with *N*.NaCl, and the difference between the calcium and the bicarbonate contents of the extract is taken as a measure of the replaceable calcium and hydrogen.

(*e*) Organic Chemistry

XXXV. M. M. S. Du Toit and H. J. Page. "*Studies on the Carbon and Nitrogen Cycles in the Soil. IV. Natural and Artificial Humic Acids.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 115-125.

The preparation of natural humic acids from soil, peat (Dopplerite) and " Adco," and of artificial " humic " acids from sucrose, cellulose, dextrose and glycine (Maillard), hydroquinone and lignin, and their purification are described.

Their elementary compositions and their behaviours under conductimetric titration with ammonia have been studied. The artificial products from sucrose and furfural did not behave as acids but all the natural products, and the artificial products from cellulose, hydroquinone and lignin possessed the properties of colloidal acids.

Preliminary investigations into the " humification " of furfural and ω-hydroxymethyl furfural, and into the interaction of dextrose with amino bodies, are described.

SOIL ORGANISMS

(Bacteriological, Fermentation, General Microbiological, and Mycological Departments)

(*a*) Bacteria

XXXVI. H. L. Jensen. "*A Comparison of Two Agar Media for Counting Soil Micro-organisms.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 832-843.

A statistical test was made of the variation between bacterial and actinomycete colony numbers on parallel plates on dextrose-casein agar, the medium used for the counts involved in the author's work on manure decomposition. (See Papers XLVI to XLVIII). The medium was compared in this respect with Thornton's mannitol-asparagine agar, and like the latter medium, gave generally satisfactory results, though on both media counts of actinomycetes tended to give subnormal variance.

(*b*) Protozoa

XXXVII. L. de Telegdy-Kovats. "*The Growth and Respiration of Bacteria in Sand Cultures in the Presence and Absence of Protozoa.*" Annals of Applied Biology, 1932, Vol. XIX, pp. 65-86.

Experiments were carried out on carbon dioxide production from sand treated with peptone and glucose solution, or with glucose and ammonium sulphate solutions of different C/N ratios. The media were inoculated with various types of bacteria and protozoa. It was found that while the presence of protozoa increased the carbon dioxide production, especially in the case of mixed bacteria cultures, and also caused greater bacterial efficiency, yet the number of bacteria was lower ; an increase in the number of protozoa beyond a certain point, however, reduced the output of carbon dioxide. Reducing the concentration of glucose from 0.6 to 0.2 per cent. resulted in a greater percentage production of carbon dioxide, and an intensification of the effect caused by the presence of protozoa. An increase in the C/N ratio in the presence of protozoa was followed by a marked increase in carbon dioxide production, while in their absence there was no definite effect. Where the C/N ratio was reduced to less than 10/1 there was a fluctuation of numbers in bacterial cultures.

(*c*) Fungi

XXXVIII. W. B. Brierley. "*Biological Races in Fungi and their Significance in Evolution.*" Annals of Applied Biology, 1931, Vol. XVIII, pp. 420-434.

A discussion of biological races and fungal variation in relation to the species concept and the evolution of new species. An "orbital conception" of systematic categories and evolutionary relationships is put forward.

(*d*) Biological Activities

XXXIX. D. Ward Cutler and B. K. Mukerji. "*Nitrite Formation by Soil Bacteria, other than Nitrosomonas.*" Proceedings of the Royal Society (B), 1931, Vol. CVIII, pp. 384-394.

Four species of non-spore-forming bacteria capable of oxidising ammonia into nitrite have been isolated from Rothamsted soil and all differ widely from *Nitrosomonas* or *Nitrosococcus*.

These organisms are able to carry out this reaction in artificial media as well as in soil, and some are able to assimilate nitrite.

Rapid growth takes place on nutrient agar, and the presence of 0.1 per cent. sucrose stimulates nitrite production.

F

XL. N. W. BARRITT. "*The Liberation of Elementary Nitrogen by Bacteria.*" Biochemical Journal, 1931, Vol. XXV, pp. 1965-1972.

Much confusion exists in the literature regarding the liberation of nitrogen by bacteria. This is due chiefly to inaccuracies in analytical methods and insufficient attention to the occurrence of nitrates or nitrification.

In addition to the liberation of nitrogen by reduction of nitrates it is shown that free nitrogen may be formed by the interaction of amino compounds and nitrites when the reaction falls below pH 6.0. In this way fermentation of carbohydrates by producing an acid reaction may result in the liberation of free nitrogen.

Ammonium nitrite in culture solutions is quite stable at ordinary temperatures and does not give rise to free nitrogen.

XLI. N. W. BARRITT. "*The Biological Filtration of Dilute Sucrose Solutions.*" Biochemical Journal, 1931, Vol. XXV, pp. 1419-1446.

Bacterial oxidations involve organic synthesis which in the case of sucrose involves from 25 per cent. to 33 per cent. of the material. This synthesis accounts for the incomplete absorption of oxygen in the 5-day oxygen absorption test and the accumulation of film in a biological filter.

The use of sectional filters showed the relation of nutrition gradient to the structure and functioning of the filter. The rate of purification is proportional to growth of film which is determined by the concentration of the nutrient. Growth of film tends to limit aeration which is essential to oxidation and this imposes limits on the size of the particles constituting the medium of the filter. The use of gravel passing ½ inch mesh is to be avoided since it favours the development of anaerobic conditions, indicated by a lowering of pH in the upper sections due to the formation of organic acids.

The growth of the film and the efficiency of the filter depend upon definite nitrogen and phosphorus requirements, viz., a C/N ratio of 15 and C/P_2O_5 ratio of 10. Nitrogen fixation occurs in the filter but not to a sufficient extent to ensure adequate purification.

Nitrification occurs when the concentration of oxidisable organic matter falls below the equivalent of 0.03 per cent. sucrose.

XLII. S. H. JENKINS. "*The Biological Oxidation of Carbohydrate Solutions. I. The Oxidation of Sucrose and Ammonia in Sectional Percolating Filters.*" Biochemical Journal, 1931, Vol. XXV, pp. 147-160.

A study was made of a percolating filter which consisted of six independent sections. The solution fed to the filter contained sugar plus ammonia. When the biological film was mature the amounts of sugar and nitrogen oxidised by each section were found. The results showed that the first section was most effective in oxidising sugar, while the last section was least effective. However, if the last section was placed in the position occupied by the first, and thus received a more concentrated solution of sugar it became quite as efficient as the first section. The oxidation of ammonia was found to proceed mainly in the lower sections although nitrification could occur to a limited extent in the upper sections of the filter in the presence of 0.06 per cent. of sugar.

XLIII. A. G. Norman. "*The Biological Decomposition of Plant Materials. IV. The Biochemical Activities on Straws of some Cellulose-Decomposing Fungi.*" Annals of Applied Biology, 1931, Vol. XVIII, pp. 244-259.

A number of fungi isolated from rotting straw were tested for ability to utilise different carbohydrate constituents. In general all substances but lignin were attacked to a degree relatively proportional to the apparent total loss of organic matter. The nitrogen factor, i.e., nitrogen immobilised by 100g. of straw, was determined in each case. The differences are considerable and varietal. They are not related to any particular straw constituent.

XLIV. E. H. Richards and A. G. Norman. "*The Biological Decomposition of Plant Materials. V. Some Factors Determining the Quantity of Nitrogen Immobilised During Decomposition.*" Biochemical Journal, 1931, Vol. XXV, pp. 1769-1778.

The amount of additional nitrogen immobilised during decomposition of plant materials represents only the equilibrium between immobilisation and ammonification. Besides the added nitrogen, plant proteins may also be attacked, or microbial nitrogen may be liberated and re-utilised. The term "nitrogen equivalent" is suggested as a measure of the efficiency of the microbial tissue in decomposition, and defined as the nitrogen immobilised in the course of removal of 100g. of organic matter from any material.

XLV. A. G. Norman. "*The Biological Decomposition of Plant Materials. VI. The Effect of Hydrogen-ion Concentration on the Rate of Immobilisation of Nitrogen by Straw.*" Biochemical Journal, 1931, Vol. XXV, pp. 1779-1787.

The rate of immobilisation of available nitrogen in dilute solutions of various hydrogen ion concentrations was studied by percolation of the solutions through straw filters. Slightly alkaline conditions favour immobilisation and more organic matter is fermented away than under neutral or slightly acid conditions. The alkaline filter showed an initial lag not observed in either of the others. This lag is due to a primary flora relatively inactive in cellulose decomposition. The loss of hemicellulose is more gradual in filters than in compost heaps.

XLVI. H. L. Jensen. *The Microbiology of Farmyard Manure Decomposition in Soil. I. Changes in the Microflora and their Relation to Nitrification.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 38-80.

When farmyard manure was added to soil the energy material contained in it produced a rapid increase in bacteria, actinomycetes and fungi which resulted in a part of the manure nitrogen being locked up in the form of protein. Only after the numbers of micro-organisms passed their maximum did the production of nitrate become active. After passing the maximum this nitrification diminished gradually, leaving, after a year, a considerable portion of the manure in an unavailable form. This fraction was contained partly in the cells of the micro-organisms themselves and partly in the ɘ-humus which is very resistent to decomposition and which tended to increase slightly during the period.

XLVII. H. L. JENSEN. "*The Microbiology of Farmyard Manure Decomposition in Soil. II. Decomposition of Cellulose.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 81-100.

Addition of farmyard manure to approximately neutral soil (pH 6.5-7.0) gave rise to an abundant development of cellulose decomposing bacteria of the genus *Vibrio*. When it was added to faintly acid soils (pH 5.7-6.2) these organisms were partly replaced by *Spirochaeta cytophaga*. At lower pH values only fungi were active in the decomposition of the cellulose. Similar results were obtained by adding filter paper or straw to soils of different reactions. Cellulose decomposing bacteria did not form humus-like compounds when growing on filter paper in sand culture but at least two fungi *Mycogone nigra* and *Stachybotrys sp.* gave rise to such compounds when growing in sand and in sterilised soil.

XLVIII. H. L. JENSEN. "*The Microbiology of Farmyard Manure Decomposition in Soil. III. Decomposition of the Cells of Micro-organisms.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 1-25.

The addition of microbial substances to soil resulted in a rapid but temporary increase in bacteria and especially actinomycetes. A fraction of the microbial substance was readily nitrified but there remained a very resistant residue. This was not identical with fungal chitin which is readily nitrified. In the case of *Mycogone nigra* and *Stachybotrys*, the humus-like substance contained in their mycelia formed part of this resistent residue.

THE PLANT IN DISEASE: CONTROL OF DISEASE

(Entomological, Insecticides and Fungicides, and Mycological Departments)

(a) INSECTS, AND THEIR CONTROL.

XLIX. H. F. BARNES. "*Observations on Gall Midges Affecting Fruit Trees.*" Journal of the South-Eastern Agricultural College, 1931, No. 28, pp. 170-177.

Notes on the bionomics and control of *Dasyneura pyri* Bouché, *Contarinia pyrivora* Riley, both on pear; *Thomasiniana oculiperda* Rübs. on rose and apple, and *Dasyneura* sp. on black currant. This information, which deals with recent literature and the author's own investigations, brings up to date the section dealing with the same subject in a previous paper (Barnes, *Material for a Monograph of the British Cecidomyidae or Gall Midges*, Journal of the South-Eastern Agricultural College, 1927, No. 24, pp. 65-146).

L. H. F. Barnes. "*Further Results of an Investigation into the Resistance of Basket Willows to Button Gall Formation.*" Annals of Applied Biology, 1931, Vol. XVIII, pp. 75-82.

Twelve commercial varieties of *Salix triandra* have been proved, under experimental conditions, to be very susceptible to attack by the button top midge (*Rhabdophaga heterobia* H.Lw.) ; three varieties of *S. purpurea*, one variety of *S. viminalis*, three hybrids of *S. viminalis* and *purpurea*, and *S. alba* var. *vitellina* have proved to be totally immune. It is suggested that hybridisation of *S. triandra* and *S. purpurea* or *S. viminalis* or *S. alba* should be attempted.

LI. H. F. Barnes. "*The Sex Ratio at the Time of Emergence and the Occurrence of Unisexual Families in the Gall Midges* (*Cecidomyidae*)." Journal of Genetics, 1931, Vol. XXIV, pp. 225-234.

Unisexual families are shown to occur in *Rhabdophaga heterobia* H.Lw. and *Thomasiniana oculiperda* Rübs.

LII. H. F. Barnes. "*Gall Midges* (*Cecidomyidae*) *whose Larvae Prevent Seed Production in Grasses* (*Gramineae*)." Bulletin of Entomological Research, 1931, Vol. XXII, pp. 199-203.

Brief notes are given on 18 species of Cecidomyidae, the larvae of which have been recorded from various parts of the world as preventing seed formation in grasses, with a list of the grasses attacked showing the gall midges concerned and the country of origin.

LIII. A. Steel. "*On the Structure of the Immature Stages of the Frit Fly* (*Oscinella frit Linn.*)." Annals of Applied Biology, 1931, Vol. XVIII, pp. 352-369.

The morphology of the immature stages of *Oscinella frit* Linn. are described and figured and certain observations of a biological nature are recorded.

LIV. H. C. F. Newton. "*On the so-called 'Olfactory Pores' in the Honey-Bee.*" Quarterly Journal of Microscopical Science, 1931, Vol. LXXIV, pp. 647-668.

The structure of the campaniform sensillae on the wing-bases of the honey bee is described together with the essential features of the later developmental phases in the pupae. The observations made lend no support to the view that the nerve fibres of the sensillae are exposed to the air so rendering them specially suitable to the reception of chemical stimuli from a distance. The origin of the cellular elements composing the sensillae is discussed and it is suggested that the neuron of the sensory system connected with these organs is situated in the hypodermis and is in fact the sensory cell itself.

LV. Marion A. Hamilton. "*The Morphology of the Water Scorpion, Nepa cinerea. Linn.* (*Rhynchota Heteroptera*)." Proceedings of the Zoological Society of London, 1931, pp. 1068-1134.

A description of the morphology and histology of a common freshwater Heteropteran, the "Water Scorpion." A short account of the biology and life-history is given followed by a detailed account of the anatomy, both external and internal. Particular attention is paid to the muscular and nervous systems not hitherto described, and showing various interesting adaptations and modifications to the unusual mode of life. The respiratory system and some of its peculiar points of anatomy and physiology receive considerable attention. In Nepa a great many of the normal functions of insects have become subjugated to the more pressing immediate need for air, with the result that such organs as wings and wing muscles, spiracles, etc., are being used in ways, and for purposes which are almost unique, owing to the adoption of a permanent sub-aqueous habitat. Finally an account is given of the integument and sense organs which have also been rather neglected by morphologists, with the one outstanding exception of the abdominal sense organs. These are again unique structures pertaining to the abdominal spiracles and owing their existence to the unusual needs of the insect.

LVI. R. P. Hobson. "*Calcium and Hydrogen Ion Concentration and the Interfacial Tension of Pyrethrum Extracts.*" Journal of Agricultural Science, **1931**, Vol. XXI, pp. 101-114.

The addition of a pyrethrum extract to a petroleum solvent, semi-refined white spirit, considerably lowers its interfacial tension against water. The tension also depends upon the reaction of the aqueous phase, decreasing as the alkalinity increases.

The addition of agral W.B. to a solution of pyrethrum extract further lowers the interfacial tension more especially against acid solutions, thereby decreasing the sensitivity of the tension value to the pH of the aqueous phase.

The presence of calcium salts in the aqueous phase raises the interfacial tension of solution of pyrethrum extract.

Alkaline salts counteract the effect of calcium salts and the resulting tension values can be correlated with the ratio of calcium to hydroxyl ion concentration.

LVII. J. T. Martin and F. Tattersfield. "*The Evaluation of Pyrethrum Flowers* (*Chrysanthemum Cinerariaefolium*)." Journal of Agricultural Science, **1931**, Vol. XXI, pp. 116-135.

The analytical methods of Tattersfield, Hobson and Gimingham, and Gnadinger and Corl for the determination of the pyrethrins in pyrethrum flowers are compared, and certain modifications in technique suggested.

Good concordances have been obtained between analytical data and insecticidal tests employing *Aphis rumicis*.

A new method for the rapid and approximate evaluation of unadultered samples, employing small quantities of material, is described.

Observations on the pyrethrin content of individual flowers in the various stages of development are recorded, making use of a modification of the method indicated

LVIII. F. TATTERSFIELD AND R. P. HOBSON. "*Extracts of Pyrethrum: Permanence of Toxicity and Stability of Emulsions.*" Annals of Applied Biology, 1931, Vol. XVIII, pp. 203-243.

Pyrethrum flowers (*Chrysanthemum cinerariaefolium*) both as whole heads and as powder retain their insecticidal properties at ordinary temperatures and at 28°C. for considerable periods if stored in closed vessels. If exposed to the atmosphere in a thin layer as finely ground powder there is risk of loss of toxicity.

Alcohol and petroleum extracts of pyrethrum retain their toxicity in temperate climates over many months. Alcohol extracts readily give permanent emulsions when added to water ; petroleum extracts require the incorporation of an emulsifier. Water-miscible petroleum extracts of pyrethrum can be prepared by the addition of certain materials, such as ammoniated Agral W.B. and neutral turkey-red oil.

A study has been made of the degree of permanence of the active principles of alcoholic and water-miscible petroleum extracts at ordinary British temperatures and at 28°C. and also in emulsions of these extracts in alkaline spray fluids of varying pH. The active principles proved more permanent than has usually been supposed.

The readiness with which water-miscible petroleum extracts disperse in the aqueous phase and the stability of the emulsions formed under a variety of conditions have been investigated.

LIX. F. TATTERSFIELD. "*Pyrethrum Flowers: A Quantitative Study of Their Development.*" Annals of Applied Biology, 1931, Vol. XVIII, pp. 602-635.

An account is given of the examination of the flowers of pyrethrum plants (*C. cinerariaefolium*) grown in Harpenden. The plants were divided into blocks and randomised, the flowers being harvested from a dozen plants each week over a period of 8½ weeks, the flower heads ranged from the small bud stage in the first week to the overblown stage in the last week.

The yield in numbers and weight of heads per plant, the diameters of the receptacles and the content of pyrethrin I and II were determined. There was a considerable amount of variation in all the factors in the flowers from different plants.

A statistical analysis showed that :

(*a*) there was no significant variation in the numbers of the flowers with time, but that position of the plant in the bed had a significant effect ;

(*b*) the time of harvesting had a significant effect upon the content of the pyrethrins, whether taken separately or together and whether expressed in percentages, parts per flower head or parts per plant.

There was a quantitative development of the active principles in the flower heads from the small bud stage up to the time of maturity of the flowers, which more than kept pace, on the whole, with the increase in weight of the flowers. Thus the content of pyrethrins, both relatively and absolutely, rises to a maximum at the maturity of the flowers.

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The mean percentage content of pyrethrins fell after pollination, and the fading of the flowers ; this corresponds with the rapid increase in weight of the heads on the formation of seed. There would appear to be a loss, which might be serious, both in percentage content of active principles and in yield of flowers if harvested before being fully open.

(b) Bacterial Diseases.

LX. R. H. Stoughton. "*The Influence of Environmental Conditions on the Development of the Angular Leaf-Spot Disease of Cotton. III. The Influence of Air Temperature on Infection.*" Annals of Applied Biology, 1931, Vol. XVIII, pp. 524-534.

Experiments carried out in the Rothamsted control chambers on the influence of air temperature on the angular leaf-spot disease of cotton plants, resulting from spray inoculation of young plants, show that high air temperatures favour the development of the disease. Maximum infection occurs at an air temperature of 35-36°C. with decreasing incidence at progressively lower temperatures. At a constant air temperature of 39-40°C. cotton plants make no growth, and eventually die.

Infection takes place more readily when the inoculation is carried out during the non-illuminated period.

The relation of these results to the experiments on the influence of soil temperature is discussed.

(c) Virus Diseases

LXI. J. Caldwell. "*The Physiology of Virus Diseases in Plants. II. Further Studies on the Movement of Mosaic in the Tomato Plant.*" Annals of Applied Biology, 1931, Vol. XVIII, pp. 279-298.

The results of experiments discussed in this paper support the general view that the agent of virus diseases will travel only through living tissue. No entry into the living tissues is possible through the epidermis, the root hair, or the xylem vessel walls. The agent can and does travel, however, in the water stream, if it be injected mechanically into the xylem. The absence of the agent from the hydathode exudate has been demonstrated. The agent cannot enter an unbroken cell nor can it move through areas of dead cells. Traces of toxic substances from the inocula to be tested may prevent the infection of experimental plants, even when the virus agent is present. Movement upwards and downwards in the plant takes place more or less at the same rate. The agent appears to move along the protoplasmic strands rather than to be carried bodily in the phloem strands. The effect of darkness on the development of the virus in the plant and on the plant itself is discussed.

LXII. F. M. L. Sheffield. "*The Formation of Intracellular Inclusions in Solanaceous Hosts Infected with Aucuba Mosaic of Tomato.*" Annals of Applied Biology, 1931. Vol. XVIII, pp. 471-493.

A description is given of the mode of formation of intracellular inclusions produced by aucuba mosaic of tomato in *Solanum nigrum*, *S. nodiflorum*, *S. lycopersicum*, *Nicotiana tabacum* and *Hyoscyamus niger*.

Soon after infection the rate of streaming of the cytoplasm is increased, then minute particles of protein appear in the cytoplasm, which carries them passively about the cell. These particles aggregate and fuse to form large masses which are still carried passively but more slowly about the cell. These fuse until all the protein material is contained in one or occasionally more granular masses. In the three Solanum species examined this mass becomes rounded, and it may lose its granular appearance and become vacuolated. In *N. tabacum* the body does not always round off and in *H. niger* it very seldom does so, but remains as an irregularly shaped granular mass which may, however, become vacuolate.

There is no evidence at any time of autonomous movement, the particles and the fully formed body being carried, as are the cell nucleus, mitochondria, etc., of the normal plant, in the cytoplasmic stream.

After the spherical body is formed a spike-like crystal appears in the cell.

The cell remains at rest for the space of several weeks. Often the rounded inclusion body and the nucleus are juxtaposed, but there is no special significance in this, it is merely the accidental result of the mode of formation of the body. Particles tend to accumulate where a number of strands of plasm meet ; usually several strands converge on the nucleus.

Ultimately the body breaks down, giving a number of protein crystals. After some months these dissolve. In *H. niger* the inclusion bodies are confined to the chlorotic areas, where they are abundant in all tissues. In the other species studied they are distributed over green and yellow tissues. They are very abundant in the hairs, less so in the epidermis, and very rare in the palisade and spongy tissues. In *H. niger* the development of the palisade tissue is arrested, in the other species the development is not so obviously affected, although growth is retarded.

These inclusions appear not to be organismal in nature ; they seem to be products of reaction of the host cell to the virus, but they may contain the etiological agent of the disease.

TECHNICAL AND OTHER PAPERS

GENERAL

LXIII. G. W. Scott Blair and R. K. Schofield. "*On the Anomalous Flow of a Strong Solution of Lithium Chloride through Narrow Glass Tubes.*" Philosophical Magazine, 1931, Vol. XI, pp. 890-896.

In connection with plastometric measurements of clay pastes the behaviour of non-colloidal solutions was investigated in the plastometer. A strong solution of lithium chloride was found not to obey Poiseuille's law for the flow of viscous liquids through glass capillary tubes. It seems that small strains are not immediately dissipated during flow, possibly owing to the tendency of the ions to maintain a non-random distribution. In addition, evidence was found of anomalous flow close to the tube-wall, which has hitherto been found only with suspensions. This phenomenon was unexpected and no explanation can be given at present.

Mixtures of glycerine and water behave normally, showing that the anomalies observed with lithium chloride solutions are not due to defects in experimental methods.

LXIV. HUGH NICOL. "*Ueber ein ungewohnliches Beispiel regionaler Sedimentation.*" Kolloid–Zeitschrift, 1932, Vol. LVIII, pp. 302-305.

A suspension of cellulose is described, which shews two kinds of regional sedimentation (producing visible layers in the liquid). One of these kinds is discussed at length, and a theory of the mode of its formation and persistence is put forward. It is supposed that the formation of the layers of cellulose is not due to temperature gradients in the liquid, but to small differences of specific gravity of the particles induced by a general cooling of the suspension.

LXV. R. H. STOUGHTON. "*An Improved Method of Maintaining Constant Humidity in Closed Chambers.*" Journal of Scientific Instruments, 1931, Vol. VIII, pp. 164-166.

An account of a device used for controlling the humidity within plant chambers. The apparatus depends for its action on the controlled vapourisation of water from wet muslin, the humidified air being carried into the chamber by a rapid air stream.

LXVI. E. J. RUSSELL. "*The Feeding of Britain.*" School Nature Study, 1931, Vol. XXVI, pp. 29-33.

LXVII. E. J. RUSSELL. "*Can Farming be Made to Pay?*" Country Life, 1931, Vol. LXX, pp. 63-64.

LXVIII. E. J. RUSSELL. "*Agricultural Development of the Empire.*" Science Progress, 1931, Vol. XXV, pp. 87-108.

LXIX. E. J. RUSSELL. "*Science and Crop Production, 1930.*" National Farmers' Union Year Book, 1931, p. 89.

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WOBURN EXPERIMENTAL FARM

REPORT FOR 1931

BY DR. J. A. VOELCKER, C.I.E., M.A.

The season was very unfavourable, for corn crops in particular. Wheat came up well in the mild winter, but the cold and cheerless spring and an almost sunless rainy summer prevented crops from maturing well. But these conditions were favourable to grass, and gave heavy crops of hay and grass for feeding. A sunny period towards the end of June fortunately favoured the getting in of hay. Root and forage crops did fairly well, and spraying with Bordeaux mixture saved the potato crop. The corn harvest was prolonged by the uncertain weather, but the experimental crops were gathered in with fair success.

Woburn Meteorological Records, October, 1930—December, 1931.

	Rainfall.			*Temperature (Mean).*			
	Total Fall.	No. of Rainy Days (0.01 in. or more).	Bright Sun-shine.	Max.	Min.	1 ft. in Ground.	Grass Min.
1930—	ins.	No.	Hours.	°F.	°F.	°F.	°F.
Oct. ..	1.01	14	126.5	57.2	44.3	50.8	39.2
Nov. ..	3.74	19	64.8	50.0	35.7	43.5	32.4
Dec. ..	2.28	19	18.9	43.8	34.1	40.0	32.1
1931—							
Jan. ..	1.24	19	52.7	42.3	31.8	37.5	28.0
Feb. ..	1.70	21	59.3	43.6	32.9	38.0	30.4
March	0.08	6	146.3	46.7	30.4	39.6	25.8
April ..	3.54	19	105.8	52.4	39.6	46.2	36.4
May ..	2.82	20	159.8	60.1	43.6	53.7	40.3
June ..	2.84	13	173.4	66.2	50.2	61.6	48.6
July ..	3.74	17	137.2	67.1	52.0	63.3	49.0
Aug. ..	3.65	18	133.9	65.1	49.8	60.0	47.6
Sept. ..	2.44	13	106.2	59.6	45.0	55.6	42.0
Oct. ..	0.64	5	100.9	55.2	37.8	49.3	35.5
Nov. ..	2.61	17	59.8	50.5	40.0	45.1	35.5
Dec. ..	0.88	12	34.6	45.4	35.9	41.5	33.2
Total or Mean of 1931 ..	26.18	180	1269.9	54.5	40.7	49.3	37.7

FIELD EXPERIMENTS

1.—CONTINUOUS GROWING OF WHEAT AND BARLEY.

STACKYARD FIELD, 55TH YEAR.

Wheat.

"Square Head's Master" was drilled on October 2nd, 1930, after dressing with "Corvusine," and the crop came up well. No manures were applied, the last having been put on the crop of 1925-6, after which followed two years' fallow (1927-8), wheat sowing being resumed in October, 1928. Accordingly the present is the third crop since fallowing, and the fifth since any manurial application. The harvest results are given in Table I.

Table I.—CONTINUOUS GROWING OF WHEAT, 1931
Stackyard Field—Produce per acre.

Plot.	Manures Applied Annually to 1926 (before the two years Fallow 1926-28). For amounts see Report 1927-28. No Manures in 1929, 1930 or 1931.	Dressed Corn per acre. Bushels	Total Corn per acre. Cwt.	Weight per bushel. lb.	Straw, Chaff, etc., per acre. Cwt.
1	Unmanured	2.4	1.37	58.0	7.21
2a	Sulphate of Ammonia	2.6	1.50	—	4.64
2aa	As 2a, with Lime, Jan. 1905, repeated 1909, 1910, 1911	3.6	2.14	—	6.64
2b	As 2a, with Lime, Dec. 1897	10.9	5.82	57.0	12.57
2bb	As 2b, with Lime, repeated Jan. 1905	—	1.89	—	6.00
3a	Nitrate of Soda	4.9	2.75	59.0	4.75
3b	Nitrate of Soda	4.2	2.25	56.0	3.87
4	Mineral Manures (Superphosphate and Sulphate of Potash)	6.8	3.60	55.8	9.60
5a	Mineral Manures and Sulphate of Ammonia ..	11.8	6.51	59.7	17.47
5b	As 5a, with Lime, Jan. 1905	5.7	3.14	59.0	10.51
6	Mineral Manures with Nitrate of Soda	9.2	4.86	58.6	11.53
7	Unmanured	3.3	1.73	57.0	4.17
8a	Mineral Manures and, in alternate years, Sulphate of Ammonia	5.4	2.92	58.0	8.85
8aa	As 8a, with Lime, Jan. 1905, repeated Jan. 1918	12.9	7.21	60.0	14.85
8b	Mineral Manures and Sulphate of Ammonia (omitted in alternate years)	8.1	4.34	58.0	9.60
8bb	As 8b, with Lime, Jan. 1905, repeated Jan. 1918	10.2	5.60	59.0	12.25
9a	Mineral Manures and, in alternate years, Nitrate of Soda	6.2	3.46	61.0	10.05
9b	Mineral Manures and Nitrate of Soda (omitted in alternate years)	8.9	4.89	60.0	13.07
10a	Superphosphate and Nitrate of Soda	4.8	2.54	59.0	5.20
10b	Rape Dust	5.6	3.07	59.0	4.14
11a	Sulphate of Potash and Nitrate of Soda	7.9	4.25	59.5	9.73
11b	Farmyard Manure	7.0	3.80	60.5	13.50

This season's crop may fairly be taken as representative, and the results as comparable with those of 1929, the first year after the two years' fallow. On every plot, even on 2a and 8a, known to be very acid, there was a crop of some kind, and not one that came at first and then died amidst a mass of weeds. The crop on plot 2a (sulphate of ammonia only) was 2.6 bushel per acre, the best since 1900. But in spite of the early promise, the lack of sunshine caused the grain yield to be disappointingly small in relation to the straw. The unmanured produce was 2.8 bushels per acre only, the mineral manure plot (Plot 4) gave 6.8 bushels, and the farmyard manure plot (11b) 7.0 bushels per acre respectively. These figures compare with 10 bushels, 17.8 bushels and 21.3 bushels of corn per acre, respectively, in 1929, the first year after the two years' fallowing.

The highest yield was 12.9 bushels, on Plot 8aa, which had received sulphate of ammonia with minerals and lime in earlier years, and which in 1929 had yielded only 7.9 bushels of corn per acre. Indeed, the highest yield of corn in 1931 were obtained on plots previously treated with sulphate of ammonia (2b, 5a, 8aa, 8bb), while nitrate of soda showed a distinct lowering, Plot 3a having fallen from 12.8 bushels in 1929 to 4.9 bushels, Plot 6 from 12.8 bushels to 9.2, and Plot 9a from 17 bushels to 7.5 bushels.

The yield of the farmyard manure plot has fallen from 21.3 bushels in 1929 to 7.0 bushels in 1931, a value only slightly above that from the rape dust plot. Plot 2b, which last had lime in December, 1897 and in 1929 gave a grain yield of 1.1 bushels per acre only, produced—without any further application of lime or any artificial fertiliser—no less than 10.9 bushels of corn per acre in 1931.

Mayweed and vetchling were the chief weeds. Mayweed did not thrive on the acid plots (2a, 5a, 8a), but appeared wherever lime had been applied.

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Table II.—CONTINUOUS GROWING OF BARLEY, 1931.

Stackyard Field — Produce per acre.

Plot	Manures Applied Annually to 1926. (before the two years Fallow 1926-28). For amounts see Report 1927-28. No manures in 1929 or 1930. For manures in 1931 see footnote.	Plumage. Dressed Corn per acre.	Plumage. Total Corn per acre.	Plumage. Weight per bushel.	Plumage. Straw, Chaff, etc., per acre.	Archer. Dressed Corn per acre.	Archer. Total Corn per acre.	Archer. Weight per bushel.	Archer. Straw, Chaff, etc., per acre.
		bushel.	cwt.	lb.	cwt.	bushel.	cwt.	lb.	cwt.
1	Unmanured	9.2	3.98	45.5	10.65	13.3	5.98	48.5	12.35
2a	Sulphate of Ammonia		No yield.				No yield.		
2aa	As 2a, with Lime, Mar., 1905, repeated 1909, 1910, 1912 and 1923	9.5	3.93	42.0	11.61	13.4	5.55	44.0	12.88
2b	As 2a, with Lime, Dec., 1897, repeated 1912	6.9 *	2.96	43.1 *	11.00	13.3	5.23	43.0	11.93
2bb	As 2a, with Lime, Dec., 1897, repeated Mar., 1905..	5.8 *	2.71	43.1 *	9.57	12.7	5.28	44.0	10.57
3a	Nitrate of Soda	8.0	3.78	47.0	11.78	9.2	3.71	40.0	11.50
3aa	As 3a, with Lime, Jan., 1921	10.5	4.36	44.0	10.28	14.3	6.14	46.0	9.86
3b	Nitrate of Soda	10.0	3.93	40.0	12.21	10.6	4.78	46.0	12.14
3bb	As 3b, with Lime, Jan., 1921	8.0	3.00	38.0	10.21	12.0	4.86	44.0	9.28
4a	Mineral Manures (Superphosphate and Sulphate of Potash) ..	16.0	6.68	44.3	14.21	17.7	7.68	47.0	13.61
4b	As 4a, with Lime, 1915	7.4	2.82	40.0	11.04	11.5	4.71	45.0	11.25
5a	Mineral Manures and Sulphate of Ammonia		No yield.				No yield.		
5aa	As 5a, with Lime, Mar., 1905, repeated 1916	10.5	4.28	42.0	12.00	9.5	3.43	38.0	10.78
5b	As 5a, with Lime, Dec., 1897, repeated 1912	11.3	4.37	40.5	13.43	15.5	6.72	48.0	13.54
6	Mineral Manures and Nitrate of Soda	10.7	4.12	41.6	14.25	13.1	5.27	44.0	13.11
7	Unmanured	10.3	3.86	40.5	9.73	9.8	4.18	45.5	9.14
8a	Mineral Manures and, in alternate years, Sulphate of Ammonia ..		No yield.				No yield.		
8aa	As 8a, with Lime, Dec., 1897, repeated 1912	23.5	10.29	47.0	19.43	21.4	9.93	50.0	17.28
8b	Mineral Manures and Sulphate of Ammonia (omitted in alternate years)		No yield.				No yield.		
8bb	As 8b, with Lime, Dec., 1897, repeated 1912	32.0	13.28	45.0	22.27	32.0	14.43	50.0	24.28
9a	Mineral Manures and, in alternate years, Nitrate of Soda ..	28.8	11.99	45.6	23.46	27.9	11.49	45.6	22.32
9b	Mineral Manures and Nitrate of Soda (omitted in alternate years)	25.8	10.31	43.5	22.00	24.1	10.07	46.2	21.95
10a	Superphosphate and Nitrate of Soda..	24.6	10.54	46.7	18.12	29.7	13.47	50.0	20.49
10b	Rape Dust	5.9	2.36	43.0	9.48	5.7	2.51	48.0	8.72
11a	Sulphate of Potash and Nitrate of Soda	21.6	8.73	43.5	19.73	29.0	12.11	45.8	22.32
11b	Farmyard Manure	19.8	7.92	42.8	21.28	24.3	10.04	44.5	22.11

* Estimated.

Manuring in 1931.

Plots—	Quantity per acre.
1-7	Unmanured.
8a, 8b, 8aa, 8bb.	3 cwt. Superphosphate, 1½ cwt. Sulphate of Potash, 1¾ cwt.Sulphate of Ammonia.
9a, 9b	3 cwt. Superphosphate, 1½ cwt. Sulphate of Potash, 2.28 cwt. Nitrate of Soda.
10a.	3 cwt. Superphosphate, 2.36 cwt. Nitrate of Soda.
10b.	Unmanured.
11a	1½ cwt. Sulphate of Potash, 2.36 cwt. Nitrate of Soda.

Barley

Two different varieties, " Plumage " and " Archer " were sown on all the plots in alternate longitudinal strips, each from 5 to 10 rows wide, according to the width of the plots ; and, in addition, Plots 8, 9, 10a, 11a were remanured but not relimed in order to see the relative influence of certain manures on the two varieties. The manures supplied were :

Plot.	Ammonia per acre.		Superphosphate per acre.		Sulphate of Potash per acre.	
	1926 and before	1931	1926 and before	1931	1926 and before	1931
	lb.	lb.	cwt.	cwt.	cwt.	cwt.
8—Sulphate of Ammonia and Minerals ..	50	50	3	3	½	1½
9—Nitrate of Soda & Minerals	50	50	3	3	½	1½
10a–Super and Nitrate of Soda	25	50	3	3	—	—
11a–Sulphate of Potash and Nitrate of Soda	25	50	—	—	1	1½

The seed was drilled on March 19th. A furrow along certain plots, the result of ordinary instead of the usual one-way ploughing, caused some unevenness of germination and growth.

Spurry was very thick on Plot 2a (sulphate of ammonia alone), but where lime had been used (2b, 2bb, 5aa, 5b, 8aa, 8bb) with sulphate of ammonia, the barley continued to thrive. The farmyard manure plot (11b) was quite fair, but the crop on 10b (rape dust) failed almost entirely. As the season progressed, the barley did not seem to thrive as well as the adjoining wheat crop, and Plots 2a, 5a, 8a and 8b (all unlimed) carried little more than spurry. On the plots (4a, 4b) which had had minerals only but no nitrogen, the crop on the unlimed half (4a) was decidedly superior to that on the limed portion (4b), this being the reverse of what had been noted before. The results are given in Table II. Since fallowing, the drop in yield is shown by the following returns :

	1929. bushels.	1930. bushels.	1931. bushels.
No Manure	20.3	12.8	10.7
Minerals only	23	14	16.9
Treatment prior to 1926 (¹)			
Sulphate of Ammonia with lime ..	24.9	15.0	10.1
Sulphate of Ammonia with lime and minerals	24.2	18.1	13.4
Nitrate of Soda alone	33.4	14.6	8.6
Nitrate of Soda with minerals	30.6	18.3	11.9
Farmyard Manure	34.7	21.7	22.1

(¹) After 1926 there have been two years of fallow and then the crops have been grown without manure.

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The two varieties behaved rather differently. During the period of growth, " Archer " appeared to be the more delicate and more affected by the weather, yet on the fully-manured plot (9) it gave the same yield as Plumage, and on the plots deficient in potash, phosphate or nitrogen, it gave higher yields. The results were :

Plot.		Yield, lb. per acre.		Plumage as Percentage of Archer.
		Plumage.	Archer.	
Fully manured	9	1249	1208	103.4
No manure	1	446	670	66.6
No Nitrogen	4a	748	860	87.0
No Phosphate	11a	978	1356	72.1
No Potash	10a	1180	1509	78.2
Very acid plots	8a & b, 2a, 5a	no grain	no grain	—
Rather acid plots	2 & 5b	391	638	61.3
Only faintly acid plot	3	422	546	77.3

A curious result was obtained, however, on the plots which had formerly received nitrate of soda and were therefore less acid than the rest, and had also been limed. Here the earlier additions of lime did not benefit the Plumage, though it did improve the Archer.

Lime added to very acid plots.				Lime added to slightly acid plots.			
	Plumage	Archer	Plumage as per centage of Archer		Plumage	Archer	Plumage as per centage of Archer.
Twice limed (2bb)	304	592	51.4	Unlimed (3a, 3b)	432	476	90.8
Twice limed (2b)	332	586	56.7				
Five times limed (2aa)	440	622	70.7	Limed (3aa, 3bb)	412	616	66.9

The yields of straw varied in much the same way as the yields of grain, except that nitrogen deficiency lowered the yield to approximately the same extent for both varieties.

Weeds.

Polygonum convolvulus was abundant on Plot 5a, which had had minerals, but absent from 3a, which had had none. Mayweed was much less common on the barley plots than on the wheat.

2.—ROTATION EXPERIMENTS

THE UNEXHAUSTED MANURIAL VALUE OF CAKE AND CORN (STACKYARD FIELD)

Series C.

The swede crop of 1930—about 12 tons per acre, being $1\frac{1}{4}$ tons more on the cake-fed than on the corn-fed plot—was pulled in January, 1931, and fed off by 40 sheep.

" Plumage Archer " barley, at the rate of 3 bushels per acre, was drilled on March 16th, on the land ready earliest, and over the

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remainder on April 8th. Despite the late sowing, the barley came up well. Meantime, alsike clover had been undersown, to form the crop of 1932, and grew very well. The barley crop was cut on August 24th, and the results are given in Table III.

Table III.—BARLEY AFTER SWEDES.

Produce per acre.

Plot.	Nitrogen in corn or cake, per cent.	Nitrogen supplied by corn or cake, lb. per acre.	*Head Corn.* Bush.	Weight per Bushel. lb.	Tail. Corn. Weight. lb.	Straw, Chaff, etc. cwt.
1. Corn-fed	1.75	30.4	28.6	51.2	19	19.8
2. Cake-fed	4.32	77.3	28.0	50.5	23	19.3

On this rotation corn and cake had been respectively fed with roots in the years 1923, 1927 and now again in 1931, but so far, without increasing the yield of barley from the cake-feeding by more than 1.3 to 2 bushels per acre.

During the feeding-off of the roots the cake plot had received more than $2\frac{1}{2}$ times as much additional nitrogen from the cake as the corn plot had received, yet the yields on the two crops are identical. In 1930 the cake plot had given 9 bushels of corn per acre more than the corn plot.

Series D

The barley crop of 1930 had been considerably laid and the undersown red clover was very patchy, very poor during the winter and dead by the end of March. It was ploughed up and alsike was sown on April 8th, but came very slowly. Tares were then drilled in—3 bushels of seed per acre—on May 28th, and came up moderately well mixed with alsike ; the crop, cut on September 29th, yielded :

	Tares—as Hay *—per acre. cwt.
Corn-fed plot	15.9
Cake-fed plot	13.9

* Reckoned on a basis of 15% moisture.

The land was ploughed after removal of the hay crop and put into wheat.

3.—GREEN CROP AND GREEN MANURING EXPERIMENTS

(a) *Stackyard Field—Series A*

Upper half. 1931. Wheat after Green Crops fed off by Sheep.

In 1930 it was found possible to grow and to feed off two crops. The sheep had also received $\frac{3}{4}$ cwt. of cotton cake per acre, while feeding on each crop. "Red Standard" wheat, at the rate of 3 bushels per acre, was drilled on October 18th ; it came up well, and, as usual at this early period, looked as well as any wheat on the farm ; in contradistinction to the usual experience, it did not fall away in May, and also the wheat after tares looked better than that after mustard. The crop was cut August 18-19. The results are given in Table IV.

Table IV.—WHEAT AFTER GREEN-CROPS, FED OFF BY SHEEP. Produce per acre, 1931.

Plot.	*Head Corn.* No. of Bushels.	*Head Corn.* Weight per Bushel. lb.	Tail Corn. lb	Straw, Chaff, etc. Cwt.
1. After Tares fed off (unlimed)	10.5	60.0	5½	12.0
2. After Tares fed off (limed)	8.7	59.7	9	9.1
3. After Mustard fed off (unlimed)	8.7	60.0	7	7.3
4. After Mustard fed off (limed)	8.6	58.4	8¾	7.3

Lower Half

After ploughing up the wheat stubble of 1930, the land was cultivated during the winter, and a good deal of twitch removed. Tares (3 bushels per acre) were drilled on May 7th and mustard (30 lb. per acre) on May 26th—both lots coming up well. They were fed off by sheep with mixed linseed and cotton cake (1½ cwt. per acre of the cake giving 4.74 per cent. of nitrogen). The land was then ploughed and second green-crops were drilled on August 17th, these being likewise fed off and the land prepared for wheat. The second green crops did not grow well, owing to the want of warmth ; consequently only ½ cwt. per acre of mixed cake was given to the sheep.

Table V gives the respective weights of green and dry matter and of nitrogen from the green-crops grown.

Table V.—GREEN MANURING EXPERIMENT, Stackyard Field (Lower Half), 1931.

Plots.	*First Crop.* Green Matter per acre. lb.	Dry Matter per acre. lb.	Nitrogen per cent.	Nitrogen per acre. lb.	*Second Crop.* Green Matter per acre. lb.	Dry Matter per acre. lb.	Nitrogen per cent.	Nitrogen per acre. lb.	*Total.* Green Matter per acre. lb.	Dry Matter per acre. lb.	Total Nitrogen, peracre lb.
Tares (unlimed)	6831	1238	3.79	46.3	582	109	4.69	5.1	7413	1347	51.4
Tares (limed)	14437	2151		80.4	825	155		7.3	15262	2306	87.7
Mustard (unlimed)	4000	842	2.10	17.7	1005	178	3.69	6.6	5005	1020	24.3
Mustard (limed)	3587	765		16.1	918	162		6.0	4505	927	22.1

(b) *Lansome Piece. Green-crops ploughed in.*

Here, as in Stackyard Field, it had been possible in 1930 to grow and plough down two successive green-crops before drilling "Red Standard" wheat at the rate of 3 bushels per acre, on October 17th. This came up well and the land was kept very fairly clean throughout the season. The newer series looked rather better than the old, and the tares plot somewhat better than the mustard plot. The results are given in Table VI.

Table VI.—GREEN MANURING EXPERIMENT, Lansome Piece, 1931. WHEAT AFTER GREEN CROPS PLOUGHED IN.

Produce per acre.

Plot.	*Head Corn.*		Tail Corn. lb.	Straw, Chaff, etc. cwt.
	Bushels per acre.	Weight per Bushel. lb.		
1. Mustard plot : old series..	9.8	58.5	3	10.1
2. Tares plot : old series ..	14.1	56.5	4	16.2
3. Mustard plot : new series	13.0	56.2	15	14.6
4. Tares plot : new series ..	12.4	53.4	22	22.2
5. Control : new series (weeds only)	9.1	58.3	2	10.9

The yield of straw from the tares plots exceeds that from the mustard.

4.—PERMANENT PASTURE, MANURIAL EXPERIMENT. BROAD MEAD

The five plots in Broad Mead comprising this series were grazed in 1931, no further manurial application being given. All the plots improved considerably through the closer grazing of them with both cattle and sheep, but the finest and best grazed plot was, however, undoubtedly Plot 4 (limed), which again was characterised by the presence of many daisies ; these occur only sparsely on the other plots.

5.—FORAGE CROPS, LANSOME FIELD

Mixtures of wheat and beans did well together, and the crops stood up well, except that when tares were used along with wheat, they had the effect of throwing the wheat down.

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The sowing down of the poorest parts of the farm to grass, commenced the previous year, has now been completed. In April, 1931 Road Piece and Great Hill were sown down under barley. The wet season caused this to grow rankly, and in a few of the low-lying parts of the field it was badly lodged. The grain yields were considerably lower than the appearance of the crop had indicated, and delays arose through wet weather and the demands of the experimental plots.

The following mixtures were sown :

No. 1. 25 lb. Provence Lucerne (per acre).
 1 ,, Kentish Wild White Clover.

No. 2. 25 ,, Provence Lucerne.
 1 ,, Perennial Birdsfoot Trefoil.
 1 ,, Wild Trefoil.

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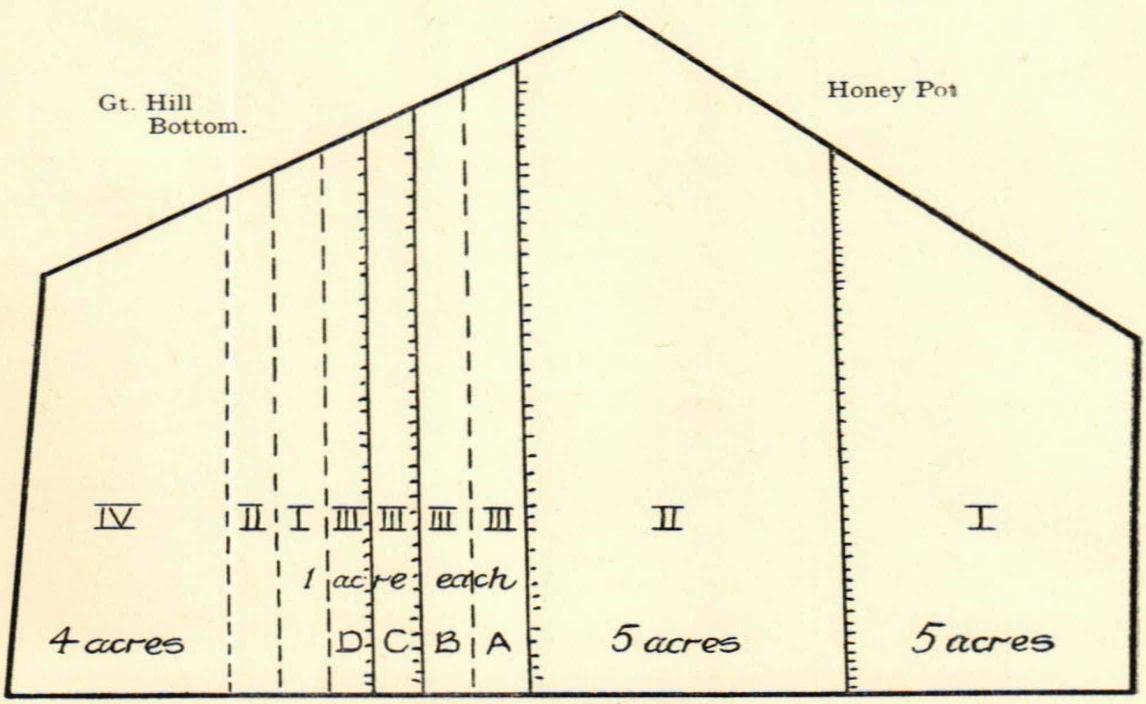
No. 3.
(A) 12½ lb. Provence Lucerne.
15 ,, Kentish Indigenous Perennial Ryegrass.
1 ,, Kentish Wild White Clover.
(B) As (A), with Grimm Lucerne instead of Provence.
(C) As (A), with cultivated Wild White Clover instead of Kentish.
(D) As (B), with cultivated Wild White Clover instead of Kentish.

No. 4. 7 lb. Provence Lucerne.
12 ,, Kentish Indigenous Perennial Ryegrass.
5 ,, English Grazing Cocksfoot.
2 ,, Kidney Vetch.
1 ,, Cultivated Wild White Clover.

The division between Road Piece and Great Hill has now been re-arranged by grubbing up the old boundary hedge, and erecting a fence at right angles to the Ridgmont Road, this fence dividing the whole 20 acres into two equal areas. The following diagram indicates the relative positions of the different mixtures :



The shading indicates narrow, uninoculated strips, all the rest being inoculated. In the 5 acres of Mixture No. 1 were placed a few small plots of different varieties of lucerne, but the barley above them lodged, and near Honey Pot the young seeds were rather thin and were therefore patched in April, 1932, about 4 acres being done there and on one or two other portions of the field. The estate is now

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laying water on to this new grass, to the portion of Road Piece sown down in 1928 and to the 3 acres of Butt Furlong sown in 1930.

The details of the cropping are given on pp. 103-6. Three acres of Brussels sprouts were grown in Butt Close in the hope that we might sell some as well as having the tops for the sheep, but prices were so low that the whole was fed to the animals.

As at Rothamsted, we found that spring oats did considerably better than winter oats in 1930-31; they were, however, sown early under favourable conditions of soil and fertility.

In the spring the Estate carried out their periodical repairs to the farm buildings, and took the opportunity of effecting several notable improvements, extending and improving the accommodation for pigs, putting more windows in the roofs and reconstructing the boundaries of the covered yards. All this has greatly improved the appearance and utility of the buildings.

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, WOBURN, 1931

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring, cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
I.—Arable and Replicated Experiments—								
Warren Field (1)	Oats	Grey Winter	Oct. 15-17, 1930, plough and tractor cultivate.	5 I.C.I. No. 7	Oct. 20	Aug. 25	Sept. 20	13 cwt.
(2)	Oats	Garton's Marvellous	Nov. 15, 1930, tractor plough. March 14 harrow.	5 I.C.I. No. 7	March 14	Sept. 1	Sept. 28	15 cwt.
Butt Close (1)	Brussel Sprouts	—	After rye, grazed & ploughed in. May 16-June 6, plough and roll. July 6, horse hoe. Hand hoe throughout summer.	2 N/Soda, 20 tons dung in spring (after 1 N/S top dressing on rye, Feb.)	July 1-4 (planted)	Used during winter		—
(2)	Kale	Thousand Head	After rye, grazed and plough in. July 1 plough and roll. July 9 harrow, roll, drill and harrow. Aug. 11 and Sept. 4 horse hoe.	Do. Do.	July 9	Kept for spring use		—
Butt Furlong (1)	Sugar Beet	Kuhn	Feb. 21 sow 1 ton Carbonate of lime per acre. March 26 plough. March 31 harrowed and rolled. April 17 simared and harrowed. April 23 harrowed. May 6 rolled. June 3-July 11 horse and hand hoed.	see p. 162	May 8	—	Nov. 4-18 (lifted)	see p. 163-5
(2)	Sugar Beet (Micro-plot Expt.)	Kuhn	Feb. 21 sow 1 ton Carbonate of Lime per acre. March 26 plough. March 31 twice harrow and roll. May 6 horse rolled. May 7 and 8 hoed and rolled by hand. June 1 hand hoed.	see p. 160	May 9	—	Nov. 23 (lifted)	see p. 160-1
(3)	Seeds Hay	It. Ryegrass B. Red Clover	Feb. 21. Sow 1 ton carbonate of lime per acre.	5 I.C.I. No. 7	Mar. 19, 1930	June 13	June 22	2 tons

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DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, WOBURN, 1931 (*Continued*)

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring, cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
Road Piece	Barley (undersown)	Plumage Archer	Feb. 26-March 13 spread lime. March 25-31 plough. April 10 harrow and drill. May 3 Cambridge roll. April 28-30 sow grass seeds.	2 Pot. Salt, 2 Super., 2 I.C.I. No. 7 2 tons burnt lime*	April 10	Aug. 18-22	Sept. 20-28	12 cwt.
Great Hill	Barley (undersown)	Plumage Archer	Feb. 11-14 plough in beet tops. March 25 Cambridge roll and harrow. May 2 roll. April 28-30 sow grass seeds.	2 Pot. Salt, 2 Super, 2 I.C.I. No. 7 2 tons burnt lime*	March 31	Aug. 28	Sept. 20-21	12 cwt.
Lansome Piece (1)	Forage Mixture	—	Oct. 11-13, 1930 plough. Oct. 17, 1930 drill and harrow. Jan. 9 resow and harrow.	5 I.C.I. No. 7	Oct. 17 and Jan. 9	June 28	July 17	42 cwt. (as hay)
(2)	Oats	Grey Winter	Oct. 11-15, 1930 plough. Oct. 22, 1930 drill and harrow. April 13-14 Cambridge roll.	5 I.C.I. No. 7	Oct. 22	Aug. 12	Sept. 10	Badly laid Used un-threshed
II.—Classical and Rotation Experiments— Stackyard Field	Permanent Wheat	Squarehead's Master	Sept. 17, plough. Oct. 2 harrow. March 19-20 Cambridge roll. May 20-June 2. Hand hoe.	see p. 93	Oct. 2	Aug. 20	Aug. 28 (threshed)	see p. 94
	Permanent Barley	Plumage, and Archer	Dec. 22-29 plough. March 16 cultivate, March 18 harrow and roll. March 19-23 Cambridge roll. June 2-3 hand hoe.	see p. 96	March 18	Aug. 24	Aug. 31 (threshed)	see p. 95
Series A (*a*) (1)	Tares	Garton's Baltic	Oct 23 gather and burn twitch. Oct. 24, 1930 cultivate. March 12 plough. March 14-18 cultivate. April 1 double harrow and cultivate. May 7 drill and harrow. July 20-Aug. 13 eat off with 26 sheep receiving 1½ cwt. mixed cake (cotton and linseed). Aug. 13 and 14 plough and harrow. Oct. 9-12, 1930 eat off with sheep, receiving 1½ cwt. mixed cake.	1 S/Pot. 3 Super.	May 7 (resow) Aug. 18	—	—	—

* Applied before 1930 Sugar Beet, but omitted from last Report.

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DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, WOBURN, 1931 (*Continued*)

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring, cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
(2)	Mustard		Cultivations same as Tares.	1 S/Pot. 3 Super.	May 26 Aug. 18	—	—	—
Series A (*b*)	Wheat	Red Standard	After green crop fed off, Oct. 13-15, 1930 plough. Oct. 18, 1930 double harrow. March 19 Cambridge roll. June 4 cut out thistles. June 22-July 10 pull poppies.	—	Oct. 18, 1930	Aug. 18	Aug. 26 (threshed)	see p. 99
6 Course Rotation—	Vetches (after clover failure)	Garton's Baltic	Clover sown in barley 1930. April 1 clover ploughed in after severe pheasant damage. April 8 sow 16 lbs. Alsike. April 14 Cambridge roll. May 27 cross cultivate and roll (sow vetches). July 8 horse hoe. July 10 hand hoe.	see p. 138	May 27	Sept. 9	Sept. 9 (green)	see p. 139
	Sugar Beet	Kuhn	Dec. 22, 1930 plough. May 6 cross cultivate. May 7 sow manures flat roll, July 2 hand hoe. Aug. 10 hand hoe.	see p. 138	May 7	—	Oct. 29 31 (lifted)	see p. 139
	Barley	Plumage Archer	After sugar beet. Dec. 20, 1930 plough in tops. March 17 harrow. March 18 Cambridge roll. May 5 hand hoe. May 7 undersown with Alsike and roll.	see p. 138	March 18	Aug. 21	Aug. 29 (threshed)	see p. 139
	Wheat	Yeoman II	Sept. 20, 1930 plough. Oct. 15-16 1930 plough. May 9-12 hand hoe.	see p. 138	Oct. 18	Aug. 18	Aug. 28 (threshed)	see p. 138
	Forage	—	Oct. 15-16, 1930 plough. Oct. 18, 1930 harrow. May 9-12 hand hoe. June 22 one way plough. June 25 double harrow. July 7 Cambridge roll. Aug. 18-20 plough in mustard. Sept. 19 harrow.	see p. 138	Forage Mixt., Oct. 18. Mustard June 25. Rye Sept. 19	June 15	June 19	see p. 138
	Potatoes	Ally	April 1 plough. April 28 double harrow and ridge. June 4 harrow and ridge up.	see p. 138	May 1	—	Sept. 30 (lifted)	see p. 138

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, WOBURN, 1931 (*Continued*)

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring, cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
Series C	Barley	Plumage Archer	After swedes fed off. March 6 plough half. March 16 harrow. March 31 plough other half. April 8 harrow. May 11 flat roll.	—	March 16 first half. April 8 second half.	Aug. 25	Oct. 1	see p. 98
Series D	Vetches (after clover failure)	Garton's Baltic	Broad red clover sown March 27, 1930. Failed during winter, March 16-17 tractor plough. Alsike sown April 8, but came too slowly, so land was cultivated and harrowed and sown with vetches.	—	May 8 Alsike May 27-28	Aug. 27-28	Sept. 29	see p. 98
Lansome Piece	Wheat (after green manuring)	Red Standard	Oct. 7-8 plough. Oct 17 harrow in.	—	Oct. 17	Aug. 12	Aug. 25	see p. 100
III. Grassland–								
Butt Furlong	Grazing	—	—	2 I.C.I. No. 7	—	—	—	—
Warren Field	Grazing	—	—	2 tons lime, 1 N/Soda, 2 M/Potash	—	—	—	—
Broad Mead								
(1)	Grazing	—	Feb. 14 chain harrow and apply first dressing of N/Soda. Follow with remaining 6 sections at weekly intervals. Second application of N/Soda commenced June 10, and went on at weekly intervals, omitting Honey Pot.	1 N/Soda, 1st dressing 1 N/Soda, 2nd dressing	—	June 28 (plot 4)	July 23-24	25 cwt.
(2)	Grazing	—						
(3)	Grazing	—						
(4)	Grazing, then hay	—						
Honey Pot (5)	Grazing	—						
Gt. Hill Bottom (6)	Grazing	—						
(7)	Grazing	—	—	—	—	—	—	—
Long Mead	Grazing	—	—	—	—	—	—	—
Mill Dam Close	Grazing	—	—	—	—	—	—	—

YIELDS OF EXPERIMENTAL PLOTS 1931

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THE USE OF THE SUMMARY TABLES

The summaries of the significant results from the replicated experiments, whether these are stated as produce per acre or as a percentage of the average yield, are accompanied by estimates of the standard errors to which these results are liable. The agricultural precautions which have to be taken in order that these shall be certainly valid were explained in the Report for 1925-26. An explanation of their purpose is desirable here in order that a full use of the summaries may be made by those who do not wish to make for themselves a detailed examination of the yields recorded for individual plots.

An experimental yield will differ from its true value either in excess or deficit by an amount exceeding its standard error almost as frequently as once in 3 trials ; it will, however, be wrong by more than twice its standard error only about once in 22 trials, and by more than three or four times its standard error once in 370 or 15,780 trials respectively. The odds against an error of any size having occurred thus increase very rapidly in a small range of multiples of the standard error. Whereas experimental differences of less than twice their standard error might always be ascribed to chance, and are, therefore, for safety, ignored as "insignificant," differences only slightly greater than these, in contrasts which the experiment was designed to examine cannot reasonably be disregarded, but must be ascribed to genuine manurial or cultural effects.

The rejection of the insignificant differences is thus a necessary preliminary, but only a preliminary, to the interpretation of the experimental results. All significant results are noted, and so far as has been practicable, exhibited in the summaries of results. In the more successful and extensive experiments the standard error has been reduced to a very low figure, so that quite small differences in yields can be detected, whereas with a larger standard error, all but big and obvious differences in yield must be ignored. The change in precision from standard errors of 5 per cent. to standard errors of 2 per cent. thus represents a very large extension in the range of agricultural effects which can be examined experimentally.

Once an effect is shown to be definitely significant it makes little difference whether the odds against its being due to chance are 100 to 1 or 1,000,000 to 1. Chance is effectively excluded in both cases, and the interest in the result is now concentrated on the actual gain in crop, either in yield per acre or in yield per cent., which the experiment has demonstrated. The relation of this gain to any additional item of expense incurred, such as the cost of a manurial application, then determines the balance of advantage in practical procedure. Read in this way the summary tables give the direct results of critical experimentation.

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DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1931

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
I. Arable and Replicated Experiments—								
Pastures (1)	Mangolds	Yellow Globe	Jan. 26 plough, Feb. 26 horse harrow. April 15 roll. May 13, 29 and June 25 grubbed. June 2-3 side hoe. June 19-July 8 single. Hoed throughout summer.	2 S/Amm. 1 S/Potash $\frac{3}{4}$ Super.	April 14	—	Oct. 2 and 3	30 tons
(2)	Potatoes (Expt.)	Ally	Jan. 26, Mar. 4-21 plough. Mar. 28 cultivate with tractor, then roll and harrow. Mar. 30 cultivate 2nd time.	see p. 154	April 13	—	Sept. 30	see p. 154-5
(3)	Oats	Marvellous	Jan. 26 plough, Feb. 26 horse harrow. Feb. 27 harrow in.	—	Feb. 27	Aug. 18	Sept. 9	14 cwt.
(4)	Beans and Barley		Jan. 26 plough. Feb. 26 horse harrow. Feb. 27 harrow in.	—	Feb. 27	Aug. 21	Sept. 10	23 cwt.
(5)	Kale		June 27 plough in spring oats near gate. Work down and harrow in with tractor. Folded off in Sept.	1 S/Amm.	June 27	—	—	—
Gt. Harpenden (1)	Winter Oats	Grey Winter	Sept. 23, 1930, plough. Oct. 7 tractor harrow and harrow in oats. Mar. 23-25 harrow. April 24 sow N/Soda.	3 Super. 3 Potash Salt $\frac{3}{4}$ N/Soda late spring.	Oct. 6-7	Aug. 7	Aug. 24 and 25	18 cwt.
(2)	Wheat Varieties	Wilhelmina Swedish Iron Victor	Sept. 23, 1930, plough. Oct. 7 tractor harrow. Oct. 14-15 harrow in. April 24 sow N/Soda.	3 Super. 3 Potash Salt $\frac{3}{4}$ N/Soda late spring.	Oct. 14-15	Aug. 21	Aug. 24 and 25	17 cwt. (W) 19 ,, (S) 18 ,, (V)
(3)	Spring Oats (Expt.)	Marvellous, Victory and Golden Rain	Dec. 29, 1930-Jan. 12 horse plough. Feb. 25 horse harrow and then harrow in. Mar. 19 sow N/Soda.	3 Super. 3 Potash Salt $\frac{3}{4}$ N/Soda early spring.	Feb. 25	Aug. 17	Sept. 7	see p. 143-4

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DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1931 (*Cont.*)

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
Gt. Harpenden (*cont.*) (4)	Rye	—	Sept. 22, 1930, plough. Oct. 7 tractor harrow. Oct. 14-15 harrow in. April 24 sow N/Soda. All undersown trefoil (5 lb.) and Western Wolths Ryegrass (20 lb.) on April 15. April 17-24 horse harrow.	3 Super. 3 Potash Salt $\frac{3}{4}$ N/Soda late spring.	Oct. 14-15	Aug. 7	Aug. 24 and 25	18 cwt.
(5)	Sugar Beet (Expt.)	Kuhn	Mar. 17 plough in dung with horses, harrow after with tooth harrows. May 1 harrow and roll. Hand dig the plots marked for this treatment. May 8 cultivate with Duotrac implements, harrow and roll. June 15-July 9 hand hoe.	see p. 157	May 8 and 9	—	Nov. 3	see p. 157-9
Little Hoos (1)	Wheat (Cultivation Expt.)	Million	Oct. 3-10, 1930, cultivate. April 1 harrow and roll.	see p. 148	Oct. 10	Aug. 24	Sept. 9-11	see p. 148-9
(2)	Wheat (Top Dressing Expt.)	Million	Sept. 18, 1930, tractor plough. Oct. 10, tooth-harrow twice. Mar. 26 roll.	see p. 145	Oct. 10	Aug. 19-22	Sept. 7-9	see p. 145-6
(3)	Forage (Expt.)	Oats, Wheat, Vetches, Peas and Beans	Sept. 18-23, 1930, horse plough. Oct. 10-11 horse drag and disc harrow. Mar. 26 tooth-harrow and roll.	see p. 150	Oct. 9-11	July 9-14	Sept. 11-17	see p. 151-3
Pennell's Piece	Spring Oats	Marvellous	Jan. 13 plough. Feb. 26 horse harrow before and after drilling.	—	Feb. 26	Aug. 20	Sept. 10	24 cwt.
Great Knott	Beans	Winter	Sept. 10-22, 1930, plough. Oct. 1 harrow in. Horse and hand hoe Feb.-June.	3 Potash Salt 3 Super.	Oct. 1	Aug. 10-12	Sept. 8-12	26 cwt.
Long Hoos (I)	Kale (after Rye for sheep)	Marrow-stem and Thousand-headed	Sept. 1930 cart dung and plough in. Sept. 26 sow rye. Eaten by sheep April-May. May 21-June 12 several times tractor plough and cultivate. Aug. 4 horse hoe.	15 tons dung for rye. 2 N/Soda.	June 13	Sheep folded and Feb	January ruary	16-18 tons
(II and III)	Linseed (after Rye for sheep)	Argentine ?	April 30-May 6 plough and cultivate. May 7 roll and harrow.	15 tons dung for rye. 1 S/Amm.	May 7	Sept. 16-19	Oct. 7	$10\frac{1}{2}$ cwt.

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1931 (*Cont.*)

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring, cwt. per Acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
Long Hoos (V) (*cont.*)	Temporary Ley (Expt.)	—	April 11 roll. June 16-18 plough with horses, plots that had one crop only.	see p. 141	April 11	July 2, 1st crop Aug. 27, 2nd crop	July 3, 1st crop, for silage Sept. 21, 2nd crop, for hay	see p. 141
(VI)	Maize after Rye	Giant Horse Tooth	May 20-21 tractor plough. May 30 harrow, then roll. Harrow in. June 1 roll. July 22-Sept. 1 hand and horse hoe.	2 S/Amm.	May 30	Sept. for cows	—	—
(VII)	Rape Kale (after Rye)	—	July 25 harrow. July 27-30 carting and spreading dung. Aug. 1 harrow and roll. Sept. 14-15 horse hoe.	20 tons dung.	Aug. 1	—	—	—
Fosters	Barley (Expt. undersown for ley)	Plumage Archer	Mar. 19-21 horse plough. Mar. 23 harrow twice. Mar. 24 harrow in Mar. 27 horse roll.	see p. 142	Mar. 23 barley April 23 the rest	Aug. 27	Sept. 14	see p. 142
	Forage (Expt.)	—	July 8-11 plough. July 16 tractor cultivate. July 20-21 harrow. July 25 harrow in all seeds.	3 Super. 2 Potash Salt 3 S/Amm.	July 22-24	Nov. 17 and 18	Nov. 18 and 19	Expt. still in progress
	Seeds Hay	16lb. Ital. Rye Grass 12lb. Broad Red Clover	Dec. 3-4 sow manure. Mar. 4, 1st application of N/Soda. Apr. 25 2nd application of N/Soda. Apr. 7 horse roll.	2½ Super. 3 Potash Salt (30%). 2 N/Soda.	April 11, 1930	(1) June 11-12 for silage June 16 for Hay (2) Aug. 26	June 12-13 June 22-23 Sept. 21	40 cwt. (10 acr.) 20 cwt. (4 acr.)
II. Grass Land—								
Little Knott (1)	Grazing	—	—	—	—	—	—	—
(2)	Grazing	—	—	—	—	—	—	—
(3)	Grass for silage	—	—	—	—	June 23	June 24	—
Foster's Corner	Grazing	—	—	3 Potash Salt (winter)	—	—	—	—

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1931 (*Cont.*)

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
Great Knott (1)	Grazing then hay	—	June 27 turn hay.	—	—	June 20-22	June 29	15 cwt.
(2)	Grazing	—	June 20-22 topped with tractor mower.	—	—	—	—	—
Great Field	Grazing	—	Mar. 14 horse roll. June 9 topped section 2 with horse mower. July 13 topped section 1 with tractor mower.	3½ Potash Salt (winter)	—	—	—	—
New Zealand	Grazing	—	June 21 topped with tractor mower.	—	—	—	—	—
Stackyard	Grazing	—	June 19 topped with tractor mower.	—	—	—	—	—
West Barnfield (1)	Grazing	—	July 21 topped with tractor mower.	3 Potash Salt (winter)	—	—	—	—
(2)	Grazing	—	July 21 topped with tractor mower.	3 Potash Salt (winter)	—	—	—	—
Sawyers (1)	Grazing, then hay	—	Feb. 12-13 sow N/Soda. Jun. 19 tractor topped.	1 N/Soda.	—	June 29	July 6-8	20 cwt.
(2)	Grazing, then hay	—	Dec. 9-15, 1930, Super. and Potash Salt applied. June 30-31 topped with tractor mower.	3 Super. 3 Potash Salt	—	July 1	July 9-11	20 cwt.
(3)	Hay, after early grazing	—	Dec. 9-15 Super. and Potash Salt applied. Feb. 12 N/Soda applied. May 10 closed for hay.	2¾ Super. 2 Potash Salt 1 N/Soda (spring)	—	June 26	July 3	30 cwt.
Gt. Harpenden	Grazing	—	Mid July topped with tractor mower. Then put up for crop of wild white clover seed, but weather prevented, so made into ordinary hay.	—	—	Sept. 16-21 (cut with tractor)	—	20 cwt.
III. Classical and Rotation Experiments— Broadbalk	Wheat	Red Standard	Aug. 30 and Sept. 1, 1930, tractor cultivate. Oct. 2-7 tractor plough. Oct. 15 tractor drawing disc harrows followed by drag harrow. Oct. 16 harrow in seed.	see p. 126	Oct. 16	Aug. 17 and 18	Aug. 27-29	see p. 125-6

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1931 (*Cont.*)

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring, cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
Hoos	Barley	Plumage Archer Spratt Archer	Sept. 15, 1930, cultivate. Mar. 7 plough in dung. Mar. 16 harrow all plots except 7^1 and 7^2. Mar. 18 harrow in seed. Hand and horse hoe on various dates, May 11-July 23. Rows again 18 ins. apart.	see p. 128	Mar. 17	Aug. 28 and 29	Sept. 24-25	see p. 128
Barnfield	Mangolds and Swedes	(M) Prize Winner Yellow Globe (S) Purple Top	Nov. 17-19, 1930, steam plough. Mar. 26 and 27 cultivate across. April 15 cultivate for seed bed. May 21 preparing land for re-sowing. July to Aug. horse and hand hoe.	see p. 120	April 15-17 Mangolds (Resown with Mangolds and Swedes May 26)	—	Oct. 19-28	see p. 120-1
Agdell	Wheat	Red Standard	Oct. 14 and 15, 1930, tractor plough. Oct. 31 disc harrow.	see p. 118	Oct. 31 and Nov. 1	Aug. 24	Aug. 26	see p. 118
Park	Hay	—	Mar. 28 drag harrow. Mar. 30 horse roll.	see p. 122	—	June 25-27 (1st crop) Nov. 10-13 (2nd crop)	June 30 and July 1 Nov. 13	see p. 122
Gt. Hoos 4 Course Rotation	Wheat	Yeoman	Aug. 5 and Oct. 29, 1930 plough Oct. 30 harrow before and after sowing seed. April 1 roll.	see p. 132	Oct. 30	Aug. 27	Sept. 7	see p. 133
	Swedes	Garton's Magnificent	Dec. 8-9, 1930, plough. May 8-9 plough and harrow after. May 20 harrow and roll. June 26 and Sept. 15 horse hoe.	see p. 132	May 20	—	Nov. 6-17	see p. 133
	Seeds	Italian Rye Grass, Dutch White Clover, Alsike Clover	April 1, roll.	see p. 132	April 22	June 24	June 24	see p. 133
	Barley	Plumage Archer	Dec. 8-10, 1930, plough. Mar. 6 harrow before and after sowing. Mar. 25 roll.	see p. 132	Mar. 6	Aug. 27	Sept. 14	see p. 134

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DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1931 (*Cont.*)

Field	Crop.	Variety.	Principal Cultivations and Dates.	Manuring, cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
Long Hoos 6 Course Rotation	Wheat	Yeoman II	Aug. 20-26, 1930, cultivate.	see p. 131	Oct. 3	Aug. 21	Aug. 27	see p. 135
	Sugar Beet	Kuhn	Aug. 20-26, 1930, cultivate. Feb. 5-May 6 plough. May 7 harrow and roll. June 26-July 27 hand and horse hoe.	see p. 131	May 9	—	Nov. 3-6	see p. 135
	Barley	Plumage Archer	Aug. 20-26, 1930 cultivate. Feb. 5-6 plough. Mar. 6 harrow before and after sowing. Mar. 26 roll	see p. 131	Mar. 6	Aug. 29	Sept. 7	see p. 135
	Clover	Broad Red	Aug. 20-26, 1930, cultivate. April 1 roll.	see p. 131	April 22	June 10	June 10	see p. 136
	Potatoes	Ally	Aug. 20-26, 1930, cultivate. Feb. 4 plough. April 11 harrow	see p. 131	April 14	—	Oct. 1	see p. 136
	Forage	Rye, Beans, Vetches, followed by Mustard	Aug. 20-26, 1930, cultivate.	see p. 131	Oct. 3	June 10	June 10	see p. 136

CROP YIELDS ON THE EXPERIMENTAL PLOTS

Notes.—In each case the year refers to the harvest, *e.g.*, Wheat 1931 means wheat harvested in 1931. In the tables, total straw includes straw, cavings and chaff. These were weighed separately prior to 1928. Since 1928 the figure given as total straw in the replicated experiments has been arrived at as the difference: total sheaf weight—weight of grain.

CONVERSION TABLE.

1 acre	=	0.405 Hectare	0.963 Feddan.
1 bushel (Imperial) ..	=	0.364 Hectolitre (36.364 litres)	0.184 Ardeb.
1 lb. (pound avoirdupois)	=	0.453 Kilogramme	1.009 Rotls.
1 cwt. (hundredweight, 112 lb.)	=	50.8 Kilogrammes	113.0 Rotls. 1.366 Maunds.
1 ton (20 cwt. or 2,240 lb.)	=	1016 Kilogrammes.	
1 metric quintal or Doppel Zentner (dz.) ..	=	100.0 Kilogrammes. 220.46 lb.	
1 bushel per acre ..	=	0.9 Hectolitre per Hectare ..	0.191 Ardeb per Feddan
1 lb. per acre ..	=	1.12 Kilogramme per Hectare	1.049 Rotls per Feddan
1 cwt. per acre ..	=	1.256 dz. per Hectare ..	117.4 Rotls per Feddan
1 ton per acre ..	=	25.12 dz. per Hectare.	
1 dz. per Hectare ..	=	0.796 cwt. per acre.	
1 kg. per Hectare ..	=	0.892 lb. per acre	

In America the Winchester bushel is used = 35.236 litres. 1 English bushel = 1.032 American bushels.

CONVERSION TABLE.—CWT. TO BUSHELS.

Crop.	Cwt. 1	2	3	4	5	10	15	20	25	30
Wheat (60 lb.) bushels ..	1.87	3.73	5.60	7.47	9.33	18.67	28.00	37.33	46.67	56.00
Barley (52 lb.) ,, ..	2.15	4.31	6.46	8.62	10.77	21.54	32.31	43.08	53.85	64.62
Oats (42 lb.) ,, ..	2.67	5.33	8.00	10.67	13.33	26.67	40.00	53.33	66.67	80.00

The yields of grain in the 1925–26 Report were given for the replicated experiments in standard bushels of 60, 52 and 42 lb. respectively.

Average Wheat Yield of Various Countries.

Country.	Mean yield per acre, 1919–28. cwt.	Country.	Mean yield per acre, 1919–28. cwt.
Great Britain..	17.5	Denmark	22.8
England	17.4	Argentine	6.6
Hertfordshire	16.4	Australia	6.4
France	10.9	Canada	8.9
Germany	14.5	United States..	7.6
Belgium	20.3	U.R.S.S. (Europe and Asia)*	5.8

Note.—Figures for Great Britain, England and Hertfordshire are taken from the Ministry of Agriculture's "Agricultural Statistics," Vols. 54-63. Other figures from "International Year Book of Agricultural Statistics," 1919–29.
*1924–28.

METEOROLOGICAL RECORDS, 1931

	Rain.		Drainage through soil.				Temperature (Mean).				
	Total Fall 1/1000th Acre Gauge.	No. of Rainy Days (0.01 inch or more) 1/1000th Acre. Gauge.	20 ins. deep.	40 ins. deep.	60 ins. deep.	Bright Sun-shine.	Max.	Min.	1 ft. in ground	Solar Max.	Grass Min.
1931.	Inches.	No.	Inches.	Inches.	Inches.	Hours.	°F.	°F.	°F.	°F.	°F.
Jan. ..	1.704	21	1.231	1.323	1.321	64.8	41.6	32.8	36.9	64.9	28.7
Feb. ..	1.870	20	1.180	1.329	1.301	65.4	42.7	32.7	37.1	81.4	29.8
Mar. ..	0.091	3	0.073	0.166	0.160	153.6	46.2	31.8	38.0	97.1	27.9
April ..	3.460	20	1.538	1.683	1.669	115.7	51.4	39.2	44.3	104.5	36.7
May ..	2.532	15	0.878	0.971	0.993	172.6	59.2	44.3	51.3	118.4	39.6
June ..	1.520	9	0.007	0.054	0.041	198.0	65.3	50.8	58.9	133.6	46.9
July ..	3.942	19	1.440	1.666	1.703	157.8	65.9	52.5	60.6	132.7	48.7
Aug. ..	3.455	17	1.609	1.681	1.662	155.6	64.1	51.3	58.7	127.8	47.8
Sept. ..	2.128	15	0.829	0.904	0.862	120.6	58.2	46.4	54.4	113.2	42.0
Oct. ..	0.664	9	0.000	0.010	0.003	118.4	54.4	40.9	49.2	101.1	35.7
Nov. ..	3.202	21	2.425	2.429	2.374	68.9	50.0	39.0	44.7	78.6	33.8
Dec. ..	1.109	12	0.643	0.696	0.662	40.5	44.6	36.2	41.1	62.9	32.3
Total or Mean	25.677	181	11.853	12.912	12.751	1431.9	53.6	41.5	47.9	101.3	37.5

RAIN AND DRAINAGE.
MONTHLY MEAN FOR 61 HARVEST YEARS, 1870-1—1930-31.

	Rain-fall.	Drainage.			Drainage % of Rainfall.			Evaporation.		
		20-in. Gauge.	40-in. Gauge.	60-in. Gauge.	20-in. Gauge.	40-in. Gauge.	60-in. Gauge.	20-in. Gauge.	40-in. Gauge.	60-in. Gauge.
	Ins.	Ins.	Ins.	Ins.	%	%	%	Ins.	Ins.	Ins.
Sept. ..	2.381	0.819	0.794	0.733	34.4	33.3	30.8	1.562	1.587	1.648
Oct. ..	3.139	1.791	1.760	1.629	57.1	56.1	51.9	1.348	1.379	1.510
Nov. ..	2.881	2.204	2.260	2.131	76.5	78.4	74.0	0.677	0.621	0.750
Dec. ..	2.871	2.451	2.553	2.437	85.4	88.9	84.9	0.420	0.318	0.434
Jan. ..	2.410	1.975	2.169	2.070	81.9	90.0	85.9	0.435	0.241	0.340
Feb. ..	2.029	1.511	1.625	1.552	74.5	80.1	76.5	0.518	0.404	0.477
March ..	1.966	1.048	1.176	1.112	53.3	59.8	56.6	0.918	0.790	0.854
April ..	2.051	0.673	0.754	0.718	32.8	36.8	35.0	1.378	1.297	1.333
May ..	2.068	0.483	0.551	0.518	23.3	26.6	25.0	1.585	1.517	1.550
June ..	2.213	0.531	0.561	0.540	24.0	25.3	24.4	1.682	1.652	1.673
July ..	2.739	0 728	0.758	0.709	26.6	27.7	25.9	2.011	1.981	2.030
Aug. ..	2.663	0.717	0.731	0.687	26.9	27.5	25.8	1.946	1.932	1.976
Year ..	29.411	14.931	15.692	14.836	50.8	53.3	50.4	14.480	13.719	14.575

Area of each gauge 1/1000th acre.

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CHEMICAL ANALYSES OF MANURES USED IN REPLICATED EXPERIMENTS, 1931

Manures.	% N.	Manures.	% P_2O_5 Total.	Soluble in water.	Soluble in Cit. Acid
Sulphate of Amm. (1)	20.8	Superphosphate (3) ..	16.7	15.9	—
Sulphate of Amm. (2)	21.0	Superphosphate (4) ..	17.0	15.4	—
Muriate of Amm. ..	26.0	Superphosphate (5) ..	16.1	—	—
Nitrate of Soda ..	15.7	Mineral Phosphate (90% through 120 mesh) ..	25.9	—	—
Cyanamide ..	20.0	Basic Slag—High Sol.	14.9	—	14.4
		Basic Slag—Low Sol. ..	15.1	—	3.5

Manures.	% K_2O	% Cl	Manures.	% N.	% P_2O_5	% K_2O
Sulphate of Potash	49.3	—	Chicken Manure ..	1.37	1.61	0.72
Muriate of Potash ..	51.4	—	Guano	12.1	10.3	2.82
Potash Manure Salts (30%) ..	31.2	—	Complete Fertiliser, I.C.I.	10.3	10.8	20.7
Agricultural Salt ..	—	56.8				

(1) Used in R.F. 1-144, R.W. 1-48, R.O. 1-72, R.B. 1-32.
(2) Used in R.P. 1-162, R.S. 1-48, W.S. 1-144.
(3) Used in R.F. 1-144.
(4) Used in R.P. 1-162, R.S. 1-48, W.S. 1-144.
(5) Used in T.H. 1-25, M.A. 1-150, H.G. 1-25, O.G. 1-25, K.G. 1-16, F.G. 1-25.

FOUR-COURSE ROTATION

Manures.	% Organic matter 1930	1931	% N. 1930	1931	% P_2O_5 1930	1931	% K_2O 1930	1931
Chaff	82.2	83.3	0.376	0.273	0.113	0.080	0.625	0.925
Dung	25.5	16.8	0.882	0.498	0.330	0.154	1.44	0.449
Adco	21.1	12.83	0.367	0.330	0.195	0.262	0.287	0.121
Superphosphate	—	—	—	—	17.4	16.7	—	—
Mineral Phosphate (90% through 120 mesh)	—	—	—	—	26.1	26.1	—	—
Muriate of Potash	—	—	—	—	—	—	52.6	51.4
Sulphate of Ammonia ..	—	—	21.2	20.8 (1) 21.0 (2)	—	—	—	—

(1) Used on all cases except swedes, treatments 4 and 5.
(2) Used for swedes treatments 4 and 5.

SIX-COURSE ROTATION

Manures.	% N. 1930	1931	% P_2O_5 1930	1931	% K_2O 1930	1931
Sulphate of Ammonia	20.9	20.8 (1) 21.0 (2)	—	—	—	—
Superphosphate ..	—	—	17.4	16.7 (1) 17.0 (2)	—	—
Muriate of Potash	—	—	—	—	51.3	51.4

(1) Used in all cases except potatoes and sugar beet at Rothamsted and Woburn.
(2) Used for potatoes and sugar beet at Rothamsted and Woburn.

CROPS GROWN IN ROTATION, AGDELL FIELD

PRODUCE PER ACRE.

Year.	Crop.		O. Unmanured since 1848. 5. Fallow.	O. 6. Clover or Beans.	M. Mineral Manure‡ No Nitrogen. 3. Fallow.	M. 4. Clover or Beans.	C. Complete Mineral and Nitrogenous Manure. 1. Fallow.	C. 2. Clover or Beans.
	Average of First Twenty-one Courses, 1848-1931.							
	Roots (Swedes) ..	cwt.*	32.0	16.1	174.0	206.5	352.0	310.0
	Barley—							
	Dressed Grain	bush.	21.6	19.8	22.7	26.6	30.3	35.0
	Total Straw†	cwt.	13.3	13.2	13.6	15.6	18.4	21.7
	Beans—							
	Dressed Grain	bush.‡‡	—	13.1	—	18.2	—	22.3
	Total Straw	cwt.	—	9.2	—	13.2	—	15.3
	Clover Hay	cwt.§	—	25.6	—	52.1	—	52.0
	Wheat—							
	Dressed Grain	bush.	23.1	21.6	26.9	29.4	27.5	29.0
	Total Straw† ..	cwt.	22.9	21.2	28.2	29.8	29.4	29.3
	Present Course (21st), 1928, 1929, 1930 and 1931.							
1928	Roots (Swedes)	cwt.	19.7	11.7	143.8	163.6	293.2	223.2
1929	Barley—							
	Dressed Grain	bush.	9.9	11.8	14.4	11.5	13.4	26.0
	Offal Grain	lb.	46.0	56.0	92.0	48.0	40.0	64.0
	Straw	lb.	516.0	750.0	765.0	1011.0	746.0	1619.0
	Total Straw†	cwt.	7.0	9.5	11.5	12.8	9.3	18.9
	Wt. of Dressed Grain per bush.	lb.	55.3	53.2	55.8	56.6	55.4	56.9
	Proportion of Total Grain to 100 of Total Straw		75.6	64.5	69.6	48.8	74.7	72.9
1930	Clover Hay (1st Crop)	cwt.	—	4.3	—	36.2	—	28.9
	(2nd ,,)	cwt.**	—	3.3	—	13.6	—	15.6
1931	Wheat—							
	Dressed Grain	bush.	5.0	8.2	3.2	5.6	0.1	2.0
	Offal Grain	lb.	60.0	122.5	94.4	61.9	5.0	285.0
	Straw	lb.	1170.0	1441.0	1748.0	3000.0	194.0	2064.0
	Total Straw†	cwt.	11.8	14.2	20.2	29.1	2.8	20.3
	Wt. of Dressed Grain per bush.	lb.	58.6	60.0	58.0	59.9	59.0††	58.2
	Proportion of Total Grain to 100 of Total Straw		26.6	38.4	12.5	12.3	3.2	17.8

* Plots 1, 3 and 5 based upon 19 courses. Plots 2, 4 and 6 based upon 18 courses.
† Includes straw, cavings and chaff.
‡ Mineral Manure: 528 lb. Superphosphate (35%); 500 lb. Sulphate of Potash; 100 lb. Sulphate of Soda; 200 lb. Sulphate of Magnesia. All per acre.
Nitrogenous Manure—206 lb. Sulphate of Ammonia and 2,000 lb. Rape Dust per acre.
Manures applied once every four years, prior to sowing of Swedes.
** Estimated hay yields, calculated from the dry matter.
†† Estimated from the remaining plots.
‡‡ Based on 8 courses.
§ Based on 13 courses.

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Wheat after Fallow (without Manure, 1851 and since).
Hoos Field, 1931.

	1931	Average 76 years 1856—1931
Dressed Grain { Yield per acre—bushels	12.99	14.20
Dressed Grain { Weight per bushel—lb.	61.1	58.7
Offal Grain per Acre—lb.	100.0	51.1
Straw per Acre—lb.	1270.0	—
Total straw per Acre—cwt.	14.5	12.5
Proportion of Total Grain to 100 of total Straw	54.9	—

MANGOLDS AND SWEDES—BARNFIELD, 1931*

Roots each year since 1856. **Mangolds each year since 1876.**

PRODUCE PER ACRE, MIXED ROOTS.

	Strip.	Wide—normal spacing 26in. (as hitherto). Narrow—spacing of 20in. Strip Manures. (Amounts stated are per acre).		1931.					50-Year Average, 1876-1928†				
				Cross Dressings.					Cross Dressings.				
				O	N	A	AC	C	O	N	A	AC	C
				None.	Nitrate of Soda (550 lb.)	Sulphate of Ammonia (412 lb.)	Sulphate of Ammonia (412 lb.) & Rape Cake	Rape Cake (2,000 lb.)	None.	Nitrate of Soda (550 lb.)	Sulphate of Ammonia (412 lb.)	Sulphate of Ammonia (412 lb.) & Rape Cake	Rape Cake (2,000 lb.)
				Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
ROOTS	1	Dung only (14 tons)	Wide	17.47	29.10	23.91	25.67	24.93	17.47	26.16	21.70	23.58	23.53
			Narrow	9.33	17.33	19.32	22.66	15.66					
	2	Dung, Superphosphate (3½ cwt.), Sulphate of Potash (500 lb.)	Wide	19.03	30.14	24.88	25.84	27.44	18.94	26.68	24.71	27.57	26.50
			Narrow	20.25	28.88	24.24	27.65	26.51					
	4	Complete Minerals: Super. and Potash as 2, Salt (200 lb.), Sulphate of Magnesia (200 lb.)	Wide	4.55	(b)21.04	15.10	27.75	20.42	4.60	(a)17.35 (b)17.81‡§	14.37	26.06	20.96
			Narrow	4.47	(a)17.16**	15.32	25.46	17.54					
	5	Superphosphate only (3½ cwt.)	Wide	3.64	17.87	12.51	12.13	13.05	4.47	14.63	6.70	9.49	10.16
			Narrow	4.67	18.76	14.60	14.89	14.38					
	6	Super. (3½ cwt.) Sulphate of Potash (500 lb.) ..	Wide	3.52	16.32	14.62	21.89	15.70	4.03	15.12	13.50	22.55	18.14
			Narrow	3.62	19.05	15.00	24.81	15.08					
	7	Super (3½ cwt.) Sulphate of Magnesia (200 lb.) & Sodium Chloride (200 lb.)	Wide	2.73	16.84	16.92	21.99	19.68	4.86	16.04	14.70	22.31	19.10
			Narrow	3.26	20.03	16.28	22.97	16.92					
	8	No Mineral	Wide	1.31	11.25	11.34	15.27	13.14	3.34	9.61	5.32	8.52	8.89
			Narrow	2.08	15.80	15.14	17.87	16.24					
	9	Sodium Chloride (200 lb.), Nit. Soda (550 lb.), Sulph. Potash (500 lb.) and Sulph. Mag. (200 lb.)	Wide	16.23	—	—	—	—	—	—	—	—	—
			Narrow	16.00	—	—	—	—					
LEAVES	1	Dung only (14 tons)	Wide	5.66	9.05	8.81	8.68	7.42	3.04	4.65	4.93	5.25	4.54
			Narrow	3.27	5.61	7.22	6.82	4.75					
	2	Dung, Superphosphate (3½ cwt.), Sulphate of Potash (500 lb.)	Wide	5.14	8.73	6.80	6.68	6.84	3.16	5.15	5.49	6.29	4.80
			Narrow	6.30	10.13	8.58	9.03	8.07					
	4	Complete Minerals: Super. and Potash as 2, Salt (200 lb.) Sulphate of Magnesia (200 lb.)	Wide	1.01	(b) 8.16	4.44	7.23	4.82	1.04	(a) 3.87 (b) 4.09‡§	2.88	5.33	3.37
			Narrow	0.95	(a) 6.67	3.96	7.80	4.34					
	5	Superphosphate only (3½ cwt.)	Wide	0.92	5.61	4.45	7.42	4.83	1.05	3.19	2.61	3.29	2.84
			Narrow	0.84	6.04	4.44	8.20	4.47					
	6	Super. (3½ cwt.) Sulphate of Potash (500 lb.)	Wide	0.83	4.85	2.94	6.63	3.85	0.93	3.04	2.81	5.20	2.87
			Narrow	0.94	5.58	3.44	7.02	3.66					
	7	Super. (3½ cwt.) Sulphate of Magnesia (200 lb.) and Sodium Chloride (200 lb.) ..	Wide	0.84	4.95	3.67	8.44	5.30	1.10	3.31	3.01	5.23	3.31
			Narrow	0.85	6.37	4.17	7.58	4.24					
	8	No Minerals	Wide	0.51	3.33	3.22	6.76	4.87	0.98	3.19	2.52	3.30	2.84
			Narrow	0.87	4.82	3.54	7.52	5.47					
	9	Sodium Chloride (200 lb.), Nit. Soda (550 lb.), Sulph. Potash (500 lb.) and Sulph. Mag. (200 lb.)	Wide	3.49	—	—	—	—	—	—	—	—	—
			Narrow	3.31	—	—	—	—					

* The first sowing of Mangolds failed. For the second sowing a mixture of Mangolds and Swedes was used.

** From 1904 onwards plot 4N has been divided, 4(a) receiving Superphosphate, Sulphate of Potash, Sulphate of Magnesia, Sodium Chloride and Nitrate of Soda, amounts as above; 4(b) receiving Superphosphate, Calcium Chloride (190 lb.), Potassium Nitrate (570 lb.), and Calcium Nitrate (100 lb.). Nitrogenous manures are applied as to one-third at time of sowing and two-thirds as top dressing at a later date, except with Rape Cake which all goes on with seed.

† Excluding 1885, when Nitrogenous fertilisers were not applied, owing to poor crop, and 1908 and 1927 when the crop was swedes.

§ 23 years only, 1904–1928. For this period the average yield of plot 4(a) was 18.11 for roots and 4.05 for leaves.

‡ Normal spacing.

MANGOLDS AND SWEDES—BARNFIELD, 1931 (*Continued*)

PERCENTAGE YIELD AND PLANT NUMBER OF MANGOLDS.

Strip.		Yield of Mangolds Expressed as Percentage of Total Yield. ROOTS. Cross Dressings.					Yield of Mangolds Expressed as Percentage of Total Yield. LEAVES. Cross Dressings.					Plant Number of Mangolds Expressed as Percentage of Total Plant Number. Cross Dressings.				
		O	N	A	AC	C	O	N	A	AC	C	O	N	A	AC	C
		None.	Nitrate of Soda (550 lb.)	Sulphate of Ammonia (412 lb.)	Sulphate of Ammonia (412 lb.) and Rape Cake	Rape Cake (2,000 lb.)	None	Nitrate of Soda (550 lb.)	Sulphate of Ammonia (412 lb.)	Sulphate of Ammonia (412 lb.) and Rape Cake.	Rape Cake (2,000 lb.)	None	Nitrate of Soda (550 lb.)	Sulphate of Ammonia (412 lb.)	Sulphate of Ammonia (412 lb.) and Rape Cake	Rape Cake (2,000 lb.)
1	Wide	95.4	97.2	91.8	89.5	96.1	97.2	97.8	94.3	92.1	97.4	96.7	97.6	95.9	96.1	97.6
	Narrow	87.7	92.9	66.6	16.3	77.6	93.4	95.4	71.8	21.4	85.5	94.2	94.8	83.6	61.9	88.3
2	Wide	99.5	97.8	94.5	96.6	99.1	99.7	98.7	96.4	97.4	99.5	98.8	99.0	97.6	98.5	99.2
	Narrow	86.7	93.3	87.7	89.0	94.8	93.3	95.7	93.1	92.0	96.7	95.9	95.9	94.8	95.0	97.0
4	Wide	56.3	89.0	72.6	84.0	84.6	75.4	80.7	84.2	88.2	89.3	84.3	94.0	86.4	90.2	90.9
	Narrow	63.8	79.6	66.2	81.3	84.4	78.9	88.9	82.4	87.7	89.2	88.4	89.5	88.0	90.7	91.5
5	Wide	57.7	76.2	39.1	45.2	57.2	76.7	83.3	56.2	52.9	68.4	87.9	90.8	81.0	81.5	85.7
	Narrow	58.3	73.5	35.6	44.0	50.7	68.5	83.5	52.4	49.5	64.2	84.7	89.0	77.6	78.6	83.3
6	Wide	38.0	90.7	50.5	63.7	85.5	65.6	95.2	68.2	74.6	90.3	78.4	93.2	80.4	85.6	91.8
	Narrow	35.2	79.5	53.8	68.2	82.6	66.2	89.8	70.1	78.3	87.5	80.0	90.7	83.2	87.1	90.5
7	Wide	48.3	76.0	53.8	64.7	78.5	76.6	85.7	68.4	65.9	84.1	82.9	89.0	82.1	83.4	90.2
	Narrow	35.1	72.8	55.7	57.4	77.4	63.2	83.9	71.7	64.9	83.5	77.2	87.8	81.6	80.9	87.8
8	Wide	41.0	49.3	21.9	21.6	43.0	69.4	65.1	41.1	33.0	59.1	75.0	75.0	69.8	73.1	80.1
	Narrow	65.5	51.7	12.8	18.7	31.6	87.7	66.1	26.5	30.1	49.8	83.4	75.6	66.3	67.3	75.9
9	Wide	57.4	—	—	—	—	83.2	—	—	—	—	81.4	—	—	—	—
	Narrow	47.1	—	—	—	—	64.6	—	—	—	—	71.7	—	—	—	—

HAY—THE PARK GRASS PLOTS

Plot.	Manuring (amounts stated are per acre).		1931. Yield of Hay per acre. 1st Crop.	2nd* Crop.	Total.	Dry Matter per acre. 1st Crop.	2nd Crop.	Total.	Plot.
			cwt.	cwt.	cwt.	lb.	lb.	lb.	
1	Single dressing (206 lb.) Sulphate of Ammonia (=43 lb. N.); (with Dung also 8 years 1856–63)	not limed	22.5	12.3	34.8	2138	1103	3241	1
		limed ..	19.8	8.8	28.6	1886	789	2675	
2	Unmanured (after Dung 8 years, 1856–63) ..	not limed	16.0	6.2	22.2	1501	559	2060	2
		limed ..	18.1	6.7	24.8	1690	601	2291	
3	Unmanured	not limed	12.1	6.1	18.2	1094	544	1638	3
		limed ..	14.5	5.4	19.9	1314	488	1802	
4-1	Superphosphate of Lime (3½ cwt.)	not limed	25.3	9.2	34.5	2442	820	3262	4-1
		limed ..	20.9	4.0	24.9	1982	357	2339	
4-2	Superphosphate of Lime (3½ cwt.) and double dressing (412 lb.) Sulphate of Ammonia (=86 lb. N.)	not limed	20.3	8.9	29.2	1897	794	2691	4-2
		limed	33.2	9.9	43.1	3250	890	4140	
5-1	(N. half) Unmanured following double dressing Amm. salts (=86 lb. N.) 1856–97	not limed	21.1	10.8	31.9	2113	968	3081	5-1
5-2	(S. half) Superphosphate (3½ cwt.) Sulphate of Potash (500 lb.); following double dressing Amm. salts (=86 lb. N.) 1856–97	not limed	24.3	11.6	35.9	2326	1040	3366	5-2
6	Complete Mineral Manure as Plot 7; following double dressing Amm. salts (=86 lb. N.) 1856–68	not limed	28.3	15.0	43.3	2776	1343	4119	6
7	Complete Mineral Manure: Super. (3½ cwt.); Sulphate of Potash (500 lb.); Sulphate of Soda (100 lb.); Sulphate of Magnesia (100 lb.) ..	not limed	31.6	13.2	44.8	2946	1185	4131	7
		limed ..	36.2	13.8	50.0	3310	1232	4542	
8	Mineral Manure without Potash	not limed	23.6	10.5	34.1	2308	943	3251	8
		limed ..	21.5	10.6	32.1	2085	951	3036	
9	Complete Mineral Manure and double dressing (412 lb.) Sulphate of Ammonia (=86 lb. N.) ..	not limed	55.9	25.9	81.8	5320	2319	7639	9
		limed ..	63.1	22.9	86.0	5992	2052	8044	
10	Mineral Manure (without Potash) and double dressing Amm. salts (=86 lb. N.)	not limed	36.6	15.8	52.4	3594	1414	5008	10
		limed ..	40.7	15.8	56.5	4110	1412	5522	
11-1	Complete Mineral Manure and treble dressing (618 lb.) Sulphate of Ammonia (129 lb. N.) ..	not limed	49.7	27.6	77.3	5849	2474	8323	11-1
		limed ..	65.1	22.0	87.1	5917	1972	7889	
11-2	As Plot 11-1 and Silicate of Soda	not limed	54.4	32.4	86.8	4798	2900	7698	11-2
		limed ..	67.7	27.3	95.0	5884	2444	8328	
12	Unmanured	not limed	17.0	6.6	23.6	1592	590	2182	12
13	Dung (14 tons) in 1905, and every fourth year since (omitted 1917), Fish Guano (6 cwt.) in 1907 and every fourth year since	not limed	51.9	21.9	73.8	4928	1966	6894	13
		limed ..	50.9	18.8	69.7	4751	1680	6431	
14	Complete Mineral Manure and double dressing (550 lb.) Nitrate of Soda (=86lb. N.) ..	not limed	56.3	23.3	79.6	5396	2088	7484	14
		limed (sun)	51.1	18.8	69.9	4961	1682	6643	
		lmd (shade)	37.5	12.1	49.6	3376	1081	4457	
15	Complete Mineral Manure as Plot 7; following double dressing Nitrate of Soda (=86 lb. N., 1858–75)	not limed	32.3	14.1	46.4	3056	1263	4319	15
		limed ..	31.6	9.5	41.1	2989	848	3837	
16	Complete Mineral Manure and Single Dressing (275 lb.) Nitrate of Soda (= 43 lb. N.)	not limed	41.7	13.0	54.7	3798	1163	4961	16
		limed	33.4	10.8	44.2	3133	965	4098	
17	Single dressing (275 lb.) Nitrate of Soda (=43lb. N.)	not limed	24.4	8.3	32.7	1749	741	2490	17
		limed ..	25.6	7.1	32.7	2376	638	3014	
18	Mineral Manure (without Super.), and double dressing Sulphate of Amm. (=86 lb. N.), 1905 and since; following Minerals and Amm. salts supplying the constituents of 1 ton of Hay, 1865–1904..	not limed	35.4	23.5	58.9	3465	2106	5571	18
		limed (6788 lb.)	49.4	17.2	66.6	4541	1540	6081	
		limed (3951 lb.)	37.3	15.9	53.2	3434	1429	4863	
19	Farmyard Dung (14 tons) in 1905 and every fourth year since (omitted in 1917), following Nitrate of Soda (=43 lb. N.) and Minerals, 1872–1904..	not limed	26.8	17.4	44.2	2530	1562	4092	19
		limed (3150 lb.)	23.6	12.1	35.7	2194	1082	3276	
		limed (570 lb.)	25.0	15.8	40.8	2292	1412	3704	
20	Farmyard Dung (14 tons) in 1905 and every fourth year since (omitted in 1917); each intervening year Plot 20 receives Sulphate of Potash (100 lb.); Superphosphate (200 lb.) and 1½ cwt. Nitrate of Soda (=26 lb. N.); following Nitrate of Potash and Superphosphate, 1872–1904 ..	not limed	41.6	17.1	58.7	4015	1529	5544	20
		limed (2772 lb.)	39.1	14.7	53.8	3698	1319	5017	
		limed (570 lb.)	37.8	18.0	55.8	3627	1618	5245	

Ground Lime was applied to the southern portion (limed) of the plots at the rate of 2,000 lb. to the acre in the Winters of 1903–4, 1907–8, 1915–16, 1923–24, 1927–28, and at the rate of 2,500 lb. to the acre in the Winter of 1920-21, except where otherwise stated.

Up to 1914 the Limed and Unlimed plot results were not separately given in the Annual Report, but the mean of the two was given. From 1915 onwards the separate figures are given.

* The second crop was carted green; the figures given are estimated hay yields, calculated from the dry matter.

PARK GRASS PLOTS
BOTANICAL COMPOSITION PER CENT.
1926 (1st Crop)

Plot	Manuring.	Liming	Gramineæ	Leguminosæ	Other Orders	"Other Orders" consist largely of
3	Unmanured.	Limed	61.7	7.8	30.5	*Plantago lanceolata*
		Unlimed	49.6	6.1	44.3	*Plantago lanceolata*
7	Complete Mineral Manure.	Limed	81.5	4.8	13.7	*Heracleum sphondylium*
		Unlimed	73.3	6.2	20.5	*Achillea millefolium*
9	Complete Mineral Manure and double Amm. Salts.	Limed	98.7	0.1	1.2	*Rumex acetosa*
		Unlimed	99.6	—	0.4	*Heracleum sphondylium*
14	Complete Mineral Manure and double Nitrate of Soda.	Limed (sun)	95.0	0.6	4.4	*Taraxacum vulgare* *Anthriscus sylvestris* *Rumex acetosa*
		Limed (Shade)	94.8	1.8	3.4	*Anthriscus sylvestris*
		Unlimed	97.9	0.1	2.0	*Anthriscus sylvestris* *Rumex acetosa*
15	As plot 7 following double Nitrate of Soda, 1858-75.	Limed	Not analysed.			—
		Unlimed				—
17	Single Nitrate of Soda.	Limed				—
		Unlimed				—
18	Mineral Manure (without Super) and double Sulphate Amm. 1905 and since	L. 6,788 lb.	93.8	0.1	6.1	*Rumex acetosa*
		L. 3,951 lb.	89.5	0.1	10.4	*Rumex acetosa*
		Unlimed	77.8	—	22.2	*Rumex acetosa*
19	Farmyard Dung in 1905 and every fourth year since (omitted 1917).	L. 3,150 lb.	90.4	1.2	8.4	*Rumex acetosa* *Ranunculus spp.*
		L. 570 lb.	84.1	1.6	14.3	*Rumex acetosa* *Ranunculus spp.*
		Unlimed	84.8	2.5	12.7	*Rumex acetosa* *Ranunculus spp.*
20	Farmyard Dung in 1905 and every fourth year since (omitted in 1917) each intervening year Sulphate of potash, Super., and Nitrate of Soda.	L. 2,772 lb.	87.6	3.5	8.9	*Ranunculus spp.* *Rumex acetosa* *Taraxacum vulgare*
		L. 570 lb.	90.6	1.2	8.2	*Ranunculus spp.* *Rumex acetosa* *Taraxacum vulgare*
		Unlimed	87.7	3.8	8.5	*Ranunculus spp.* *Rumex acetosa*

PARK GRASS PLOTS
BOTANICAL COMPOSITION PER CENT.
1927 (1st Crop)

Plot	Manuring	Liming	Gramineæ	Leguminosæ	Other Orders	"Other orders" consist largely of
3	Unmanured.	Limed	62.4	4.4	33.2	*Plantago lanceolata*
		Unlimed	71.3	2.4	26.3	—
7	Complete Mineral Manure.	Limed	62.7	25.3	12.0	—
		Unlimed	69.4	9.7	20.9	—
9	Complete Mineral Manure and double Amm. Salts.	Limed	99.1	0.3	0.6	—
		Unlimed	99.3	—	0.7	*Heracleum sphondylium*
14	Complete Mineral Manure and Double Nitrate of Soda.	Limed (sun)	96.2	1.6	2.2	—
		Limed (shade)				
		Unlimed	97.4	1.0	1.6	*Taraxacum vulgare*
15	As plot 7 following double Nitrate of Soda, 1858-75.	Limed	58.3	28.7	13.0	*Plantago lanceolata* *Achillea millefolium*
		Unlimed	74.9	5.9	19.2	*Achillea millefolium* *Plantago lanceolata*
17	Single Nitrate of Soda.	Limed	82.4	1.3	16.3	*Plantago lanceolata*
		Unlimed	76.0	0.1	23.9	*Plantago lanceolata*
18	Mineral Manure (without Super.) and double Sulphate Amm. 1905 and since.	L. 6,788 lb.	97.7	0.1	2.2	*Heracleum sphondylium* *Rumex acetosa*
		L. 3,951 lb.	97.0	—	3.0	*Achillea millefolium* *Rumex acetosa*
		Unlimed	98.2	—	1.8	*Rumex acetosa*
19	Farmyard Dung in 1905 and every fourth year since (omitted 1917).	L. 3,150 lb.	87.9	3.0	9.1	*Heracleum sphondylium* *Ranunculus spp.*
		L. 570 lb.	88.0	2.1	9.9	*Ranunculus spp.* *Rumex acetosa*
		Unlimed	90.3	1.3	8.4	*Rumex acetosa*
20	Farmyard Dung in 1905 and every fourth year since (omitted in 1917) each intervening year Sulphate of Potash, Super., and Nitrate of Soda.	L. 2,772 lb.	88.8	3.5	7.7	*Centaurea nigra* *Taraxacum vulgare*
		L. 570 lb.	94.3	0.6	5.1	*Centaurea nigra* *Conopodium denudatum*
		Unlimed	93.2	1.8	5.0	*Rumex acetosa*

WHEAT—BROADBALK FIELD, 1931

Plot.	Manurial Treatment (amounts stated are per acre).	Dressed Grain, bushels per acre (in some cases estimated from half or quarter-bushel¹)				Total Grain, cwt. per acre.				74-year Average 1852-1925 (prior to fallow). Total Grain, cwt.
		II	III	IV	V	II	III	IV	V	
2A	Farmyard Manure (14 tons)	14.0	18.4	22.1	18.9	9.6	11.9	14.7	12.8	16.3**
2B	Farmyard Manure (14 tons)	13.5	20.1	23.4	22.2	9.3	13.0	15.2	14.3	19.4
3	Unmanured since 1839	5.9	5.7	4.3	10.8	4.2	3.7	3.0	7.0	6.7
5	Complete Mineral Manure §§	7.6	3.7	8.5	10.3	5.4	2.6	5.9	7.4	7.8
6	As 5, and 206 lb. Sulphate of Ammonia	13.2	17.8	18.6	14.2	8.0	10.4	10.8	9.1	12.5
7	As 5, and 412 lb. Sulphate of Ammonia	14.0	27.0	20.2	14.5	9.4	17.5	13.3	9.5	17.6
8	As 5, and 618 lb. Sulphate of Ammonia	15.0	20.5	19.1	14.6	10.2	14.1	13.4	11.0	20.1
9	As 5, and 275 lb. Nitrate of Soda	14.9	21.4	20.3	16.4	9.6	13.4	12.5	10.3	13.9††
10	412 lb. Sulphate of Ammonia	20.8	28.7	26.0	24.3	12.6	17.0	16.1	15.2	10.9
11	As 10, and Superphosphate (3½ cwt.)	23.8	31.2	29.8	25.8	14.8	18.8	18.1	16.0	12.3
12	As 10, and Super. (3½ cwt.) and Sulph. Soda (366 lb.)	21.4	30.2	33.0	19.6	13.5	18.3	20.3	12.8	15.7
13	As 10, and Super. (3½ cwt.) and Sulph. Potash (200 lb.)	15.7	21.8	24.5	13.9	9.8	14.2	15.3	9.4	17.0
14	As 10, and Super. (3½ cwt.) and Sulph. Magnesia (280 lb.)	14.3	31.2	29.9	13.2	9.8	19.1	18.6	9.1	15.5
15	As 5, and 412 lb. Sulphate of Ammonia all applied in Autumn	19.6	25.1	17.1	19.7	11.6	15.0	11.8	11.9	16.1
16	As 5, and 550 lb. Nitrate of Soda	16.3	23.0	22.8	15.8	10.9	14.9	14.5	10.7	17.8††
17	Minerals alone as 5 or 412 lb. Sulphate of Ammonia alone in alternate years	M 9.7	9.0	9.3	3.7	6.0	5.5	5.7	2.4	M8.1
18		A20.0	26.2	19.2	12.1	12.8	16.7	12.7	8.6	A16.1 *
19	Rape Cake (1,889 lb.)	20.4	23.3	23.9	14.9	12.8	14.8	15.5	9.6	12.6‡
20	As 7, without Super.	14.5	—	—	—	8.7	—	—	—	10.3§

For notes see p. 126.

WHEAT—BROADBALK FIELD, 1931

Plot.	Manurial Treatment (amounts stated are per acre).	Bushel Weight in lb. (in some cases estimated from half or quarter-bushel)				Total Straw†, cwt. per acre.				74-year Average 1852-1925 (prior to fallow). Total Straw, cwt.
		II	III	IV	V	II	III	IV	V	
2A	Farmyard Manure (14 tons)	58.0	59.8	60.0	59.8	37.1	45.2	46.0	47.1	32.1**
2B	Farmyard Manure (14 tons)	58.5	60.8	60.5	60.8	43.3	40.5	42.4	44.9	34.2
3	Unmanured since 1839	59.0	59.5	62.0	60.5	10.4	7.8	6.2	12.3	9.8
5	Complete Mineral Manure §§	58.5	62.0	59.8	60.5	14.2	5.2	10.9	15.6	11.5
6	As 5, and 206 lb. Sulphate of Ammonia	58.2	59.5	59.5	60.5	22.3	22.5	23.5	22.0	20.3
7	As 5, and 412 lb. Sulphate of Ammonia	58.5	60.0	59.9	59.5	33.7	47.7	46.2	49.2	32.1
8	As 5, and 618 lb. Sulphate of Ammonia	58.5	58.4	58.2	58.0	50.6	57.7	57.1	59.5	39.8
9	As 5, and 275 lb. Nitrate of Soda	58.8	60.2	60.0	60.0	28.3	34.8	33.6	37.3	24.6††
10	412 lb. Sulphate of Ammonia	59.2	59.8	59.8	59.8	29.2	37.4	37.8	39.1	17.8
11	As 10, and Superphosphate (3½ cwt.)	59.5	59.7	59.8	59.5	31.8	40.5	40.5	39.6	21.4
12	As 10, and Super. (3½ cwt.) and Sulph. Soda (366 lb.)	58.9	59.8	59.7	59.2	35.2	41.5	45.5	42.8	26.8
13	As 10, and Super. (3½ cwt.) and Sulph. Potash (200 lb.)	59.5	60.8	59.5	58.8	35.7	40.8	47.5	49.5	30.6
14	As 10, and Super. (3½ cwt.) and Sulph. Magnesia (280 lb.)	60.2	59.8	60.2	58.8	31.8	41.8	45.9	43.1	26.8
15	As 5, and 412 lb. Sulphate of Ammonia all applied in Autumn	59.9	60.8	61.5	60.8	28.7	30.3	31.6	29.3	28.2
16	As 5, and 550 lb. Nitrate of Soda	60.5	60.9	60.4	58.2	45.3	51.3	51.9	51.2	35.2††
17	Minerals alone as 5 or 412 lb. Sulphate of Ammonia	M60.5	60.5	60.5	63.0	13.0	11.0	13.6	10.9	M12.3
18	alone in alternate years	A60.8	60.9	61.0	60.0	36.6	41.3	41.0	44.8	A28.1*
19	Rape Cake (1,889 lb.)	60.8	59.8	60.9	60.0	27.7	33.2	39.4	30.5	22.0‡
20	As 7, without Super	58.0	—	—	—	27.5	—	—	—	18.6§

† Includes straw, cavings, and chaff. *A=Ammonia series, M=Mineral series.
** 26 years only, 1900-1925. †† 41 years only, 1885-1925. ‡ 33 years only, 1893-1925. § 18 years only, 1906-1925 (no crop in 1912 and 1914).
§§ Complete Mineral Manure: 3½ cwt. Super., 200 lb. Sulph. Potash, 100 lb. Sulph. Soda, 100 lb. Sulph. Magnesia.
Sulphate of Ammonia is applied as to one-third in Autumn and two-thirds in Spring, except for Plot 15. Nitrate of Soda is all given in Spring, there being two applications at an interval of a month on Plot 16.

In 1926 and 1927 the crop was confined to the lower (eastern) part of the field (IV and V) the upper part (I, II and III) being completely fallowed for 2 years. This was the first complete fallow on this area since the experiment began in 1843. In October, 1927, the upper or western part (I and II) was sown with wheat, and again in 1928, while in 1929 the whole field was sown, and harvested in 1930 in five separate portions. In 1931 Section I was fallowed.

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BARLEY—HOOS FIELD, 1930

Corrected results to replace Table on p. 124 of 1930 Report.

As in 1929 the rows were widely spaced to facilitate weed control. In 1930, however, the field was sown longitudinally with a row spacing of 18 inches, instead of the 24 inch spacing adopted in 1929. The two varieties were sown by the half-drill strip method, and to equalise the area certain rows at the sides of each plot were not included in the weighed produce. In computing the yields per acre the whole area harvested experimentally was unfortunately taken as being the area occupied by each variety separately; the yields per acre published in the 1930 Report were therefore half what they should have been.

Plot	Manuring (Amounts stated are per acre)	Total Grain per acre: Plumage Archer	Total Grain per acre: Spratt Archer	76 Years' Average 1852-1928 Dressed Grain per acre.	Total Straw per acre: Plumage Archer	Total Straw per acre: Spratt Archer	76 Years Average 1852-1928 Total Straw per acre.
		cwt.	cwt.	bush.‖	cwt.	cwt.	cwt.†
1O	Unmanured	0.7	0.7	13.4	1.9	1.6	7.8
2O	Superphosphate only (3½ cwt.) ..	9.8	9.1	19.0	8.2	7.6	9.8
3O	Alkali Salts only (200 lb. Sulphate of Potash; 100 lb. Sulphate of Soda; 100 lb. Sulphate of Magnesia)	3.6	3.0	14.3	5.6	4.3	8.7
4O	Complete Minerals; as 3O with Superphosphate (3½ cwt.) ..	7.2	9.5	19.0	6.7	8.1	11.2
5O	Potash (200 lb.) and Superphosphate (3½ cwt.)	8.4	8.3	15.5	8.3	9.2	9.4
1A	Ammonium Salts only (206 lb. Sulphate of Ammonia)	2.9	4.1	23.7	4.3	6.6	13.7
2A	Superphosphate and Amm. Salts ..	18.0	18.9	35.8	17.7	16.8	20.4
3A	Alkali Salts and Amm. Salts ..	7.8	5.3	25.8	11.1	8.2	16.0
4A	Complete Minerals and Amm. Salts	14.8	17.7	39.3	16.9	17.3	23.6
5A	Potash, Super. and Amm. Salts ..	13.3	12.1	33.8	19.4	17.3	21.7
1AA	Nitrate of Soda only (275 lb.) ..	4.7	4.8	24.3*	8.6	8.3	15.4*
2AA	Superphosphate and Nitrate of Soda	18.1	19.0	38.8*	18.6	18.8	23.1*
3AA	Alkali Salts and Nitrate of Soda ..	8.0	8.0	24.5*	11.0	10.9	16.6*
4AA	Complete Minerals and Nitrate of Soda	17.0	17.4	37.7*	18.7	16.9	23.6*
1AAS	As Plot 1AA and Silicate of Soda (400 lb.)	6.9	11.0	30.2*	7.6	13.4	18.2*
2AAS	As Plot 2AA and Silicate of Soda (400 lb.)	20.5	21.4	39.7*	21.1	22.4	23.9*
3AAS	As Plot 3AA and Silicate of Soda (400 lb.)	12.8	13.5	31.2*	14.3	14.2	19.9*
4AAS	As Plot 4AA and Silicate of Soda (400 lb.)	19.2	21.0	39.9*	20.7	20.8	25.4*
1C	Rape Cake only (1,000 lb.) ..	11.9	12.5	35.5	13.3	12.9	20.6
2C	Superphosphate and Rape Cake ..	18.0	18.1	38.1	21.3	19.8	22.0
3C	Alkali Salts and Rape Cake ..	14.6	16.4	33.7	19.1	18.6	20.4
4C	Complete Minerals and Rape Cake	16.6	17.8	37.5	19.9	20.2	22.6
7-1	Unmanured (after dung (14 tons) for 20 years (1852–71) ..	7.9	9.8	22.5‡	8.8	10.1	13.5‡
7-2	Farmyard Manure (14 tons) ..	15.3	16.3	44.6	18.2	19.9	28.1
6-1	Unmanured since 1852	3.3	1.9	14.7	5.4	4.6	8.6
6-2	Ashes from Laboratory furnace ..	4.6	5.7	15.7	5.4	6.6	9.3
1N	Nitrate of Soda only (275 lb.) ..	4.2	3.4	28.7§	5.2	4.8	17.8§
2N	Nitrate of Soda only (275 lb.) ..	13.5	10.3	31.7§§	17.5	14.4	20.0§§

‖ 1 cwt = 2.15 bushels. 1912, all plots were fallowed.
† Total straw includes straw, cavings and chaff.
* 60 years, 1868–1928. ‡ 56 years, 1872–1928. § 75 years, 1853–1928. §§ 69 years, 1859–1928.

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BARLEY—HOOS FIELD, 1931

Plot.	Manuring. (Amounts stated are per acre).	Dressed Grain, bushels per acre (in some cases estimated from half or quarter bushel).		Total Grain, cwt. per acre.		76 Years' Average, 1852-1928 Dressed Grain per acre bush.‖	Bushel Weight in lb. (in some cases estimated from half or quarter bushel).		Total Straw, cwt. per acre.		76 Years' Average, 1852-1928 Total Straw per acre cwt.†
		Plumage Archer.	Spratt Archer.	Plumage Archer.	Spratt Archer.		Plumage Archer.	Spratt Archer.	Plumage Archer.	Spratt Archer.	
1O	Unmanured	12.6	17.4	6.0	8.2	13.4	51.5	51.2	10.6	13.0	7.8
2O	Superphosphate only (3½ cwt.)	16.4	16.4	7.9	7.9	19.0	52.5	53.2	11.5	17.9	9.8
3O	Alkali Salts only (200 lb. Sulphate of Potash; 100 lb. Sulphate of Soda; 100 lb. Sulphate of Magnesia ..	8.8	16.8	4.3	8.2	14.3	54.0	53.0	9.6	13.1	8.7
4O	Complete Minerals; as 30 with Superphosphate (3½ cwt.)	22.8	25.6	11.0	12.4	19.0	53.0	53.1	14.7	18.7	11.2
5O	Potash (200 lb.) and Superphosphate (3½ cwt.)	14.1	21.4	7.2	10.7	15.5	55.0	54.5	11.0	13.0	9.4
1A	Ammonium Salts only (206 lb. Sulphate of Ammonia) ..	8.9	12.9	5.8	7.6	23.7	54.0	53.0	12.7	14.4	13.7
2A	Superphosphate and Amm. Salts	25.7	31.0	13.8	16.4	35.8	53.2	53.0	19.0	17.5	20.4
3A	Alkali Salts and Amm. Salts	3.6††	13.3	2.4	7.9	25.8	—	54.0	15.4	13.9	16.0
4A	Complete Minerals and Amm. Salts	27.3	37.6	14.6	20.0	39.3	54.5	55.4	19.2	19.1	23.6
5A	Potash, Super. and Amm. Salts	26.1	30.3	12.8	14.9	33.8	53.5	53.8	19.0	21.3	21.7
**1AA	Nitrate of Soda only (275 lb.)	11.2	22.1	6.5	12.2	24.3*	54.5	54.4	18.2	16.3	15.4*
1AAS	As 1AA and Silicate of Soda (400 lb.)					30.2*					18.2*
**2AA	Superphosphate and Nitrate of Soda	28.0	36.1	14.6	19.0	38.8*	53.2	54.2	19.0	18.7	23.1*
2AAS	As 2AA and Silicate of Soda (400 lb.)					39.7*					23.9*
**3AA	Alkali Salts and Nitrate of Soda	7.7	20.6	4.7	11.6	24.5*	53.5	53.6	15.9	15.4	16.6*
3AAS	As 3AA and Silicate of Soda (400 lb.)					31.2*					19.9*
**4AA	Complete Minerals and Nitrate of Soda	29.7	38.3	16.0	20.5	37.7*	54.1	54.9	16.4	21.0	23.6*
4AAS	As 4AA and Silicate of Soda (400 lb.)					39.9*					25.4*
1C	Rape Cake only (1,000 lb.)	25.3	34.3	13.8	18.2	35.5	55.0	54.6	17.8	19.7	20.6
2C	Superphosphate and Rape Cake	32.3	41.8	17.1	22.4	38.1	54.0	55.2	22.9	21.8	22.0
3C	Alkali Salts and Rape Cake	15.8	30.0	8.9	16.2	33.7	54.5	55.4	13.0	18.3	20.4
4C	Complete Minerals and Rape Cake	31.0	37.3	16.7	20.5	37.5	55.2	55.5	18.3	21.4	22.6
7-1	Unmanured after dung (14 tons) for 20 years (1852-71) ..	29.8	35.2	14.5	16.8	22.5‡	53.2	52.8	21.4	23.3	13.5‡
7-2	Farmyard Manure (14 tons)	31.9	41.6	17.6	23.4	44.6	54.2	55.4	26.8	32.6	28.1
6-1	Unmanured since 1852	11.6††	15.8	5.8	7.6	14.7	—	52.5	9.9	11.6	8.6
6-2	Ashes from Laboratory furnace	9.3	15.9	4.7	7.7	15.7	53.0	52.0	8.8	12.3	9.3
1N	Nitrate of Soda only (275 lb.)	13.7††	16.8	6.8	8.5	28.7§	—	55.0	11.3	13.9	17.8§
2N	Nitrate of Soda only (275 lb.)	22.9	28.7	11.1	13.8	31.7§§	53.0	53.2	17.7	22.0	20.0§§

‖ 1 cwt. 2.15 bushels. 1912, all plots were fallowed. † Total straw includes straw, cavings and chaff. * Sixty years, 1868-1928. ‡ 56 years, 1872-1928. § 75 years, 1853-1928.
§§ 69 years, 1859-1928. ** Produce from the pairs of these plots bulked together. †† Estimated.
In 1931 the same procedure of sowing in widely spaced drills (18 inches apart) was adopted as in 1930. The two varieties were again sown by the half-drill strip method, the whole of the area of each variety being included in the weighed produce.

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SCHEME FOR CONTINUOUS ROTATION EXPERIMENTS COMMENCING 1930

FOUR COURSE ROTATION EXPERIMENT, ROTHAMSTED.

The Rotation experiment in Great Hoos field was designed primarily for investigating the residual effects of certain humic and phosphatic fertilisers. Previous rotation experiments, at Rothamsted and elsewhere, suffered from a radical defect in design, which resulted in large experimental errors. The arrangement of these experiments was such that with the same crop, the same treatment fell repeatedly on the same plot of land, and repetitions thus did nothing to eliminate permanent soil differences between the plots. The present experiment avoids this defect by ensuring that the period of the cycle of crop rotation differs from the period of the cycle of manurial treatment.

The cropping follows a Norfolk Rotation, involving a four year cycle of barley, seeds, wheat, swedes.* The seeds mixture is Commercial White Clover and Italian Rye-grass, selected in order to lessen the risk of Clover sickness. To minimise the risk of Frit-fly attack in the subsequent wheat crop, the seeds ley is ploughed in before the middle of August.

There are four areas (termed " Series "), each bearing one crop of the rotation, so that all four crops are represented annually.

Treatments.

The treatments compared are :

Humic fertilisers	1. Dung. 2. Adco. compost. 3. Straw and Artificials.
Phosphatic fertilisers	4. Superphosphate. 5. Rock phosphate (Gafsa).

Any given plot receives always the same treatment, but the treatment is applied to the plot only once in five years. The period of the manurial cycle (five years) thus differs from that of the crop rotation (four years).

Information is thus obtained of the effect of the fertilisers, not only in the year of application, but also in the first, second, third and fourth years after application.

Each " series " of the experiment comprises twenty-five plots, and in the fifth year of the experiment and in succeeding years, all plots will have been treated, and there will be represented for each treatment plots which have had application of fertilisers in the current year, and one, two, three, and four years previously. The harvest results for 1930-33, therefore, belong to the preparatory period, and will not be included in the final analysis.

There is no replication in any one year, but this will be provided by carrying on the experiment over a fixed period. In twenty years, on any given plot each stage of the treatment will have occurred once with every crop.

The quantities of fertilisers to be applied are calculated as follows :

Dung and Adco are each given in quantities which supply 50 cwt. of organic matter per acre. As much straw is applied as went to make the calculated amount of Adco, *i.e.*, that amount which gives 50 cwt. of organic matter per acre in the form of Adco. The quantity of straw applied will in general give a considerably greater amount of organic matter than the Dung or Adco, since there is a loss of organic matter during the maturation of these fertilisers.

The Adco is made in a pit or bin, so that there is no outside unrotted portion. To prevent straw (applied as chaff) blowing away, it is thoroughly soaked before application, and moistened subsequently if necessary.

The nutrient-content of the three humic fertilisers is equalised by adding sulphate of ammonia, muriate of potash and superphosphate, to raise the applications to 1.8 cwt. N per acre, 3.0 cwt. K_2O per acre, and 1.2 cwt. P_2O_5 per acre. The artificials given with the straw are applied in three doses, to minimise loss by leaching.

The phosphatic fertilisers of treatments 4 and 5 are given at the rate of 1.2 cwt. total P_2O_5 per acre, and with them are given sulphate of ammonia at the rate of 1.8 cwt. N per acre, and muriate of potash at the rate of 3.0 cwt. K_2O per acre.

The rock phosphate is Gafsa, ground so that 90 per cent. passes through the 120 mesh.

The artificials given with the humic fertilisers are all applied with them in the first year of the manurial cycle.

The phosphatic fertilisers of treatments 4 and 5 are applied only in the first year of the manurial cycle, but the accompanying sulphate of ammonia and muriate of potash are applied one fifth annually throughout the cycle.

* It has been decided to substitute potatoes for swedes in 1932 and following years.

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Time of Application of Fertilisers.

In determining the time of application of the fertilisers, the principle followed has been to give the fertilisers to each crop at a time when they are likely to be most effective.

The scheme adopted is as follows:

(1) *Wheat.*—Dung and Adco and accompanying artificials in one dose in the Autumn.

Straw in one dose in Autumn, but accompanying artificials split into three doses, one applied in Autumn, the remainder through the Winter.

Treatments 4 and 5. Phosphates and potash in seed-bed.

Sulphate of Ammonia of treatments 4 and 5, split into two parts, one applied in the seed-bed, the other as a spring top dressing.

(2) *Clover.*—Dung and Adco and accompanying artificials in one dose in Autumn, unless plant is very weak, when the manures should be split into two or three doses.

Straw and artificials—application to be determined by state of plant, but to be completed by the end of January.

Treatments 4 and 5. Phosphates and potash in the Autumn.

Sulphate of Ammonia in two doses, one in Autumn, and one in Spring.

(3) *Barley and Swedes.*—Dung and Adco and accompanying artificials in one dose in Autumn. Straw in one dose in Autumn, and accompanying artificials in three doses, one in Autumn, and the remaining two through the winter.

Treatments 4 and 5. All artificials to be given in the seed-bed.

Arrangement of Plots.

The experiment consists of four series of plots, each series growing one crop of the Norfolk rotation. Each series has 25 plots, in 5 blocks of 5 plots each. Each treatment is assigned to one plot in each block, chosen at random; and each block has one treated plot in each year, chosen initially at random; finally each treatment is applied once in each year to one plot in each series.

Hence treatments are assigned as to five Randomised blocks of five plots each in each series, but a Latin Square scheme determines the year of application of the treatment in each series.

The plots are approximately 1/40th acre in area (.02436 acre in series A, B and C, but .023347 acre in series D).

First Series (Plots 1-25).—Years of Application.

Treatments:	Blocks. A	B	C	D	E
1	III	V	I	II	IV
2	I	III	IV	V	II
3	V	I	II	IV	III
4	II	IV	III	I	V
5	IV	II	V	III	I

(I, II, III, IV, V = the successive years of the cycle.)

(Hence treatment 1 is applied to the appropriate plot in block C in the first year of the experiment; to that in block D in the second year; A in the third, and so forth.)

Second Series (Plots 26-50).—Years of Application.

Treatments:	Blocks. A	B	C	D	E
1	IV	II	III	I	V
2	I	III	II	V	IV
3	II	V	IV	III	I
4	III	I	V	IV	II
5	V	IV	I	II	III

Third Series (Plots 51-75).—Years of Application.

Treatments:	Blocks. A	B	C	D	E
1	V	III	IV	I	II
2	III	IV	I	II	V
3	I	V	II	IV	III
4	IV	II	V	III	I
5	II	I	III	V	IV

Fourth Series (Plots 76-100).—Years of Application.

Treatments:	Blocks. A	B	C	D	E
1	IV	II	I	V	III
2	I	IV	III	II	V
3	V	I	II	III	IV
4	II	III	V	IV	I
5	III	V	IV	I	II

SIX COURSE ROTATION EXPERIMENT, ROTHAMSTED AND WOBURN

This experiment is designed to furnish data on the effect of varying amounts of the three standard fertilisers, nitrogen, phosphate, and potash, on the yield of six crops of a rotation in the different weather conditions of successive years.

Rotation.

The six courses of the rotation are : barley, clover hay, wheat, potatoes, forage-crop, sugar-beet. The forage-crop consists of equal parts (1 bushel per acre each) of rye, beans and vetches. It is sown in autumn, cut green and followed by a catch crop of mustard. The mustard is ploughed in in early autumn, and followed by rye to be ploughed in before sowing sugar-beet. After wheat, rye is sown and ploughed in in spring before planting potatoes.

The variety of barley used is Plumage-Archer, and of wheat Yeoman II.

Arrangement.

There are six areas, called " series," in Long Hoos IV, which are cropped in this rotation so that each crop is represented every year. There are fifteen plots of 1/40th acre in each series, each of which receives a different treatment. Thus there is no replication of a given crop with a given treatment in any one year. Plots do not receive the same treatments throughout, but on each plot the fifteen treatments follow one another in a definite order in successive years, and in this way cumulative effects of a treatment are avoided.

Treatments.

The fifteen treatments are :

Nitrogen set.	4, 3, 2, 1, 0 units of N, each with 2 units P and 2 units K.
Phosphate set.	4, 3, 2, 1, 0 units of P, each with 2 units K and 2 units N.
Potash set.	4, 3, 2, 1, 0 units of K, each with 2 units N and 2 units P.

1 unit of N=0.15 cwt. of N per acre.
1 unit of P=0.15 cwt. of P_2O_5 per acre.
1 unit of K=0.25 cwt. of K_2O per acre.

The fertilisers used are Sulphate of Ammonia, Superphosphate and Muriate of Potash. The amount of Superphosphate applied is calculated on the basis of total P_2O_5 content.

The potassic and phosphatic fertilisers are applied to the autumn sown crops, wheat and forage-mixture, and to the clover, sown under barley in the previous spring, in the Autumn, and the nitrogenous fertiliser is given as a spring top dressing. The spring sown crops receive all their fertilisers at the time of sowing.

Within each of the three sets of treatments, the treatments 4, 3, 2, 1, 0 units follow each other in that order in successive years.

On series 2, 4, 6 the order of the sets of treatments is N, P, K, and on series 1, 3, 5, the order is N, K, P, *i.e.*, on plots of series, 2, 4, 6 treatment ON is followed by treatment 4P, OP by 4K and OK by 4N, while on series 1, 3, 5, ON is followed by 4K, OK by 4P, and OP by 4N.

Continuance of the Experiment.

After 30 years on the same land, each plot has completed 5 rotations by crops, and 2 by treatments. If continued for a further period, it will be necessary to omit one stage of the crop rotation on each series, without breaking the sequence of manurings. After two such breaks the experiment could be continued until every crop with every treatment had occurred on each plot.

Estimate of Error.

Although there is no actual replication, an estimate of error can be made from the deviations of the Yield/Quantity of fertiliser curve, from a smooth form.

In 1929-30 the six crops of the rotation were scattered in various fields of the farm, so that the experiment proper started on its permanent site in Long Hoos IV in season 1930-31.

Four-Course Rotation, Great Hoos Field, Rothamsted, 1931 (Second Preliminary Year).

For full particulars of experiment see p. 129.

Plots $\frac{1}{40}$ acre.

TREATMENTS:
1. Farmyard manure. } 50 cwt. organic matter per acre.
2. Artificial farmyard manure prepared by Adco process. }
3. Straw equivalent to that used in (2) treated on land with artifical fertilisers.
4. Superphosphate (1.2 cwt. total P_2O_5 per acre) Muriate of Potash (3 cwt. K_2O per acre) Sulphate of Ammonia (altogether 1.8 cwt. N per acre). One-fifth only applied in 1931.
5. As (4) but equivalent Gafsa Phosphate instead of Superphosphate. Nutrient content of (1), (2) and (3) equalised by adding Sulphate of Ammonia, Muriate of Potash and Superphosphate to raise the applications to the level given in (4) and (5).

Plots treated in 1931 shown in bold type.

MANURES APPLIED.

Season 1929-30.

Treatment.	Organic Fertilisers. Organic Matter (cwt. per acre).	Artificial Fertilisers. N. cwt. per acre as Sulphate of Amm.	K_2O cwt. per acre as Mur. of Potash.	P_2O_5 cwt. per acre as Superphosphate (except in T'mt. 5).
1 ..	50 (as F.Y.M.)	0.067	0.168	0.552
2 ..	50 (as Adco)	0.930	2.322	0.741
3 ..	84.58 (as Straw)	1.413	2.355	1.082
4 ..	None	0.36	0.6	1.2
5 ..	None	0.36	0.6	1.2 (as Gafsa rock phos.)

Season 1930-31.

Treatment.	Organic Fertilisers. Organic Matter (cwt. per acre).	Artificial Fertilisers. N. cwt. per acre as Sulphate of Amm.	K_2O cwt. per acre as Mur. of Potash.	P_2O_5 cwt. per acre as Superphosphate (except in T'mt. 5).
1 ..	50 (as F.Y.M.)	0.317	1.663	0.741
2 ..	50 (as Adco)	0.519	2.530	0.179
3 ..	134.22 (as Straw)	1.358	1.517	1.071
4 ..	None	0.36	0.6	1.2
5 ..	None	0.36	0.6	1.2 (as Gafsa rock phos.)

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A W—Wheat (Plots 1-25) (Harvested by sampling method).

Seed sown: Oct. 30th, 1930. Harvested: Aug. 27th. Variety: Yeoman.

N.W. ↑

Yield of Grain in cwt. per acre.

BLOCKS	Plot						Plot
a	1	(5) 14.4	(2) 16.2	(1) 14.2	(3) 11.2	(4) **20.3**	5
b	6	(5) **19.1**	(1) 12.4	(3) 11.0	(4) 10.3	(2) 12.5	10
c	11	(3) **21.4**	(2) 10.6	(5) 10.5	(4) 9.7	(1) 11.2	15
d	16	(1) **22.0**	(3) 11.4	(4) 20.2	(5) 6.4	(2) 6.3	20
e	21	(4) 14.4	(1) 10.8	(5) 15.5	(3) 9.2	(2) **19.8**	25

Yield of straw in cwt. per acre.

BLOCKS	Plot						Plot
a	1	(5) 31.9	(2) 30.2	(1) 24.4	(3) 21.8	(4) **37.2**	5
b	6	(5) **36.6**	(1) 22.4	(3) 20.5	(4) 21.4	(2) 25.5	10
c	11	(3) **45.0**	(2) 19.3	(5) 19.2	(4) 21.0	(1) 23.6	15
d	16	(1) **44.3**	(3) 21.3	(4) 42.0	(5) 16.4	(2) 14.5	20
e	21	(4) 28.3	(1) 20.1	(5) 30.0	(3) 17.6	(2) **45.0**	25

A G—Swedes. (Plots 26-50.)

Seed sown: May 20th. Lifted: Nov. 6-17th. Variety: Garton's Magnificant.

N.W. ↑

Washed Roots—tons per acre.

BLOCKS	Plot						Plot
a	26	(3) **12.74**	(2) 8.40	(5) 5.91	(4) 6.70	(1) 5.69	30
b	31	(4) 10.01	(2) 4.54	(1) **13.00**	(5) 5.99	(3) 5.73	35
c	36	(1) 7.22	(4) 6.03	(3) 6.86	(5) 11.28	(2) **13.23**	40
d	41	(4) 7.85	(5) **10.74**	(3) 8.11	(2) 8.04	(1) 11.72	45
e	46	(2) 7.36	(4) **10.31**	(3) 8.73	(1) 7.02	(5) 8.71	50

Tops—tons per acre.

BLOCKS	Plot						Plot
a	26	(3) **1.46**	(2) 1.19	(5) 1.20	(4) 1.29	(1) 1.49	30
b	31	(4) 1.17	(2) 0.78	(1) **1.46**	(5) 1.14	(3) 1.57	35
c	36	(1) 1.01	(4) 0.90	(3) 0.93	(5) 1.75	(2) **2.50**	40
d	41	(4) 1.05	(5) **1.11**	(3) 0.96	(2) 1.32	(1) 2.02	45
e	46	(2) 1.02	(4) **1.03**	(3) 1.08	(1) 1.25	(5) 1.64	50

A H—Seeds Hay. (Plots 51-75).

Seed sown: April 22nd. Cut: June 24th.

Yield of Dry Matter in cwt. per acre.

N.W.

BLOCKS	Plot						Plot
a	51	(3) 33.0	(4) 33.0	(1) 31.9	(2) 31.2	(5) **36.6**	55
b	56	(3) 34.4	(4) **43.6**	(5) 40.3	(2) 29.3	(1) 30.4	60
c	61	(2) 35.2	(4) 43.6	(3) **58.6**	(1) 30.8	(5) 34.8	65
d	66	(5) 38.1	(1) 46.5	(3) 33.7	(4) 32.6	(2) **43.2**	70
e	71	(4) 43.6	(2) 37.4	(1) **46.9**	(5) 40.0	(3) 35.2	75

A B—Barley. (Plots 76-100.) (Harvested by sampling method.)

Seed sown: March 6th. Harvested: August 27th. Variety: Plumage Archer.

N.W. ↑

Yield of Grain in cwt. per acre.

BLOCKS							
a	76	4 26.5	2 20.9	5 14.0	3 12.8	1 12.0	80
b	81	5 14.5	2 14.1	1 25.9	4 11.4	3 26.3	85
c	86	2 16.4	1 18.9	5 15.5	4 11.3	3 22.1	90
d	91	2 23.1	4 8.9	1 10.5	5 15.5	3 12.8	95
e	96	5 19.8	2 7.0	3 9.0	1 10.5	4 23.9	100

Yield of Straw in cwt. per acre.

76	4 35.4	2 27.0	5 18.4	3 19.0	1 17.0	0
81	5 18.9	2 18.9	1 35.0	4 25.2	3 36.2	85
86	2 27.2	1 27.2	5 25.5	4 21.2	3 25.2	90
91	2 30.2	4 12.8	1 17.8	5 27.1	3 23.8	95
96	5 30.9	2 9.7	3 16.4	1 18.2	4 35.8	100

Six-Course Rotation, Long Hoos IV., Rothamsted. 1931.

For full particulars of experiment see p. 131.

Plots 1/40th acre.

TREATMENTS:

N—4, 3, 2, 1 and O units of N, each with 2 units P_2O_5 and 2 units K_2O.
K—4, 3, 2, 1 and O units of K_2O, each with 2 units N and 2 units P_2O_5.
P—4, 3, 2, 1 and O units of P_2O_5, each with 2 units N and 2 units K_2O.

1 unit of N—0.15 cwt. N per acre as Sulphate of Ammonia.
1 unit of K—0.25 cwt. K_2O per acre as Muriate of Potash.
1 unit of P—0.15 cwt. P_2O_5 per acre as Superphosphate.

BW—Wheat—(Plots 1-15) (Harvested by sampling method).

Manures applied: Oct. 29-30th, 1930. Seed sown: Oct. 3rd, 1930. Harvested - Aug. 21st. Variety: Yeoman II.

N. ↑

Yield of Grain in cwt. per acre.

3P 23.8	0P 22.7	0N 14.2	4K 18.3	2K 20.6
4N 23.8	2P 21.8	3N 19.5	0K 17.5	1K 17.9
1P 18.5	2N 19.8	1N 14.0	3K 19.3	4P 16.4

Yield of Straw in cwt. per acre.

3P 43.2	0P 42.8	0N 27.7	4K 36.7	2K 44.1
4N 51.0	2P 40.9	3N 42.7	0K 36.8	1K 38.4
1P 38.2	2N 42.2	1N 28.1	3K 41.9	4P 35.0

BS—Sugar Beet—(Plots 16-30)

Manures applied: May 9th. Seed sown: May 9th. Lifted: Nov. 3-6th. Variety: Kuhn.

N. ↑

Washed Roots—tons per acre.

3N 6.04	4P 6.32	2P 6.99	3P 7.40	3K 7.33
0N 5.88	2N 6.54	1P 6.39	0K 6.89	4N 7.81
1N 5.53	0P 6.40	4K 7.34	2K 7.11	1K 7.16

Tops—tons per acre.

3N 8.65	4P 7.80	2P 9.67	3P 10.23	3K 9.07
0N 8.04	2N 8.24	1P 9.54	0K 9.99	4N 11.33
1N 9.33	0P 10.70	4K 10.28	2K 10.40	1K 9.56

Sugar Percentage in Roots

3N 17.76	4P 17.81	2P 18.11	3P 17.88	3K 17.87
0N 17.65	2N 17.99	1P 17.54	0K 17.99	4N 17.48
1N 17.82	0P 17.99	4K 17.87	2K 18.24	1K 18.14

BB—Barley—(Plots 31-45) (Harvested by sampling method)

Manures applied: Feb. 27th. Seed Sown: March 6th. Harvested: Aug. 29th. Variety: Plumage Archer.

N. ↑

Yield of Grain in cwt. per acre.

2K 22.2	0K 19.2	0P 19.2	2P 22.6	3N 20.4
3K 20.0	1K 25.2	4N 21.4	4K 20.9	0N 13.2
4P 19.4	3P 19.6	1P 18.9	2N 20.6	1N 18.9

Yield of Straw in cwt. per acre.

2K 27.4	0K 23.7	0P 23.4	2P 23.6	3N 23.8
3K 27.7	1K 30.4	4N 31.9	4K 30.4	0N 18.3
4P 23.0	3P 26.7	1P 24.9	2N 27.5	1N 22.2

B C—Clover—(Plots 46-60).

Manures applied: Oct. 31st, 1930. Seed sown: April 22nd. Cut: June 10th.

Yield of Dry Matter in cwt. per acre.

N. ↑

3P 12.9	0P 12.9	1K 11.8	4N 15.0	2N 13.2
1P 18.9	4K 20.0	2K 18.2	3N 16.1	1N 10.0
2P 23.2	0K 18.9	3K 17.5	0N 13.6	4P 18.2

B P—Potatoes—(Plots 61-75)

Manures applied: April 14th. Planted: April 14th. Lifted: Oct. 1st. Variety: Ally.

Yield of Roots in tons per acre.

N. ↑

4P 8.04	0K 4.33	1P 7.46	0P 6.52	1N 7.63
3K 8.82	1K 7.16	2P 8.73	0N 7.83	4K 10.28
2K 7.79	3P 8.45	4N 8.40	2N 8.14	3N 7.67

B F—Forage Crop—(Plots 76-90).

Manures applied: March 18th. Seed sown: Oct 3rd, 1930. Harvested: June 10th (followed by mustard).

Yield of Dry Matter in cwt. per acre.

N. ↑

4K 29.3	0P 29.3	3K 29.3	0K 28.2	0N 22.5
2P 30.7	3P 31.8	4N 43.9	2N 32.9	3N 38.9
1P 40.4	2K 33.6	1K 32.1	4P 30.4	1N 27.1

SUMMARY OF RESULTS.

1.—Table showing increments in yield per cwt. of N, P_2O_5 and K_2O, together with the standard errors of the increments.

Crop.	Mean Yield.	N		P		K	
Wheat—Grain, cwt. ..	19.2	**16.4**	± 4.8	—4.9	± 4.8	1.2	± 2.8
Straw, cwt.	39.3	**41.0**	± 7.5	—7.1	± 7.5	1.3	± 4.5
Sugar Beet—Roots, tons ..	6.74	**2.91**	± 1.02	0.57	± 1.02	0.43	± 0.61
Tops, tons ..	9.52	3.94	± 1.87	—3.41	± 1.87	0.04	± 1.12
Sugar Per Centage	17.88	—0.27	± 0.44	—0.01	± 0.44	—0.20	± 0.26
Barley—Grain, cwt. ..	20.1	**11.8**	± 4.6	0.7	± 4.6	—0.6	± 2.7
Straw, cwt. ..	25.6	**19.2**	± 5.1	0.7	± 5.1	4.3	± 3.1
Clover—dry matter, cwt.	15.7	5.7	± 6.2	2.1	± 6.2	2.3	± 3.7
Potatoes—tons	7.82	0.79	± 1.21	2.70	± 1.21	**5.42**	± 0.72
Forage—dry matter, cwt.	32.0	**29.9**	± 9.0	2.7	± 9.0	—6.1	± 5.4

2.—Table showing the average percentage increments in yield for each application of N, P_2O_5 and K_2O, with their standard errors.

Crop.	N	P	K	Standard Error.
Wheat—Grain ..	**12.83**	—3.85	1.56	± 3.73
Straw ..	**15.58**	—2.72	0.80	± 2.87
Sugar Beet—Roots	**6.48**	1.26	1.59	± 2.27
Tops	6.20	—5.36	0.09	± 2.94
Sugar Percentage	—0.22	—0.01	—0.28	± 0.37
Barley—Grain ..	**8.88**	0.55	—0.78	± 3.41
Straw ..	**11.23**	0.37	4.22	± 2.98
Clover—dry matter ..	5.41	1.97	3.63	± 5.92
Potatoes	1.51	5.15	**17.34**	± 2.31
Forage—dry matter ..	**14.04**	1.25	—4.76	± 4.22

Significant results are in bold type. Negative sign means depression.

Six-Course Rotation; Stackyard Field, Woburn, 1931

For full particulars of experiment see p. 131, Rothamsted Report.

PLOTS: 1/40th acre.
TREATMENTS:
N=4, 3, 2, 1 and 0 units of N, each with 2 units P_2O_5 and 2 units K_20.
K=4, 3, 2, 1 and 0 units of K_2O, each with 2 units N and 2 units P_2O_5.
P=4, 3, 2, 1 and 0 units of P_2O_5, each with 2 units N and 2 units K_2O.
1 unit of N=0.15 cwt. N per acre as Sulphate of Ammonia.
I unit of K=0.25 cwt. K_20 per acre as Muriate of Potash.
I unit of P=0.15 cwt. P_2O_5 per acre as Superphosphate.

C P—Potatoes (Plots 1-15).

Manures applied: April 30th. Planted: May 1st. Lifted: Sept. 29-30th. Variety: Ally.

Yield of Roots in tons per acre.

2N 11.07	4K 11.39	3K 11.46	2K 11.57	3P 11.30
3N 12.66	0N 9.45	0K 11.18	0P 10.18	2P 11.91
1N 8.28	4P 9.91	1K 10.20	1P 9.68	4N 10.64

C F—Forage Crop (Plots 16-30)

Manures applied: April 4th. Seed sown: October 18th. Harvested: June 15th (followed by mustard).

Yield of Hay containing 15 per cent. water, in cwt. per acre.

2K 49.3	0K 52.9	4P 55.7	3N 52.3	2P 43.3
1K 47.7	4N 51.6	1N 41.3	0P 48.4	4K 53.4
3K 47.0	2N 45.4	0N 32.9	3P 54.8	1P 47.0

C W—Wheat (Plots 31-45)

Manures applied: April 4th. Seed sown: Oct. 18th. Harvested: Aug. 11-20th. Variety: Yeoman II.

Yield of Grain in cwt. per acre.

3N 10.2	4K 9.2	3K 10.9	1K 13.5	1P 14.2
0N 5.0	2N 9.3	0K 10.7	0P 11.3	2P 14.1
1N 9.7	2K 10.4	4P 10.4	4N 17.1	3P 12.6

Yield of Straw in cwt. per acre.

3N 26.2	4K 22.2	3K 25.2	1K 29.6	1P 30.0
0N 13.3	2N 25.0	0K 29.9	0P 27.6	2P 32.6
1N 21.9	2K 25.7	4P 27.9	4N 38.4	3P 32.4

https://doi.org/10.23637/ERADOC-1-65

C B—Barley (Plots 46-60).

Manures applied : March 17th. Seed sown : March 18th. Harvested : Aug. 21st. Variety : Plumage Archer.

Yield of Grain in cwt. per acre.

1N 19.8	0N 17.0	3P 25.8	0P 20.9	0K 18.4
2N 25.3	3N 25.3	1P 26.4	3K 23.9	4N 29.3
4P 24.8	2P 24.3	4K 26.1	1K 29.1	2K 27.7

Yield of Straw in cwt. per acre.

1N 41.6	0N 51.6	3P 49.3	0P 52.7	0K 52.9
2N 41.8	3N 43.0	1P 50.2	3K 68.7	4N 72.2
4P 48.8	2P 51.4	4K 53.7	1K 53.7	2K 55.4

C S—Sugar Beet (Plots 61-75).

Manures applied : May 6th. Seed sown : May 7th. Lifted : Oct. 29-31st. Variety : Kuhn.

Washed Roots—tons per acre.

1K 4.93	0K 5.70	2P 6.92	4N 7.73	3N 7.54
4P 7.38	2K 6.70	0P 6.68	1N 6.61	0N 6.22
3K 7.18	3P 7.32	1P 6.94	4K 6.97	2N 5.86

Tops—tons per acre.

1K 4.28	0K 4.36	2P 6.62	4N 10.21	3N 8.50
4P 6.94	2K 6.55	0P 7.78	1N 8.61	0N 8.63
3K 8.61	3P 7.64	1P 7.20	4K 10.25	2N 8.66

Sugar Percentage in Roots.

1K 16.86	0K 16.58	2P 17.08	4N 16.90	3N 16.31
4P 17.37	2K 17.42	0P 17.76	1N 17.28	0N 17.19
3K 17.54	3P 17.40	1P 17.48	4K 17.43	2N 16.74

C C—Tares (for Clover) (Plots 76-90).

Manures applied : April 28th. Seed sown : May 28th. Cut : Sept. 9th.

Hay containing 15% Water—cwt. per acre.

0K 26.6	1K 23.8	4P 26.0	0N 24.5	1P 27.9
2K 32.0	4N 29.5	3N 29.5	0P 28.6	4K 30.8
3K 31.1	1N 29.0	2N 32.2	2P 27.8	3P 31.1

SUMMARY OF RESULTS

1. Table showing increments in yield per cwt. of N, P_2O_5 and K_2O, together with the standard errors of the increments

Crop.	Mean Yield.	N	P	K
Potatoes—tons ..	10.72	4.52 ± 2.34	0.72 ± 2.34	0.67 ± 1.40
Forage—dry matter, cwt.	41.0	**27.6** ± 6.5	12.7 ± 6.5	0.1 ± 3.9
Wheat—Grain, cwt. ..	11.2	**16.5** ± 4.0	—2.4 ± 4.0	—2.2 ± 2.4
Straw, cwt. ..	27.2	**36.5** ± 5.2	2.1 ± 5.2	**—7.9** ± 3.1
Barley—Grain, cwt. ..	24.3	**20.0** ± 6.2	4.8 ± 6.2	4.1 ± 3.7
Straw, cwt. ..	52.5	28.5 ± 18.0	—5.7 ± 18.0	6.7 ± 10.8
Sugar Beet—Roots, tons	6.71	**2.64** ± 1.10	1.19 ± 1.10	**1.91** ± 0.66
Tops, tons* ..	8.15	3.56 ± 1.71	1.50 ± 1.71	**4.71** ± 1.02
Sugar Percentage	17.16	—1.04 ± 0.58	—0.58 ± 0.58	**0.95** ± 0.34
Tares—dry matter, cwt.	24.4	5.9 ± 4.6	—1.1 ± 4.6	5.4 ± 2.7

* Tops partially eaten by barking deer, damage visually estimated.

2. Table showing the percentage increments in yield for N, P_2O_5 and K_2O with their standard errors

Crop.	N	P	K	Standard Error.
Potatoes	6.30	1.01	1.57	± 3.26
Forage—dry matter	**10.03**	4.65	0.06	± 2.38
Wheat—Grain ..	**22.01**	—3.18	—4.99	± 5.29
Straw ..	**20.02**	1.15	**—7.28**	± 2.87
Barley—Grain ..	**12.32**	2.98	4.19	± 3.84
Straw ..	8.13	—1.64	3.20	± 5.13
Sugar Beet—Roots	**5.88**	2.65	**7.14**	± 2.46
Tops	6.51	2.75	**14.45**	± 3.13
Sugar Percentage	—0.90	—0.50	1.39	± 0.50
Tares—dry matter	3.68	—0.70	5.48	± 2.79

Significant results are in bold type. Negative sign means depression.

REPLICATED EXPERIMENTS AT ROTHAMSTED

HAY

Temporary Ley Experiment: Preparation for Wheat in 1932.

R H—Long Hoos (Section 5) 1931.

N.E.

I.	CR(2)	CR(1)	C (2)	C (1)
II.	C (1)	CR(2)	CR(1)	C (2)
III.	CR(1)	C (2)	C (1)	CR(2)
IV.	C (2)	C (1)	CR(2)	CR(1)

System of Replication: 4×4 Latin Square.
Area of Each Plot: .121 acre.
Treatments:
C=Clover.
CR=Clover and Ryegrass.
First crop cut: July 1st-2nd. On plots marked (2), a second crop was cut on Aug. 27th.
Previous crop: Barley.

Actual Green weights in lb.

Row	First Crop.				Second Crop.	
	C (1)	C (2)	CR (1)	CR (2)	C (2)	CR (2)
I	2059	2171	1899	1696	316	442
II	1534	1856	1922	1824	271	422
III	2072	2219	1417	1921	265	401
IV	2188	1310	1981	1793	436	395

Summary of Results—Dry Matter.

Average yield.	Clover.	Clover and Ryegrass.	Mean.	Standard Error.
First Crop.				
Cwt. per acre ..	39.8	37.3	38.6	1.08
Per cent. ..	103.2	96.8	100.0	2.80
Second Crop.				
Cwt. per acre ..	12.5	16.1	14.3	—
Per cent. ..	87.3	112.7	100.0	—

The difference between the mixtures is not significant for either crop.

BARLEY

Undersowings for temporary ley of clover and ryegrass. Nitrogenous Fertiliser. Sulphate of Ammonia.

R B—Fosters, 1931.

N.E.

I.	R	—	—	O	—	C	CR	—
II.	—	O	R	—	CR	—	C	—
III.	—	CR	—	C	R	—	O	—
IV.	C	—	CR	—	O	—	—	R

System of Replication: 4×4 Latin Square, with split plots

Area of Each Sub-Plot: .05355 acre.

Variety: Plumage Archer undersown with Italian Rye Grass (R) and Broad Red Clover (C).

Treatments: Sulphate of Ammonia at the rate of 0.2 cwt. N per acre, applied to one out of each pair of sub-plots (indicated by the treatment symbol occurring on that half).

Manures applied: March 23rd.

Seed sown: Barley, March 23rd; Rye Grass and Clover, April 23rd.

Barley Harvested: August 27th.

Previous crop: Temporary Ley.

Actual weights in lb.—Grain.

Row.	Without Sulphate of Ammonia.				With Sulphate of Ammonia.			
	O	C	R	CR	O	C	R	CR
I. ..	106.50	70.50	108.00	68.75	95.25	98.25	90.00	97.25
II. ..	112.25	82.00	100.50	76.25	112.50	99.50	120.50	61.75
III. ..	81.00	111.75	77.75	134.00	87.00	117.50	83.25	130.25
IV. ..	80.00	119.00	86.00	91.00	97.25	131.50	93.00	110.75

Actual weights in lb.—Straw.

Row.	Without Sulphate of Ammonia.				With Sulphate of Ammonia.			
	O	C	R	CR	O	C	R	CR
I. ..	145.00	106.50	147.25	94.75	128.75	119.25	164.25	122.75
II. ..	151.50	105.00	128.00	114.75	164.00	117.50	163.00	155.75
III. ..	86.00	156.75	88.25	165.00	129.50	166.00	119.25	179.75
IV. ..	98.25	152.75	109.25	122.50	130.75	159.50	116.25	159.00

Summary of Results.

Average Yield	Cwt. per acre.					Per cent.				
	No Ley	Clover	Ryegrass	Clover + Ryegrass	Mean.	No Ley	Clover	Ryegrass	Clover + Ryegrass	Mean
Grain— Without S./Amm.	15.8	16.0	15.5	15.4	15.7	97.0	97.9	95.1	94.5	96.2
With S./Amm.	16.3	18.6	16.1	16.7	16.9	100.2	114.2	98.8	102.2	103.8
Mean ..	16.1	17.3	15.8	16.0	16.3	98.6	106.0	97.0	98.4	100.0
Straw— Without S./Amm.	20.0	21.7	19.7	20.7	20.5	90.1	97.7	88.6	93.2	92.4
With S./Amm.	23.0	23.4	23.5	25.7	23.9	103.7	105.4	105.5	115.7	107.6
Mean ..	21.5	22.6	21.6	23.2	22.2	96.9	101.6	97.1	104.5	100.0

Standard Errors:	*Grain.*	*Straw.*
Single treatment	=1.01 cwt. or 6.2%	1.05 cwt. or 4.7%
Mean of S./Amm. and No S./Amm.	=0.80 cwt. or 4.9%	0.82 cwt. or 3.7%

The effect of Sulphate of Ammonia on the straw is definitely significant, but the difference does not reach the 5% level of significance for grain. There are no other significant effects.

OATS

Variety Trial.

Nitrogenous Fertiliser: Sulphate of Ammonia at four levels.

R O—Gt. Harpenden, 1931

E

A						B						C					
M		G		V		G		V		M		V		G		M	
4	2	3	2	3	1	1	2	4	2	4	1	1	2	3	2	2	4
3	1	1	4	2	4	4	3	3	1	3	2	3	4	4	1	1	3

M		V		G		M		V		G		G		M		V	
3	1	2	3	2	4	1	4	1	3	1	4	3	1	2	1	4	3
4	2	1	4	1	3	3	2	4	2	2	3	2	4	4	3	1	2
D						E						F					

System of Replication: 6 randomised blocks of 3 plots, each sub-divided into 4.
Area of Each Plot: 1/80th acre.
Treatments (sub plots):
1=No Nitrogen.
2=S/Amm. at the rate of 0.2 cwt. N per acre.
3=S/Amm. at the rate of 0.4 cwt. N per acre.
4=S/Amm. at the rate of 0.6 cwt. N per acre.
Manures applied: Feb. 25-26th.

Varieties (main plots): V=Victory.
G=Golden Rain II.
M=Marvellous.
Seed sown: February 25th.
Oats Harvested: August 18-20th.
Previous crop: Temporary Ley: 1st crop taken for hay, aftermath eaten off by sheep given turnips and corn.

Actual weights in lb.—Grain.

Block.	M				G				V			
	1	2	3	4	1	2	3	4	1	2	3	4
A	15.75	17.50	27.25	24.75	20.00	20.50	23.50	31.50	15.50	22.50	25.00	29.00
B	22.25	32.25	33.00	31.00	15.00	25.50	22.25	24.00	17.00	16.00	28.00	21.50
C	24.25	24.75	29.75	30.25	22.25	20.50	21.50	26.00	13.25	18.50	29.50	28.25
D	26.25	35.00	29.50	39.00	29.25	28.50	40.25	35.25	27.75	32.50	39.25	43.50
E	17.50	22.25	26.00	29.25	16.00	25.75	33.00	33.25	18.50	22.25	20.25	30.50
F	24.00	31.00	30.25	36.00	17.50	27.00	31.50	37.25	15.25	22.75	24.25	25.00

Actual weights in lb.—Straw.

Block.	M				G				V			
	1	2	3	4	1	2	3	4	1	2	3	4
A	23.50	28.00	38.50	35.25	28.00	30.75	40.75	42.00	31.50	32.00	37.50	41.25
B	32.75	39.75	38.00	42.50	25.00	37.75	38.50	39.75	36.50	34.50	43.75	38.25
C	34.50	35.75	41.50	40.75	40.50	36.00	43.00	41.75	26.50	37.50	41.00	45.25
D	28.50	36.75	35.00	44.25	28.75	35.00	40.50	43.50	31.75	47.25	42.50	44.75
E	21.50	27.75	31.00	33.50	32.00	34.75	43.00	47.25	30.00	31.75	38.50	49.75
F	30.50	34.75	33.25	39.25	27.25	44.00	39.50	48.75	30.50	35.50	45.25	51.25

https://doi.org/10.23637/ERADOC-1-65

Summary of Results.

Average yield cwt. per acre	Grain					Straw				
	No Nitrogen	.2 cwt. Nitrogen	.4 cwt. Nitrogen	.6 cwt. Nitrogen	Mean	No. Nitrogen	.2 cwt. Nitrogen	.4 cwt. Nitrogen	.6 cwt. Nitrogen	Mean
Victory	12.8	16.0	19.8	21.2	17.4	22.2	26.0	29.6	32.2	27.5
Golden Rain II ..	14.3	17.6	20.5	22.3	18.7	21.6	26.0	29.2	31.3	27.0
Marvellous	15.5	19.4	20.9	22.6	19.6	20.4	24.1	25.9	28.0	24.6
Mean	14.2	17.7	20.4	22.0	18.6	21.4	25.4	28.2	30.5	26.4
Per cent.										
Victory	68.8	86.2	106.6	114.0	93.9	84.3	98.6	112.1	122.1	104.3
Golden Rain II ..	76.9	94.7	110.3	120.1	100.5	81.9	98.5	110.7	118.7	102.4
Marvellous	83.4	104.4	112.7	122.0	105.6	77.3	91.5	98.0	106.3	93.3
Mean	76.4	95.1	109.9	118.7	100.0	81.2	96.2	107.0	115.7	100.0

Standard Errors.

	cwt. per acre.			per cent.		
	Single treatment.	Mean of 3 varieties.	Mean of 4 treatments	Single treatment.	Mean of 3 varieties.	Mean of 4 treatments.
Grain ..	1.23	0.56	0.89	6.6	3.0	4.8
Straw ..	1.22	0.62	0.78	4.6	2.4	3.0

The response to nitrogen is definitely significant, but the experiment is not sufficiently precise to show any difference between the varieties, either in differential response or in average yield.

WHEAT.

Comparison of Sulphate and Muriate of Ammonia in early and late top dressings.

R W—Little Hoos, 1931.

A E B

S.E.	M.E.L.	S.E.L.	O(1)	S.L.	S.E.L.	M.E.	O(1)
M.E.	O(2)	S.L.	M.L.	M.E.L.	M.L.	S.E.	O(2)
M.E.L.	M.L.	S.E.	M.E.	M.E.	O(1)	S.E.	S.E.L.
S.E.L.	S.L.	O(1)	O(2)	S.L.	M.E.L.	O(2)	M.L.
M.E.L.	O(1)	O(2)	S.E.L.	O(1)	M.E.	S.E.	S.L.
M.L.	M.E.	S.L.	S.E.	S.E.L.	M.L.	M.E.L.	O(2)

C (left) D (right)

E F

System of Replication: 6 randomised blocks of 8 plots each.

Area of Each Plot: 1/60th acre.

Treatments: Sulphate or Muriate of Ammonia applied early or late, or neither or both, making 8 combinations, of which two (without either dressing) are identical.

Basal manure: 13-16 tons farmyard manure per acre.

Early manures applied: March 20th.

Late manures applied: May 1st.

Wheat sown: October 10th.

Wheat harvested: August 22nd.

Variety: Million.

Previous crop: Oats.

Actual weights in lb.—Grain.

Block	O(1)	O(2)	S.E.	M.E.	S.L.	M.L.	S.E.L.	M.E.L.
A	35.00	38.25	40.00	47.00	39.75	42.25	37.50	36.50
B	43.75	41.75	43.50	41.75	41.00	46.50	41.50	44.75
C	38.50	36.25	38.00	41.00	37.75	41.25	43.75	44.00
D	45.75	38.25	42.00	45.00	38.00	38.50	40.25	48.25
E	37.00	39.50	34.00	34.25	29.50	37.00	38.50	39.00
F	35.50	32.50	37.50	41.25	33.50	37.00	38.00	38.75

Actual weights in lb.—Straw.

Block	O(1)	O(2)	S.E.	M.E.	S.L.	M.L.	S.E.L.	M.E.L.
A	70.25	70.50	76.50	81.25	81.75	89.75	91.50	88.00
B	71.00	68.75	88.50	88.25	86.00	90.50	99.50	99.50
C	71.25	73.00	77.75	93.50	82.75	82.25	90.25	98.50
D	86.75	62.00	82.50	99.75	81.50	68.75	100.75	96.75
E	72.00	75.00	73.50	79.75	71.50	79.25	96.00	98.75
F	81.00	60.50	76.75	92.00	84.75	73.75	90.00	78.50

K

Summary of Results.

Average Yield.	No Nitrogen.	Sulphate Early.	Sulphate Late.	Muriate Early.	Muriate Late.	Sulphate Early and Late.	Muriate Early and Late.	Mean.	Standard Errors.
Grain—									
cwt. per acre	20.6	21.0	19.6	22.3	21.6	21.4	22.4	21.2	0.624
per cent.	97.3	98.9	92.4	105.4	102.1	100.8	105.8	100.0	2.94
Straw—									
cwt. per acre	38.5	42.5	43.6	47.7	43.2	50.7	50.0	44.3	1.496
per cent.	86.8	95.8	98.3	107.6	97.5	114.4	112.8	100.0	3.37

Mean of Sulphate and Muriate.

Average yield.	Grain.			Straw		
	Not applied early.	Applied early.	Mean.	Not applied early.	Applied early.	Mean.
cwt. per acre.						
Not applied late ..	20.6	21.7	21.1	38.5	45.1	41.8
Applied late	20.6	21.9	21.3	43.4	50.4	46.9
Mean	20.6	21.8	21.2	40.9	47.7	44.3
per cent.						
Not applied late ..	97.3	102.2	99.7	86.8	101.7	94.2
Applied late	97.3	103.3	100.3	97.9	113.6	105.8
Mean	97.3	102.7	100.0	92.4	107.6	100.0

Standard Errors: Grain—Single Treatment 0.44 cwt. or 2.08%. Straw—1.06 cwt. or 2.39%.
Mean of 2 Treatments 0.31 cwt. or 1.47%. 0.75 cwt. or 1.69%.

Taking the average of sulphate and muriate, both grain and straw are increased significantly by the early application, but only straw by the late application. The plots receiving muriate have given higher yields than those receiving sulphate in both grain and straw, the difference in grain being decidedly significant.

Wheat: Comparison of Sulphate of Ammonia and Cyanamide
in small repeated top dressings and two spring top dressings.

R W—Long Hoos (Section 4) 1931

NE

I.	S.C.	O.	S.S.	R.S.	R.C.
II.	R.S.	R.C.	O.	S.S.	S.C.
III.	S.S.	R.S.	S.C.	R.C.	O.
IV.	R.C.	S.C.	R.S.	O.	S.S.
V.	O.	S.S.	R.C.	S.C.	R.S.

SYSTEM OF REPLICATION: 5×5 Latin Square.
AREA OF EACH PLOT: 1/100th acre.
VARIETY: Yeoman.
TREATMENTS: Repeated Sulphate of Ammonia (RS) *v* Cyanamide (RC) each in 8 applications at end of October, November, December, January, February, March, April, May. Spring Sulphate of Ammonia (SS) *v* Cyanamide (SC) in 2 applications, March 20th and May 1st. The fifth treatment consists of no top dressing. Quantity Sulphate of Ammonia and Cyanamide at the rate of 0.4 cwt. N per acre.
Seed sown: Oct. 3.
Harvested: Aug. 21st.
Previous crop: Temporary Ley.

Actual weights in grammes.

Row.	Grain.					Straw.				
	O.	R.S.	R.C.	S.S.	S.C.	O.	R.S.	R.C.	S.S.	S.C.
I.	360	479	357	446	482	678	986	739	910	982
II.	340	488	375	408	524	676	868	776	839	980
III.	319	507	308	441	396	612	982	597	842	720
IV.	356	399	390	422	520	710	815	781	847	976
V.	416	449	378	452	430	755	851	763	875	860

Summary of Results.

Average yield.	No Nitrogen.	Repeated S/Amm.	Repeated Cyanamide	Spring S/Amm.	Spring Cyanamide	Mean.	Standard Error.
Grain—							
cwt. per acre	15.6	20.2	15.7	18.9	20.5	18.2	0.688
per cent.	85.8	111.2	86.6	103.8	112.6	100.0	3.73
Straw							
cwt. per acre	29.9	39.2	31.8	37.6	39.4	35.6	1.39
per cent.	84.0	110.2	89.5	105.6	110.6	100.0	3.91

For the two types of nitrogen taken together, spring dressings are significantly superior to repeated dressings. For the two methods of application taken together sulphate of ammonia is superior to cyanamide. Repetition treatment is strikingly unfavourable in the case of cyanamide.

Wheat Cultivation Experiment

R W—Little Hoos, 1931

E

	A						B					
	S		P		O		O		S		P	
	H	N	N	HR	N	R	N	R	H	N	N	R
	HR	R	R	H	H	HR	HR	H	HR	R	H	HR
	O		S		P		S		O		P	
	HR	R	HR	H	HR	H	R	N	HR	H	N	HR
	N	H	R	N	R	N	H	HR	N	R	R	H
	C						D					

System of Replication: 4 randomised blocks of 3 plots, each plot sub-divided into 4.
Area of each Sub-Plot: 1/60th acre.
Cultivations (main plots):
O = Ordinary plough.
S = Simar.
P = Pulverator plough.

Cultivations (sub-plots):
H = Harrowed.
R = Rolled.
HR = Harrowed and Rolled.
N = Neither Harrowed nor Rolled.
Basal Manure: 13-16 tons farmyard manure per acre.
Variety: Million.
Seed sown: October 10th.
Harvested: August 24th.
Previous crop: Winter oats.

Actual weights in lb.—Grain.

Block	S				P				O			
	H	R	N	HR	H	R	N	HR	H	R	N	HR
A	23	20	16	22	30	26	20	34	29	28	22	31
B	28	28	29	28	35	32	32	38	30	30	26	32
C	28	25	27	31	36	30	32	34	32	31	29	24
D	30	32	28	34	32	32	31	34	34	30	34	32

Actual weights in lb.—Straw.

Block	S				P				O			
	H	R	N	HR	H	R	N	HR	H	R	N	HR
A	72	76	70	59	72	79	75	67	55	70	58	66
B	68	73	78	67	75	85	76	74	67	64	64	75
C	65	76	64	76	74	68	67	63	79	90	82	85
D	74	71	64	70	70	93	88	75	88	88	78	71

https://doi.org/10.23637/ERADOC-1-65

Summary of Results.

Average yield.	Ordinary.	Simar.	Pulverator	Mean.	Standard Single Treatment.	Errors. Mean.
Grain—cwt. per acre.						
Neither Harrowed nor Rolled	14.9	13.4	15.4	14.6	0.795	0.403
Rolled only	15.9	14.1	16.1	15.4		
Mean	15.4	13.7	15.7	15.0	0.624	0.285
Harrowed only ..	16.7	14.6	17.8	16.4	0.795	0.403
Harrowed and Rolled ..	15.9	15.4	18.8	16.7		
Mean	16.3	15.0	18.3	16.5	0.624	0.285
General Mean	15.9	14.4	17.0	15.8	0.517	
Grain—per cent.						
Neither Harrowed nor Rolled	94.4	85.0	97.8	92.4	5.05	2.56
Rolled Only	101.2	89.3	102.1	97.5		
Mean	97.8	87.2	99.9	95.0	3.96	1.81
Harrowed only ..	106.3	92.7	113.1	104.0	5.05	2.56
Harrowed and Rolled ..	101.2	97.8	119.1	106.0		
Mean	103.8	95.2	116.1	105.0	3.96	1.81
General Mean	100.8	91.2	108.0	100.0	3.28	
Straw—cwt. per acre.						
Neither Harrowed nor Rolled	37.8	37.0	41.0	38.6	2.36	0.932
Rolled only	41.8	39.6	43.5	41.6		
Mean	39.8	38.3	42.2	40.1	2.06	0.659
Harrowed only	38.7	37.4	39.0	38.4	2.36	0.932
Harrowed and Rolled ..	39.8	36.4	37.4	37.9		
Mean	39.2	36.9	38.2	38.1	2.06	0.659
General Mean	39.5	37.6	40.2	39.1	1.90	
Straw—per cent.						
Neither Harrowed nor Rolled	96.6	94.5	104.8	98.6	6.03	2.38
Rolled only	106.8	101.4	111.3	106.5		
Mean	101.7	97.9	108.0	102.6	5.28	1.68
Harrowed only ..	99.0	95.5	99.6	98.0	6.03	2.38
Harrowed and Rolled ..	101.7	93.2	95.5	96.8		
Mean	100.3	94.3	97.6	97.4	5.28	1.68
General Mean	101.0	96.1	102.8	100.0	4.86	

For the grain pulverator cultivation is significantly superior to simar cultivation. The pulverator is not significantly superior to ordinary cultivation, and the inferiority of the simar to ordinary cultivation is barely significant. Harrowing significantly increases grain. For the straw the significant loss due to harrowing is only shown on the rolled plots.

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FORAGE CROPS

Correction to 1930 Experiment. (See p. 156.)

The conclusions drawn from this experiment stand without alteration, with the exception that the response to potash for grain and straw should have been stated to be significant on the oats mixtures as well as the barley mixtures, this response not being in fact significantly different for the two cereals. In the table showing Effect of Potash and Superphosphate (p. 144) the yields of the different mixtures are based on different numbers of plots, and are not equalised for rows and columns.

There is, also, an arithmetical error in the same table (Effect of Potash and Superphosphate). The yields for straw, barley with peas, without and with potash should read 26.2 and 28.8 respectively, instead of 20.9 and 34.1. The corresponding means of all mixtures now become 27.8 and 29.8 instead of 26.5 and 31.2.

The systematic arrangement of the strips of vetches and peas, and oats and barley, not commented on in the 1930 report, was an error in sowing. In the original design the layout consisted of *randomised* pairs of strips, after the manner of the 1929 experiment on sugar beet.

Forage Crop: Comparison of Oats and Wheat, Vetches and Peas. Basal Crop of Beans.

Effect of Sulphate of Ammonia and Nitrate of Soda. Effect of Muriate of Potash and Superphosphate.

R F—Little Hoos, 1931.

N.E.

	O	W	W	O	O	W	O	W	W	O	W	O	
I.	4	8	6	2	10	7	5	11	1	3	12	9	V
II.	11	3	7	5	9	2	4	8	6	12	1	10	P
III.	3	7	1	12	8	10	6	4	11	5	9	2	P
IV.	7	10	4	11	6	9	2	3	5	1	8	12	V
V.	12	5	8	6	3	1	9	10	4	11	2	7	V
VI.	6	1	10	9	4	3	8	5	12	2	7	11	P
VII.	5	6	9	4	12	11	10	1	2	7	3	8	V
VIII.	1	4	5	3	7	12	11	2	8	9	10	6	P
IX.	10	11	2	7	5	8	12	9	3	4	6	1	P
X.	9	2	12	1	11	6	3	7	10	8	4	5	V
XI.	8	9	3	10	2	5	1	12	7	6	11	4	V
XII.	2	12	11	8	1	4	7	6	9	10	5	3	P

Key to Treatments.

1	2	3	4	5	6	7	8	9	10	11	12
— — —	— K —	— — P	— K P	S/A — —	S/A K —	S/A — P	S/A K P	N/S — —	N/S K —	N/S — P	N/S K P

SYSTEM OF REPLICATION: 12×12 Latin Square, with randomised pairs of rows and columns allotted to different seedings.
AREA OF EACH PLOT: 1/50th acre. Half cut for hay, half harvested.
Manurial Treatments: No Nitrogen *v.* Sulphate of Ammonia (S/A) at the rate of 0.2 cwt. N per acre *v.* Nitrate of Soda (N/S) at the rate of 0.2 cwt. N per acre. Potash *v* Muriate of Potash (K) at the rate of 0.5 cwt. K_2O per acre. No Phosphate *v* Superphosphate (P) at the rate of 0.5 cwt. P_2O_5 per acre.
O=Oats at the rate of 3 bushels per acre.
W=Wheat at the rate of 2 bushels per acre.

V=Vetches at the rate of 1 bushel per acre.
P=Peas at the rate of 1 bushel per acre.
Basal Crop: Beans at the rate of 1 bushel per acre.
All plots received Adco at the rate of 14 tons (approx.) per acre (September 12th).
Manures sown: March 24th-25th.
Beans, peas and vetches sown: October 9th-10th.
Other crops: October 11th.
Peas redrilled: Mar. 25th.
Half-plots cut for hay: July 9th-14th.
Remainder harvested: August 17th-21st.
Previous crop: Winter Oats.

Actual weights in lb.—Hay (Dry Matter).

Row.	1	2	3	4	5	6	7	8	9	10	11	12
I.	69.9	74.8	59.3	73.3	69.6	80.5	77.0	64.9	70.6	80.8	66.4	72.1
II.	55.0	67.4	69.7	63.2	65.6	74.7	78.6	60.7	63.8	66.6	64.8	72.1
III.	70.3	56.3	67.8	58.8	58.6	64.6	58.9	66.2	58.4	64.8	69.7	63.8
IV.	66.6	55.7	51.7	47.6	53.5	68.6	65.1	58.8	63.8	68.8	65.5	68.3
V.	46.5	60.8	53.8	59.7	57.9	61.0	64.9	47.4	70.1	70.7	61.2	63.1
VI.	39.5	47.1	41.1	43.7	47.6	55.9	45.2	47.7	57.7	53.8	49.4	56.2
VII.	40.4	44.7	42.0	48.7	55.5	58.5	50.5	53.6	54.8	51.4	51.6	61.9
VIII.	54.6	43.0	54.2	44.1	56.7	58.0	58.0	50.2	54.7	58.0	56.8	53.7
IX.	54.3	46.4	37.6	42.2	51.1	52.7	56.5	53.2	57.3	64.1	55.1	57.1
X.	52.3	53.5	51.8	46.7	54.8	60.5	56.8	58.9	59.9	52.6	63.6	59.6
XI.	47.8	46.5	53.5	43.0	59.4	59.3	55.9	60.8	56.5	68.1	61.8	58.3
XII.	46.2	47.5	50.4	43.4	51.4	52.5	51.7	53.2	51.9	58.9	59.0	54.0

Actual weights in lb.—Grain and Pulse.

Row.	1	2	3	4	5	6	7	8	9	10	11	12
I.	24	20	28	28	22	20	18	24	21	18	20	24
II.	17	22	28	26	20	20	20	18	20	20	18	17
III.	24	24	21	23	17	17	21	22	16	18	18	22
IV.	28	30	24	24	22	28	25	25	24	25	23	22
V.	23	24	29	24	24	21	26	23	28	26	22	24
VI.	26	25	22	28	18	18	14	18	21	25	16	20
VII.	28	25	20	30	27	27	24	24	24	30	22	26
VIII.	18	22	22	22	22	18	19	21	16	13	15	18
IX.	24	29	22	29	22	19	20	22	20	18	21	20
X.	22	18	24	18	17	24	18	21	20	21	24	21
XI.	22	31	24	16	25	19	20	20	24	24	15	19
XII.	16	21	24	24	14	21	18	22	20	20	21	22

Actual weights in lb.—Straw.

Row.	1	2	3	4	5	6	7	8	9	10	11	12
I.	44	54	50	62	54	60	67	62	61	59	52	62
II.	42	48	45	44	54	49	54	50	54	58	55	50
III.	53	46	48	48	52	50	56	56	51	54	56	53
IV.	42	48	44	46	47	53	52	52	58	55	55	54
V.	57	50	60	54	62	62	52	62	61	64	52	65
VI.	51	44	44	48	46	55	50	51	61	58	46	50
VII.	49	46	48	55	61	62	46	52	61	58	54	56
VIII.	46	36	44	42	54	53	50	44	43	47	47	52
IX.	43	50	46	38	54	48	76	54	53	76	53	48
X.	50	51	49	49	51	54	54	61	58	62	54	51
XI.	42	49	49	42	55	44	46	48	51	56	40	45
XII.	49	45	49	46	48	49	46	52	48	60	54	58

https://doi.org/10.23637/ERADOC-1-65

SUMMARY OF RESULTS.

Separate yields. Mean of all seed mixtures.

Average yield in cwt. per acre.		No Nitrogen. Without Mur.Pot.	No Nitrogen. With Mur.Pot.	Sulphate of Ammonia. Without Mur.Pot.	Sulphate of Ammonia. With Mur.Pot.	Nitrate of Soda. Without Mur.Pot.	Nitrate of Soda. With Mur.Pot.
Hay—Dry matter	No Super ..	47.9	47.9	50.7	55.6	53.5	56.4
	Super	47.1	45.7	53.5	50.3	53.9	55.1
Grain and Pulse	No Super ..	20.2	21.6	18.6	18.8	18.9	19.2
	Super	21.4	21.7	18.1	19.3	17.5	19.0
Straw	No Super ..	42.3	42.2	47.5	47.5	49.1	52.6
	Super	42.9	42.7	48.3	47.9	46.0	47.9

Standard Errors : Hay, Dry Matter : 1.23 cwt. or 2.39 per cent.
Grain and Pulse : 0.69 cwt. or 3.54 per cent.
Straw : 1.05 cwt. or 2.26 per cent.

Mean of all manurial treatments.

Average yield in cwt. per acre.	Hay, Dry Matter. Oats.	Hay, Dry Matter. Wheat.	Hay, Dry Matter. Means (a)	Grain and Pulse. Oats	Grain and Pulse. Wheat	Grain and Pulse. Means (a)	Straw. Oats.	Straw. Wheat.	Straw. Means (a)
Vetches	54.1	51.7	52.9	21.4	20.1	20.8	47.8	47.7	47.8
Peas	50.7	49.4	50.0	18.2	18.4	18.3	45.7	44.3	45.0
Means (b)	52.4	50.5	51.5	19.8	19.3	19.5	46.8	46.0	46.4
Standard Errors—									
Means (a)		0.301			0.447			0.287	
Means (b)		1.277			0.745			1.290	

Mean of potash and no potash.

Average yield.	Cwt. per acre. No Nitrogen	Cwt. per acre. Sulphate of Ammonia	Cwt. per acre. Nitrate of Soda	Cwt. per acre. Mean	per cent No Nitrogen	per cent Sulphate of Ammonia	per cent Nitrate of Soda	per cent Mean
Hay, Dry Matter—								
No Super ..	47.9	53.1	55.0	52.0	93.0	103.2	106.8	101.0
Super	46.4	51.9	54.5	50.9	90.2	100.8	105.9	99.0
Mean	47.1	52.5	54.7	51.5	91.6	102.0	106.4	100.0
Grain and Pulse—								
No Super ..	20.9	18.7	19.0	19.6	107.2	95.6	97.5	100.1
Super	21.6	18.7	18.2	19.5	110.5	95.8	93.3	99.9
Mean	21.3	18.7	18.6	19.5	108.8	95.7	95.4	100.0
Straw—								
No Super ..	42.2	47.5	50.9	46.9	91.0	102.4	109.6	101.0
Super	42.8	48.1	46.9	45.9	92.2	103.7	101.2	99.0
Mean	42.5	47.8	48.9	46.4	91.6	103.0	105.4	100.0

Standard Errors : Hay, Dry Matter : 0.869 cwt. or 1.69 per cent.
Grain and Pulse : 0.488 cwt. or 2.50 per cent.
Straw : 0.741 cwt. or 1.60 per cent.

Mean of nitrogen and no nitrogen.

Average yield.	cwt. per acre.			per cent.		
	No Potash.	Potash.	Mean.	No Potash.	Potash.	Mean.
Hay, Dry Matter—						
No Super	50.7	53.3	52.0	98.5	103.6	101.0
Super	51.5	50.4	50.9	100.1	97.8	99.0
Mean	51.1	51.8	51.5	99.3	100.7	100.0
Grain and Pulse—						
No Super	19.2	19.9	19.6	98.5	101.7	100.1
Super	19.0	20.0	19.5	97.3	102.5	99.9
Mean	19.1	19.9	19.5	97.9	102.1	100.0
Straw—						
No Super	46.3	47.4	46.9	99.7	102.2	101.0
Super	45.7	46.2	45.9	98.5	99.5	99.0
Mean	46.0	46.8	46.4	99.1	100.9	100.0

Standard Errors : Hay, Dry Matter : 0.709 cwt. or 1.38 per cent.
Grain and Pulse : 0.399 cwt. or 2.04 per cent.
Straw : 0.605 cwt. or 1.30 per cent.

Differences of seed mixtures : In all cases the vetch mixtures give higher yields than the pea mixtures, and the oats mixtures give higher yields than the wheat mixtures, but the first of these differences only reaches the level of significance in the hay green weights, and the second only in the hay green weights and hay dry matter. (The experiment is not capable of giving a very precise verdict on these points.)

Manurial Effects : Nitrogen is significantly beneficial in the case of the hay and the straw, but significantly depresses the yield of grain and pulse. Nitrate of soda gives a significantly higher yield than Sulphate of Ammonia in the case of the hay and the straw ; in the case of the grain and pulse there is no significant difference. Potash significantly increases the yield of grain and pulse, and of hay weighed in the green state, but it has no significant effect on the straw, and no average effect on the hay dry matter. Phosphate shows no general effects.

For the hay dry matter the higher yield of plots receiving either potash or phosphate compared with those receiving neither or both is statistically significant, as is the higher yield in straw of the nitrate of soda plots receiving no phosphate compared with those receiving phosphate. There is no evidence that the manures act differently on the different types of crop.

https://doi.org/10.23637/ERADOC-1-65

POTATOES

Nitrogenous Fertiliser: Sulphate of Ammonia.

Potassic Fertilisers: Sulphate and Muriate of Potash and Potash Salts (30%).

Each in single and double dressings.

Superphosphate.

R P—Pastures, 1931

N.W.

	G			D			A			
	— / 8M	— / 7S	— / 4S	2 / —	— / 6P	8S / —	6S / —	— / 8P	3 / —	
	— / 1	3 / —	5P / —	— / 1	— / 9M	7P / —	— / 9S	— / 7M	— / 4P	
	2 / —	6M / —	— / 9P	— / 3	4M / —	5S / —	— / 1	— / 2	5M / —	
	1 / —	4M / —	7M / —	7S / —	— / 6S	— / 5M	— / 8S	1 / —	9M / —	
H	5S / —	— / 8P	— / 9S	— / 1	— / 4P	8M / —	3 / —	— / 4S	2 / —	B
	— / 2	6P / —	3 / —	— / 3	9P / —	— / 2	7P / —	6M / —	5P / —	
	3 / —	9M / —	4P / —	— / 2	— / 5P	9S / —	9P / —	— / 8M	— / 1	
I	— / 5M	8S / —	2 / —	— / 6M	8P / —	— / 3	— / 7S	3 / —	4M / —	C
	1 / —	— / 7P	— / 6S	— / 7M	— / 4S	— / 1	5S / —	— / 2	6P / —	
					F					

System of Replication: 9 randomised blocks of 9 plots each. Each plot divided into 2 sub-plots.

Area of Each Sub-Plot: 1/100th acre.

Treatments: Testing 0, 0.2 and 0.4 cwt. per acre N in form of Sulphate of Ammonia, 0, 0.4 and 0.8 cwt. per acre K_2O in the form of Sulphate of Potash, Muriate of Potash and Potash Salts.

Superphosphate at the rate of 0.5 cwt. per acre P_2O_5 applied to one out of each pair of sub-plots, indicated by the treatment symbol occurring on that half.

Farmyard manure: 14 tons per acre, approximately, applied to previous crop of Kale.

Manures applied: April 10th.

Potatoes planted: April 13th.

Potatoes lifted: Sept. 30th-Oct. 6th.

Variety: Ally.

Previous Crop: Kale fed off by sheep.

Key to Treatments.

Treatment No.	1	2	3	4	5	6	7	8	9
Sulph./Amm.	0	1	2	0	1	2	0	1	2
Potash ..	0	0	0	1	1	1	2	2	2

Actual weights in lb.—Sub-plots with Phosphate.

S/Amm	Potash	Blocks.								
		A	B	C	D	E	F	G	H	I
Quantities										
0	0	256.00	253.00	251.25	213.75	264.50	255.00	199.00	275.00	255.00
0	1	198.75	284.00	297.50	189.00	259.50	236.75	171.50	253.50	263.75
0	2	213.25	326.75	327.50	216.25	239.00	157.25	183.25	243.75	163.25
1	0	243.00	271.75	291.75	212.75	298.75	287.75	223.75	239.75	306.00
1	1	243.75	267.25	340.25	223.00	258.75	286.75	227.25	257.25	245.00
1	2	236.75	321.00	303.50	218.50	274.50	306.25	187.75	280.25	310.75
2	0	247.50	329.00	355.25	228.25	317.50	326.25	227.50	329.25	282.75
2	1	256.50	306.00	305.50	222.50	259.25	298.00	258.50	294.50	233.75
2	2	279.50	250.25	350.25	256.50	308.50	289.00	263.00	313.00	285.00

Actual weights in lb.—Sub-plots without Phosphate.

S/Amm	Potash	A	B	C	D	E	F	G	H	I
Quantities										
0	0	244.75	241.50	252.75	194.75	251.50	275.50	176.25	249.00	151.25
0	1	210.75	262.25	302.00	207.50	226.00	262.25	206.25	242.00	256.50
0	2	238.25	337.00	334.75	204.00	224.50	264.00	207.25	225.50	249.75
1	0	250.00	250.25	303.75	200.00	283.00	261.00	241.25	232.50	266.00
1	1	221.00	282.00	300.25	232.50	256.75	264.00	194.50	255.50	256.75
1	2	217.75	294.00	330.25	203.25	301.50	280.00	211.00	240.25	266.25
2	0	251.50	318.75	354.25	188.00	279.50	319.00	216.50	286.25	258.50
2	1	262.50	318.75	277.00	183.25	243.75	299.75	261.50	275.50	285.50
2	2	249.25	244.25	347.75	203.75	283.50	307.00	207.50	281.75	289.00

Summary of Results.

Effect of Quantity of Nitrogenous and Potassic Fertilisers, in relation to Superphosphate.

		Average yield in tons per acre.				Average yield per cent.			
		No S/Amm.	Single S/Amm.	Double S/Amm.	Mean.	No S/Amm.	Single S/Amm.	Double S/Amm.	Mean.
Without Super	No Potash ..	10.11	11.35	12.26	11.24	87.4	98.1	106.0	97.2
	Single Potash..	10.79	11.23	11.94	11.32	93.3	97.1	103.3	97.9
	Double Potash	11.33	11.63	11.97	11.65	98.0	100.5	103.5	100.7
Mean		10.74	11.40	12.06	11.40	92.9	98.6	104.3	98.6
With Super	No Potash ..	11.02	11.78	13.11	11.97	95.3	101.9	113.4	103.5
	Single Potash..	10.69	11.65	12.08	11.47	92.4	100.8	104.4	99.2
	Double Potash	10.27	12.10	12.87	11.75	88.8	104.6	111.3	101.6
Mean		10.66	11.84	12.69	11.73	92.2	102.4	109.7	101.4
Mean of super and no super		10.70	11.62	12.37	11.57	92.5	100.5	107.0	100.0

Standard Errors: Single treatment : 0.385 tons or 3.33%.
Mean of 3 treatments : 0.222 tons or 1.92%.
Mean of Super. and no Super. : 0.189 tons or 1.64%.

Effect of Quantity and Quality of Potassic Fertilisers, in relation to Superphosphate.

		Average yield in tons per acre.			Average yield per cent.		
		Sulphate of Potash.	Muriate of Potash.	Potash Salts.	Sulphate of Potash.	Muriate of Potash.	Potash Salts.
Without Super	No Potash ..		11.24			97.2	
	Single Potash ..	11.46	11.74	10.76	99.1	101.5	93.0
	Double Potash ..	11.75	11.45	11.74	101.6	99.0	101.5
Mean of Single and Double Potash		11.60	11.59	11.25	100.3	100.2	97.3
With Super	No Potash ..		11.97			103.5	
	Single Potash ..	11.22	11.66	11.54	97.0	100.8	99.7
	Double Potash ..	12.31	10.77	12.16	106.4	93.1	105.1
Mean of Single and Double Potash		11.77	11.21	11.85	101.7	97.0	102.4

Standard Errors: Single treatment = 0.385 tons or 3.33%.
Means = 0.272 tons or 2.35%.

Definitely significant response to sulphate of ammonia and significant response to superphosphate. No response to Potash.

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SUGAR BEET

Correction to 1929 Experiment.

A further examination of this experiment revealed certain defects which vitiate the original analysis. A new analysis has now been made. The principal correction is that the standard errors given in the original summary of results (1929 Report, p. 103-5) are considerably too small.

No standard errors applicable for all comparisons can be assigned to the tables (*a*), of separate treatments. The standard errors of table (*b*), comparing Sulphate of Ammonia, Nitrate of Soda and no nitrogen, should be :

	Roots.	Tops.	Sugar Percentage.
Tons per acre	0.093	0.070	
Per cent.	1.25	1.30	0.068

and the summary under (*b*) stands without correction.

No response to or interaction with phosphate is significant. Table (*c*) should therefore read as follows :

(*c*) **Effect of Salt and Chloride of Potash, averaging for Variety, Phosphate and Nitrogen.**

	Roots.			*Tops.*		
Average yield—tons per acre.	Without Mur./Pot.	With Mur./Pot.	Mean.	Without Mur./Pot.	With Mur./Pot.	Mean.
Without Salt ..	7.28	7.38	7.33	5.13	5.35	5.24
With Salt	7.54	7.52	7.53	5.56	5.60	5.58
Mean	7.41	7.45	7.43	5.34	5.48	5.41
Standard Error ..		0.107			0.081	

The summary should read :

The increase of yield due to salt is barely significant in the case of the roots, but is definitely significant in the case of the tops. Muriate of Potash shows no significant effects.

The standard errors given in Table (*d*) do not apply to the comparisons shown, and no effect of phosphate or variety can claim to be clearly significant. The same applies even more strongly to the possible interactions discussed at the foot of p. 105 ; none of these seem to produce effects of any importance.

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Sugar Beet: Comparison of Dunging immediately before ploughing, and three weeks previously. Test of loosening sub-soil by hand digging. Variation in spacing.

R S—Great Harpenden—1931

A N.E. B

	7	5	8	3	2	7	1	5	
	6	1	4	2	4	8	3	6	
C	6	5	8	3	1	4	2	5	D
	2	4	1	7	6	3	7	8	
	6	4	1	2	2	7	3	5	
	3	8	7	5	8	6	4	1	

E F

Key to Treatments.

1	2	3	4	5	6	7	8
D 1 P S1	D2 P S1	D1 H S1	D2 H S1	D1 P S2	D2 P S2	D1 H S2	D2 H S2

System of Replication: 6 randomised blocks of 8 plots each.

Area of Each Plot: .00368 acre.

Variety: Kuhn.

Treatments: All combinations of: dunged three weeks before ploughing (D1) *v* dunged immediately before ploughing (D2). Ploughed only (P) *v* Ploughed and hand dug (H). Spacing 16 ins. by 16 ins. (SI) *v* Spacing 24 ins. by 10 2/3rd ins. (S2). Dung at the rate of 20 tons per acre.

Basal Dressing: Sulphate of Ammonia at the rate of 0.4 cwt. N per acre, K cl at the rate of 0.6 cwt. K_2O per acre, Superphosphate at the rate of 0.3 cwt. P_2O_5 per acre.

Seed sown: May 8-9th.

Beet lifted: Oct. 31-Nov. 3rd.

Previous crop: Temporary ley, 1st crop taken for hay. Aftermath eaten off by sheep, which were also fed on turnips and corn.

Actual weights in lb.

Block.	Roots (dirty)							
	1	2	3	4	5	6	7	8
A ..	117	127	110	120	108	118	104	108
B ..	111	130	112	126	96	112	106	119
C ..	128	127	124	128	112	118	118	117
D ..	126	128	122	124	109	121	110	102
E ..	126	132	118	122	113	119	116	115
F ..	119	132	114	122	100	112	111	122
	Tops.							
A ..	127	143	118	138	120	129	113	134
B ..	120	136	126	142	109	134	118	144
C ..	130	135	115	162	126	132	138	128
D ..	132	146	134	132	134	140	130	126
E ..	141	154	119	143	121	140	133	136
F ..	128	150	120	124	108	128	131	143

Block.	1	2	3	4	5	6	7	8
	Sugar Percentage.							
A ..	19.26	19.38	19.38	19.53	19.20	19.61	18.86	19.32
B ..	18.76	18.98	19.47	19.43	18.76	18.70	19.20	18.81
C ..	19.03	19.09	20.06	19.50	20.06	19.61	18.86	19.38
D ..	19.32	18.53	19.61	19.38	18.92	19.03	19.90	19.20
E ..	19.32	19.26	19.61	19.67	19.26	18.98	19.61	19.09
F ..	19.61	18.52	19.06	19.38	20.06	18.86	18.70	19.26

Summary of Results.

Average yield.	tons per acre. Spacing 16″×16″	tons per acre. Spacing 24″×10⅜″	tons per acre. Mean.	per cent. Spacing 16″×16″	per cent. Spacing 24″×10⅜″	per cent. Mean.
Roots (washed)						
Dunged Early: Ploughed only ..	13.07	11.47	12.27	103.3	90.6	97.0
Dunged Early: Ploughed and hand dug	12.58	11.96		99.4	94.5	
Dunged Early: Mean	12.83	11.71		101.4	92.6	
Dunged Late: Ploughed only ..	13.95	12.58	13.04	110.2	99.4	103.0
Dunged Late: Ploughed & hand dug	13.34	12.28		105.4	97.0	
Dunged Late: Mean	13.64	12.43		107.8	98.2	
Mean of dunged early and late..	13.24	12.08	12.66	104.6	95.4	100.0
Mean of ploughed only ..	13.51	12.02		106.8	095.	
Mean of ploughed and dug ..	12.96	12.12		102.4	95.8	
Tops—						
Dunged Early: Ploughed only ..	15.73	14.52	15.12	98.6	91.0	94.8
Dunged Early: Ploughed & hand dug	14.80	15.43		92.8	96.7	
Dunged Early: Mean	15.26	14.97		95.7	93.9	
Dunged Late: Ploughed only ..	17.47	16.24	16.78	109.5	101.8	105.2
Dunged Late: Ploughed & hand dug	17.00	16.40		106.6	102.8	
Dunged Late: Mean	17.24	16.32		108.1	102.3	
Mean of dunged early and late..	16.25	15.64	15.95	101.9	98.1	100.0
Mean of ploughed only ..	16.60	15.38		104.0	96.4	
Mean of ploughed and dug ..	15.90	15.92		99.7	99.8	

Sugar Percentage in Roots.	Ploughed only. Spacing 16″×16″	Ploughed only. Spacing 24″×10⅜″	Ploughed and hand dug. Spacing 16″×16″	Ploughed and hand dug. Spacing 24″×10⅜″
Dunged early	19.22	19.38	19.53	19.19
,, late	18.96	19.13	19.48	19.18
Mean	19.09	19.26	19.50	19.18

Standard Errors.

	Tons per acre.			Per cent.		
	Single treatment.	Mean of 2 treatments.	Mean of 4 treatments.	Single treatment.	Mean of 2 treatments.	Mean of 4 treatments.
Roots ..	0.210	0.148	0.105	1.66	1.17	0.83
Tops ..	0.417	0.295	0.209	2.62	1.85	1.31
Sugar %	0.145	0.103	0.073	—	—	—

Definitely significant effect of time of applying dung, both on roots and tops, the later application being superior. The square spacing is significantly superior to the rectangular spacing, in general, and the effect is significantly greater on the plots without hand digging, both as regards roots and tops. The sugar percentage is significantly higher on the hand dug plots with square spacing than on the remaining plots. Taken in conjunction with the yields this implies that the total yield of sugar is significantly increased by square spacing, but is not affected by hand digging.

REPLICATED EXPERIMENTS AT WOBURN

Sugar Beet: Nitrogenous Fertilisers, Sulphate of Ammonia and Nitrate of Soda.

Chloride Dressing, Sodium Chloride.

W S—Butt Furlong, 1931 (Micro-Plots)

N.E.

I.	4	5	6	1	2	3
II.	3	2	1	5	4	6
III.	6	4	3	2	5	1
IV.	2	6	5	3	1	4
V.	5	1	4	6	3	2
VI.	1	3	2	4	6	5

SYSTEM OF REPLICATION: 6×6 Latin Square.

AREA OF EACH PLOT: 0.00155 acre.

VARIETY: Kuhn.

TREATMENTS: No nitrogen *v* Sulphate of Ammonia *v* Nitrate of Soda at the rate of 0.53 cwt. N per acre, Sodium Chloride at the rate of 1.3 cwt. Cl. per acre.

All plots received carbonate of lime at the rate of 1 ton per acre, Superphosphate at the rate of 0.4 cwt. P_2O_5 per acre, and Muriate of Potash at the rate of 0.8 cwt. K_2O per acre.

Manures applied: May 9th.

Seed sown: May 9th.

Beet Lifted: Nov. 23rd.

Previous crop: Seeds sown among barley.

Key to Treatments.

Treatment.	1	2	3	4	5	6
Sulphate of Ammonia		x			x	
Nitrate of Soda			x			x
Sodium Chloride		x		x		x

Yields in lb. corrected to constant plant number (46).

Row.	Roots (washed).						Tops.					
	1	2	3	4	5	6	1	2	3	4	5	6
I. ..	36	48	42	40	48	47	42	64	74	55	71	76
II. ..	32	47	42	46	50	41	46	65	72	40	56	61
III. ..	31	43	48	34	41	47	43	51	64	43	51	74
IV. ..	29	53	48	37	49	53	44	80	68	52	69	77
V. ..	36	49	42	39	47	48	43	67	60	47	63	64
VI. ..	37	47	48	39	50	44	48	61	62	55	67	63

Row.	Sugar Percentage.					
	1	2	3	4	5	6
I.	17.50	17.56	16.70	17.50	17.44	16.75
II.	17.10	17.22	16.70	17.39	17.27	16.42
III.	16.36	16.76	16.48	16.76	16.48	17.27
IV.	16.25	17.22	16.87	16.82	17.00	16.93
V.	18.01	17.22	16.47	17.50	16.92	17.62
VI.	17.22	18.02	16.70	17.44	17.56	17.84

Summary of Results corrected to constant plant number (46).

Average yield.	Tons per acre.				Per cent.			
	No Nitrog.	S/Amm.	N/Soda	Mean.	No Nitrog.	S/Amm.	N/Soda	Mean.
Roots—								
Without Chloride ..	9.65	13.68	12.96	12.10	77.4	109.8	104.0	97.0
With Chloride	11.28	13.78	13.44	12.83	90.5	110.5	107.8	103.0
Mean	10.46	13.73	13.20	12.46	84.0	110.1	105.9	100.0
Tops—								
Without Chloride ..	12.77	18.10	19.20	16.69	74.6	105.8	112.2	97.6
With Chloride	14.02	18.62	19.92	17.52	81.9	108.9	116.5	102.4
Mean	13.39	18.36	19.56	17.10	78.3	107.3	114.4	100.0

Sugar percentage.	No Nitrogen.	S/Amm.	N/Soda.	Mean.
Without Chloride	17.07	17.11	16.65	16.95
With Chloride	17.24	17.33	17.14	17.24
Mean	17.15	17.22	16.90	17.09

Standard Errors.

	Tons per acre.			Per cent.		
	Single treatment.	Mean of 2 treatments.	Mean of 3 treatments.	Single treatment.	Mean of 2 treatments.	Mean of 3 treatments.
Roots	0.430	0.302	0.248	3.45	2.44	1.99
Tops	0.510	0.361	0.294	2.98	2.11	1.72
Sugar percentage ..	0.156	0.110	0.090	—	—	—

The effect of the nitrogenous dressings is definitely significant. Nitrate of Soda is significantly superior to Sulphate of Ammonia in the case of the tops, but is not significantly inferior in the case of the roots. The effect of chloride is just significant. The sugar percentage is significantly increased by sodium chloride ; the depression with Nitrate of Soda is not significant.

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Sugar Beet: Nitrogenous Fertilisers, Sulphate of Ammonia and Nitrate of Soda.
Chloride Dressing: Agricultural Salt (NaCl), comparison of early and late dressings.
Incorporation of Fertilisers by means of Simar or Harrow.

W S—Butt Furlong, 1931.

N.

									A				B			C							
								12	3	7	6	11	3	5	2	9							
								5	1	11	1	7	10	8	6	12							
								2	8	9	12	8	4	7	3	11							
						D		4	10	6	5	2	9	10	4	1							
					11	1	4	5	4	12	6	7	4	5	10	11							
					10	2	8	9	5	3	8	11	8	9	3	7	F						
					3	7	12	6	9	1	10	2	12	2	1	6							
3	10	11	7	1	5	6	9	10	1	6	2	4	9	5	3	2	11	12	10	2	7	8	6
1	5	2	8	12	10	7	11	4	11	3	8	6	2	12	7	8	5	7	6	10	12	5	4
9	12	6	4	3	4	8	2	9	7	12	5	1	11	8	10	9	3	1	4	1	3	11	9
		G				H				I				J				K				L	

Key to Treatments.

Treatm't	Nitrogen	Salt.	Time of Appl'n
1	O	O	E
2	S	O	E
3	N	O	E
4	O	I	E
5	S	I	E
6	N	I	E
7	O	O	L
8	S	O	L
9	N	O	L
10	O	I	L
11	S	I	L
12	N	I	L

System of Replication: 12 randomised blocks of 12 plots each, one block of each pair being simared.

Area of Each Plot: 1/90th acre.

Variety: Kuhn.

Treatments: No Nitrogen *v* Sulphate of Ammonia *v* Nitrate of Soda at the rate of 0.6 cwt. N per acre. Agricultural Salt at the rate of 1.5 cwt. Cl per acre.

The whole of the area was treated with 1 ton of Carbonate of Lime per acre. All plots received Superphosphate at the rate of 0.5 cwt. P_2O_5 per acre and Muriate of Potash at the rate of 1 cwt. K_2O per acre.

The whole of the manures were applied early (E), three weeks before sowing, or late (L), at time of sowing.

Blocks B, D, F, H, J, K were simared after first manurial dressing and all other blocks harrowed. Simaring was tested against harrowing as a method of incorporating the manures with the soil, rather than as a cultivation treatment.

Manures applied early: April 17th. Late: May 8th.

Seed sown: May 8th.

Beet Lifted: November 4th-18th.

Previous crop: Seeds sown among barley.

https://doi.org/10.23637/ERADOC-1-65

Weights in lb. corrected to constant plant number (100)—Roots (dirty).

Block.	1	2	3	4	5	6	7	8	9	10	11	12
A ..	132.7	158.7	121.6	127.9	125.2	146.0	116.8	145.4	131.9	112.8	150.7	128.1
B ..	146.6	109.4	132.9	115.8	138.6	143.5	123.8	144.3	122.5	119.5	157.3	139.3
C ..	97.6	142.0	108.4	79.2	140.6	117.7	83.5	158.5	132.5	75.0	143.7	139.0
D ..	61.6	80.0	104.7	75.6	99.3	83.7	70.5	111.6	87.6	70.6	103.1	89.9
E ..	76.7	105.9	75.7	78.3	95.0	96.4	83.4	108.7	97.1	67.9	102.8	107.6
F ..	72.6	98.1	77.1	72.2	92.4	101.1	77.3	107.5	107.2	62.9	118.0	114.4
G ..	77.3	104.0	102.8	95.3	106.0	98.0	84.4	110.9	113.2	75.7	113.3	108.1
H ..	104.1	124.9	115.5	108.6	106.9	68.0	75.7	125.0	113.6	93.0	118.4	121.0
I ..	68.2	96.6	88.9	87.0	122.2	70.3	93.7	102.7	124.2	84.2	114.0	119.1
J ..	100.4	106.9	77.3	70.1	96.5	88.9	76.5	128.9	113.9	112.8	144.3	113.7
K ..	97.6	95.8	105.2	95.7	93.6	86.5	70.8	114.4	135.1	92.3	116.5	102.5
L ..	96.2	120.0	108.0	96.6	127.9	126.9	108.5	138.4	114.9	95.9	127.5	129.1

Weights in lb. corrected to constant plant number (100)—Tops.

Block.	1	2	3	4	5	6	7	8	9	10	11	12
A ..	112.9	145.4	123.3	103.9	127.6	155.6	93.4	130.7	130.5	93.4	127.4	125.9
B ..	126.2	93.0	123.0	92.5	125.2	127.5	69.6	127.9	121.0	95.4	81.4	160.7
C	90.1	140.9	141.0	59.7	128.9	163.8	83.3	146.9	75.6	56.0	180.5	194.6
D ..	37.2	62.9	104.4	46.5	75.2	55.2	43.3	77.1	64.8	55.7	87.7	65.4
E ..	43.6	74.5	51.9	47.0	75.0	73.0	50.1	61.4	66.0	37.8	72.5	87.6
F ..	34.8	61.1	48.5	44.6	62.1	64.9	43.3	74.2	76.5	35.6	89.5	81.9
G ..	67.0	107.0	101.5	84.2	106.0	103.1	69.9	122.7	118.5	54.4	101.4	111.9
H ..	96.9	100.9	120.1	88.0	101.0	46.8	50.0	100.5	88.2	71.0	85.2	130.2
I ..	39.6	62.7	53.4	60.9	88.5	39.4	57.5	71.4	102.4	49.1	87.4	93.4
J ..	70.4	67.3	45.1	38.4	68.9	63.0	38.6	86.4	84.7	69.3	112.9	84.7
K ..	63.2	66.9	76.1	68.9	66.1	71.6	45.6	65.7	112.6	70.0	79.2	92.9
L ..	70.0	108.8	100.5	81.5	114.1	131.8	81.6	128.8	120.5	79.1	124.4	125.9

Sugar Percentage in Roots.

Block.	1	2	3	4	5	6	7	8	9	10	11	12
A ..	17.13	17.56	16.07	17.56	17.39	17.41	17.76	17.62	17.22	17.27	16.88	16.87
B ..	17.04	17.22	17.22	17.84	17.38	16.67	17.62	18.01	17.56	18.24	17.68	16.99
C ..	17.73	17.79	16.65	17.68	17.98	17.04	17.44	17.90	16.47	17.04	16.42	16.93
D ..	17.90	17.61	17.24	17.62	17.89	18.30	18.64	17.73	18.24	18.53	17.84	18.47
E ..	18.42	18.24	18.48	17.95	18.18	17.74	18.12	18.12	18.61	19.24	17.96	17.78
F ..	18.84	18.30	18.07	18.18	18.06	17.95	18.24	18.07	18.41	18.35	18.01	19.10
G ..	17.56	18.35	17.56	18.13	18.04	17.22	18.36	18.19	18.04	18.41	18.96	18.07
H ..	18.24	18.04	17.58	17.95	18.24	18.07	18.18	18.58	18.39*	18.06	18.52	17.73
I ..	18.86	18.19	18.64	18.12	17.95	19.02	18.75	18.30	18.44	18.98	18.71	18.70
J ..	18.99	18.19	18.70	18.93	18.70	18.02	18.38	17.68	19.21	17.95	18.99	18.12
K ..	18.35	18.64	17.78	18.24	17.62	17.62	18.41	19.21	18.42	18.25	19.38	17.73
L ..	17.50	18.18	17.73	17.56	17.79	17.79	17.96	16.93	17.84	18.27	17.78	17.78

* Estimated.

Summary of Results corrected to constant plant number (100).

Average yield.		Early No Nitrogen	Early S/Amm.	Early N/Soda	Late No Nitrogen	Late S/Amm.	Late N/Soda
Roots (washed) tons per acre	Harrowed and no salt	—	12.94	10.78	9.96	13.61	12.71
	Harrowed and salt	10.04	12.76	11.66	9.10	13.39	13.01
	Simared and no salt	—	10.95	10.91	9.59	13.03	12.10
	Simared and salt ..	9.58	11.17	10.18	9.81	13.49	12.12
Roots— per cent.	Harrowed and no salt	—	112.6	93.8	86.6	118.4	110.5
	Harrowed and salt	87.4	111.0	101.5	79.2	116.5	113.2
	Simared and no salt	—	95.2	94.9	83.4	113.3	105.3
	Simared and salt ..	83.3	97.2	88.5	85.3	117.3	105.4
Tops— tons per acre	Harrowed and no salt	—	15.41	13.78	10.35	15.96	14.79
	Harrowed and salt	10.54	15.43	16.07	8.91	16.72	17.82
	Simared and no salt	—	10.90	12.47	8.67	12.82	13.20
	Simared and salt ..	9.13	12.02	10.34	9.57	12.92	14.84
Tops— per cent.	Harrowed and no salt	—	119.9	107.2	80.6	124.2	115.1
	Harrowed and salt	82.0	120.1	125.1	69.4	130.1	138.7
	Simared and no salt	—	84.8	97.0	67.5	99.8	102.8
	Simared and salt	71.1	93.5	80.5	74.5	100.5	115.5
Sugar Percentage—	Harrowed and no salt	—	18.05	17.52	17.97	17.84	17.77
	Harrowed and salt	17.83	17.89	17.70	18.20	17.78	17.69
	Simared and no salt	—	18.00	17.76	18.24	18.21	18.37
	Simared and salt	18.13	17.98	17.77	18.23	18.40	18.02

Standard Errors : Roots : 0.869 tons or 7.65 per cent.
Tops : 1.702 tons or 13.54 per cent.
Sugar Percentage : 0.252.

Effect of Nitrogenous Manures.

Mean of Salt and No Salt.		No Nitrogen.	S/Amm.	N/Soda.	Mean.	Standard Error.
Roots— tons per acre	Early ..	9.81*	11.96	10.88	10.88	0.270
	Late.. ..	9.62	13.38	12.48	11.83	
	Mean ..	9.72	12.67	11.68	11.36	
Roots— per cent.	Early ..	85.4*	104.0	94.7	94.7	2.35
	Late.. ..	83.6	116.4	108.6	102.9	
	Mean ..	84.5	110.2	101.6	98.8	
Tops— tons per acre	Early ..	9.84*	13.44	13.16	12.15	0.528
	Late.. ..	9.38	14.60	15.16	13.05	
	Mean ..	9.61	14.02	14.16	12.60	
Tops— per cent.	Early ..	76.6*	104.6	102.4	94.5	4.11
	Late.. ..	73.0	113.6	118.0	101.5	
	Mean ..	74.8	109.1	110.2	98.0	
Sugar percentage—	Early ..	17.98*	17.98	17.68	17.88	0.088
	Late.. ..	18.16	18.06	17.96	18.06	
	Mean ..	18.07	18.02	17.82	17.97	

*The 12 plots without nitrogen or salt that should have received their basal dressing early received it late in error, and have been included in the late group.

Nitrogen is significantly beneficial, both to the roots and tops, and the late dressing of nitrogen is significantly superior to the early dressing. There is no indication that the late application of the basal manures is superior to the early application, except possibly in raising the sugar content.

Sulphate of ammonia is significantly superior to nitrate of soda for the roots, but there is no difference in the case of the tops.

Salt produced no effect, either in the early or late dressing.

Nitrogenous dressings significantly depress the sugar percentage ; the depression being significantly greater with nitrate of soda. The plots with early dressings have a significantly lower sugar content than those with late dressings ; this difference is most marked in the case of the sulphate of ammonia plots.

The difference between simaring and harrowing is not significant, (the experiment is incapable of giving a precise verdict on this point).

REPLICATED EXPERIMENTS AT OUTSIDE CENTRES

Grassland. Meadow Hay.

(Basic Slag Committee).

W. Eydes, Esq., Walton Lodge Farm, Walton, Chesterfield, Derby, 1931. (DH-). Second Season.

Permanent grass.

I.	H / —	L / —	— / M	— / O	— / S
II.	M / —	H / —	— / O	S / —	L / —
III.	S / —	O / —	— / L	M / —	— / H
IV.	— / L	— / M	— / S	H / —	O / —
V.	O / —	S / —	— / H	— / L	— / M

System of Replication: 5x5 Latin Square, plots split for Potash.
Area of Each Whole Plot: 1/15 acre.
Soil: Clay 6 in. deep.
Treatments:
O = No phosphate.
S = Superphosphate.
M = Mineral Phosphate.
L = Low Soluble Slag (Citric solubility 23.0%).
H = High soluble Slag (,, ,, 96.5%).
Muriate of Potash at the rate of 0.5 cwt. K_2O per acre applied to one out of each pair of sub-plots (indicated by the treatment symbol occurring on that half.)
Phosphatic dressings at the rate of 1 cwt. P_2O_5 per acre, applied March 18th.
Hay cut: July 27th.
Hay weighed: August 6-7th.

Actual weights in lb.—Dry Weights.

Row.	Without Muriate of Potash. O	S	M	L	H	With Muriate of Potash. O	S	M	L	H
I	76.7	94.4	86.3	102.5	104.7	88.5	106.9	98.8	104.7	117.2
II	97.3	108.4	117.2	97.3	107.6	99.5	112.8	123.1	101.0	120.9
III	113.9	111.7	112.1	115.6	107.6	117.2	126.2	120.9	116.1	120.9
IV	97.4	107.2	101.6	100.5	108.0	100.5	115.0	120.3	112.7	110.0
V	110.1	104.0	102.0	91.8	108.7	108.7	132.4	105.3	82.4	105.3

Summary of Results—Dry weights.

Average yield. cwt. per acre	No Phos-phate	Mineral Phosphate.	Low Slag.	High Slag.	Super.	Mean.	Standard Error
Without Potash ..	26.5	27.8	27.2	28.8	28.2	27.7	0.789
With Potash	27.6	30.4	27.7	30.8	31.8	29.6	
Mean	27.0	29.1	27.4	29.8	30.0	28.7	0.658
Average yield. per cent.							
Without Potash ..	92.6	97.0	94.9	100.3	98.2	96.6	2.75
With Potash	96.1	106.2	96.6	107.3	110.8	103.4	
Mean	94.3	101.6	95.7	103.8	104.5	100.0	2.29

Significant response to mineral phosphate, to high soluble slag, and to superphosphate. The effect of potash is also significant.

Grassland. Meadow Hay.

(Basic Slag Committee).

W. H. Limbrick, Esq., Badminton Farm, Badminton, Gloucester—1931. (GH-). Second Season.

I.	A —	— B	C —	D —	E —
II.	D —	— C	— E	B —	A —
III.	B —	— E	— D	A —	C —
IV.	— E	A —	— B	C —	— D
V.	— C	D —	A —	— E	— B

Permanent grass.

SYSTEM OF REPLICATION: 5×5 Latin Square, plots split for Potash.

AREA OF EACH SUB-PLOT: 1/20th acre.

SOIL: Light red loam, 8 ins. deep.

TREATMENTS:
B = No phosphate.
A = Superphosphate.
D = Mineral Phosphate.
C = Low Soluble Slag (Citric solubility 23.0°/ₒ).
E = High Soluble Slag (,, ,, 96.5°/ₒ).

Half of each plot received 1 cwt. Muriate of Potash per acre, applied to one out of each pair of sub-plots (indicated by the treatment symbol occurring on that half).

Phosphatic dressings at the rate of 1 cwt. P_2O_5 per acre.

Hay cut: June 29th.

Hay weighed July 4th.

Actual weights in lb. (Green weights).

Row.	A	B	C	D	E	A	B	C	D	E
	With Muriate of Potash.					Without Muriate of Potash.				
I.	365.5	296.5	326.5	335.5	323.0	325.0	257.0	323.0	286.0	307.5
II.	303.0	321.0	327.5	304.5	389.5	323.0	336.5	300.5	337.0	358.0
III.	375.5	360.0	350.5	381.0	354.5	384 5	336.0	335.5	377.0	326.5
IV.	363.5	430.0	329.0	355.0	390.5	387.5	362.0	370.5	368.5	383.0
V.	448.5	426.5	350.0	378.5	434.0	413.5	347.5	351.0	386.5	398.5

Summary of Results (Dry weights).

Average yield cwt. per acre.	No Phosphate.	Mineral Phosphate.	Low Slag.	High Slag.	Super.	Mean.	Standard Error.
Without M/Pot	40.9	44.3	43.1	45.3	46.8	44.1	} 1.17
With M/Pot ..	45.3	43.1	43.4	47.9	47.1	45.4	
Mean	43.1	43.7	43.2	46.6	47.0	44.7	0.840
Average yield per cent.							
Without M/Pot	91.5	99.1	96.4	101.2	104.7	98.6	} 2.61
With M/Pot ..	101.3	96.3	96.9	107.2	105.3	101.4	
Mean	96.4	97.7	96.7	104.2	105.0	100.0	1.88

Significant response to high slag and to superphosphate. The response to muriate of potash is also significant. High slag and super are significantly superior to low slag but not to mineral phosphate.

Barley: Effect of Nitrogenous Fertilisers, and of Sulphate of Potash and Superphosphate.

G. H. Nevile, Esq., Wellingore Hall, Lincs.—1931. (VB-).

Plan and Actual Weights.

Grain (dry weights) lb.								Straw (dry weights) lb.							
O 19.4	K 17.9	O 17.8	P 17.7	O 18.0	P 15.7	K 19.0	PK 17.6	O 19.7	K 19.3	O 19.3	P 21.5	O 20.9	P 19.3	K 20.8	PK 20.9
P 19.1	PK 19.8	K 18.5	PK 19.0	PK 17.9	K 17.2	P 19.1	O 17.3	P 21.2	PK 20.6	K 20.1	PK 21.0	PK 20.9	K 19.9	P 19.8	O 19.4
P 21.5	K 21.5	PK 23.4	O 20.3	P 19.3	K 17.9	K 18.9	P 19.2	P 28.0	K 22.6	PK 21.9	O 20.4	P 20.2	K 20.0	K 23.6	P 20.5
O 16.1	PK 15.7	K 17.5	P 15.9	PK 17.2	O 15.0	PK 18.0	O 18.4	O 17.9	PK 17.3	K 17.7	P 15.1	PK 17.9	O 15.2	PK 19.7	O 17.0
O 16.6	PK 15.5	P 14.5	O 15.8	P 15.0	K 14.7	P 16.8	K 13.2	O 20.2	PK 19.1	P 20.9	O 19.9	P 19.1	K 17.0	P 21.6	K 20.4
P 14.6	K 16.6	K 17.8	PK 17.9	PK 13.6	O 13.2	O 14.9	PK 13.9	P 21.6	K 21.2	K 19.6	PK 21.2	PK 18.1	O 12.9	O 18.8	PK 18.8
O 15.1	P 13.4	PK 14.1	K 15.4	K 15.9	PK 13.2	P 12.4	K 15.4	O 19.3	P 18.5	PK 17.5	K 18.7	K 19.0	PK 15.6	P 15.9	K 17.6
PK 15.4	K 18.8	O 15.8	P 13.3	P 15.5	O 14.0	O 16.7	PK 13.6	PK 18.2	K 21.2	O 20.8	P 20.7	P 19.8	O 17.9	O 18.5	PK 17.5

Straw computed by ratio of grain / total produce.

Plan showing Nitrogenous Treatments applied to whole plots.

O	S	N	C
S	O	C	N
N	C	O	S
C	N	S	O

System of Replication: 4 × 4 Latin Square with plots sub-divided into 4.

Area of Each Whole Plot: 1/50th acre.

Soil: Light loam on Lincoln Heath.

Variety: Plumage Archer.

Treatments:

O = No Nitrogen.
C = Cyanamide.
N = Nitrate of Soda.
S = Sulphate of Ammonia.
} at the rate of 0.2 cwt. N per acre.

Plots sub-divided to receive no Potash or Superphosphate (O), Sulphate of Potash (K), at the rate of 0.6 cwt. K_2O per acre, Superphosphate (P) at the rate of 0.4 cwt. P_2O_5 per acre, and Sulphate of Potash and Superphosphate (PK).

Plots harvested by sampling method.

Manures applied: March 27th.

Barley sown: March 27th.

Barley harvested: September 2nd.

Previous Crop: Oats.

Summary of Results.

Average yield	Cwt. per acre					Per cent.				
	No Nitrogen	Sulph./ Amm.	Nitrate of Soda	Cyana-mide	Mean	No Nitrogen	Sulph./ Amm.	Nitrate of Soda	Cyana-mide	Mean
Grain—										
No Potash or Super...	31.1	28.0	30.7	28.2	29.5	104.1	94.0	102.9	94.6	98.9
Sulphate of Potash ..	29.2	30.8	30.4	32.8	30.8	98.0	103.4	101.9	110.0	103.3
Superphosphate ..	27.9	31.9	28.0	29.6	29.4	93.4	107.0	94.0	99.2	98.4
Potash and Super. ..	31.4	27.6	29.2	30.4	29.7	105.3	92.5	98.0	101.9	99.4
Mean	29.9	29.6	29.6	30.3	29.8	100.2	99.2	99.2	101.4	100.0
Straw—										
No Potash or Super.	31.9	33.0	35.2	33.0	33.3	91.8	94.8	101.2	94.7	95.6
Sulphate of Potash ..	32.0	36.6	37.2	36.4	35.6	91.9	105.4	107.0	104.7	102.2
Superphosphate ..	31.8	40.6	36.6	35.4	36.1	91.5	116.6	105.4	101.9	103.8
Potash and Super. ..	34.9	32.5	34.5	34.9	34.2	100.2	93.3	99.1	100.4	98.2
Mean	32.6	35.7	35.9	34.9	34.8	93.8	102.5	103.2	100.4	100.0

Standard Errors : Comparisons involving	Grain. cwt. per acre.		Grain. per cent.	Straw. cwt. per acre.		Straw. per cent.
Sub-treatments only, over a single main treatment	1.43	or	4.79	1.71	or	4.92
Sub-treatments only, over all main treatments	0.714	or	2.39	0.857	or	2.46
Main treatments, over a single sub-treatment	1.35	or	4.52	1.55	or	4.47
Main treatments, over the mean of all sub-treatments	0.531	or	1.78	0.460	or	1.32

The response to nitrogen by the straw is significant, but the grain shows no such response. There is no significant difference between the different forms of nitrogen. The superphosphate and potash produce no significant effects.

Barley: Effect of Nitrogenous Fertilisers, and of Sulphate of Potash and Superphosphate.

H. B. Bescoby, Esq., South-Eastern Agricultural College, Wye, Kent—1931. (ZB-).

Plan and Actual Weights in grammes per sample.

Grain								Straw							
P 518	PK 533	P 456	PK 502	K 544	P 526	P 461	O 398	P 570	PK 623	P 429	PK 438	K 601	P 568	P 448	O 406
O 473	K 486	K 467	O 485	O 530	PK 494	K 504	PK 424	O 457	K 520	K 470	O 473	O 536	PK 523	K 509	PK 399
P 474	K 417	O 528	PK 484	K 420	P 407	P 424	K 463	P 493	K 395	O 576	PK 502	K 417	P 399	P 396	K 465
O 484	PK 454	K 526	P 464	PK 367	O 353	PK 354	O 414	O 488	PK 470	K 589	P 563	PK 323	O 371	PK 343	O 431
K 418	P 438	O 415	PK 496	O 420	K 414	O 466	PK 505	K 414	P 432	O 434	PK 528	O 433	K 398	O 555	PK 547
O 365	PK 426	P 490	K 427	P 450	PK 426	P 551	K 477	O 335	PK 413	P 500	K 402	P 476	PK 433	P 682	K 547
O 478	PK 422	PK 438	P 377	O 462	P 458	K 406	P 505	O 487	PK 425	PK 431	P 339	O 470	P 482	K 418	P 588
K 446	P 428	K 396	O 362	PK 476	K 463	O 446	PK 453	K 477	P 403	K 370	O 350	PK 528	K 485	O 463	PK 462

Plan showing Nitrogenous Treatments applied to whole plots.

N	C	S	O
S	N	O	C
O	S	C	N
C	O	N	S

SYSTEM OF REPLICATION: 4 × 4 Latin Square with plots sub-divided into 4.

AREA OF EACH WHOLE PLOT: 1/50th acre.

Soil: Silty Loam.

Variety: Plumage Archer.

TREATMENTS:

O = No Nitrogen.
C = Cyanamide.
N = Nitrate of Soda.
S = Sulphateof Ammonia

(C, N, S) at the rate of 0.2 cwt. N per acre.

Plots sub-divided to receive no Potash or Superphosphate (O), Sulphate of Potash (K) at the rate of 0.6 cwt. K_2O per acre, Superphosphate (P) at the rate of 0.4 cwt. P_2O_5 per acre, and Sulphate of Potash and Superphosphate (PK).

Plots harvested by sampling method.

Manures applied: March 26th.

Barley sown: March 26th.

Harvested: August 14th.

Previous Crop: Barley.

Summary of Results.

Average yield	Cwt. per acre: No Nitrogen	Sulph./ Amm.	Nitrate of Soda	Cyana-mide	Mean	Per cent.: No Nitrogen	Sulph./ Amm.	Nitrate of Soda	Cyana-mide	Mean
Grain.										
No Potash or Super...	18.4	23.3	24.0	22.4	22.0	81.4	103.3	106.3	99.0	97.5
Sulphate of Potash ..	21.6	22.3	24.3	22.3	22.6	95.8	98.9	107.6	98.6	100.2
Superphosphate ..	20.9	24.8	24.8	21.9	23.1	92.7	109.9	109.7	96.9	102.3
Potash and Super. ..	20.6	23.6	24.9	21.2	22.6	91.2	104.5	110.1	93.9	99.9
Mean	20.4	23.5	24.5	21.9	22.6	90.3	104.2	108.4	97.1	100.0
Straw.										
No Potash or Super.	18.2	23.9	25.6	22.7	22.6	78.2	102.8	110.1	97.6	97.2
Sulphate of Potash ..	21.3	22.6	26.6	22.5	23.3	91.5	97.2	114.6	96.9	100.0
Superphosphate ..	20.1	26.7	28.6	21.2	24.2	86.6	115.0	122.9	91.2	103.9
Potash and Super. ..	19.5	24.7	27.4	20.4	23.0	83.8	106.1	117.7	87.7	98.8
Mean	19.8	24.5	27.0	21.7	23.2	85.0	105.3	116.3	93.3	100.0

Standard Errors : comparisons involving	Grain. cwt. per acre.		Grain. per cent.	Straw. cwt. per acre.		Straw. per cent.
Sub-treatments only, over a single main treatment	0.754	or	3.34	1.140	or	4.92
Sub-treatments only, over all main treatments	0.377	or	1.67	0.570	or	2.46
Main treatments over a single sub-treatment	0.822	or	3.64	1.319	or	5.69
Main treatments over the mean of all sub-treatments	0.499	or	2.21	0.876	or	3.78

The response to nitrogen is definitely significant, the sulphate of ammonia and nitrate of soda being significantly superior to the cyanamide, both on grain and straw. There are no other significant effects.

Barley: Effect of Nitrogenous Fertilisers, and of Sulphate of Potash and Superphosphate.

J. M. Templeton, Esq., Sparsholt Farm Institute—1931. (SB-).

Plan, and actual weights in grammes per sample.

Grain								Straw							
P 314	PK 323	P 283	K 316	O 288	PK 280	O 284	K 262	P 697	PK 467	P 405	K 586	O 474	PK 381	O 459	K 410
K 297	O 305	O 339	PK 345	K 338	P 297	P 299	PK 317	K 460	O 385	O 550	PK 537	K 471	P 460	P 484	PK 425
PK 406	K 380	PK 337	O 256	O 338	PK 316	PK 328	O 355	PK 633	K 577	PK 388	O 384	O 565	PK 474	PK 449	O 559
O 380	P 384	K 331	P 285	P 313	K 355	K 322	P 362	O 545	P 555	K 481	P 414	P 512	K 581	K 526	P 566
P 344	O 385	O 392	K 336	PK 388	P 367	PK 316	K 352	P 626	O 628	O 687	K 544	PK 748	P 585	PK 486	K 505
PK 457	K 423	P 373	PK 382	K 346	O 326	P 344	O 374	PK 812	K 712	P 572	PK 661	K 633	O 615	P 549	O 800
K 401	O 339	O 359	PK 338	P 358	K 393	O 367	K 367	K 767	O 598	O 618	PK 630	P 517	K 631	O 677	K 669
P 354	PK 347	K 378	P 356	PK 384	O 315	PK 368	P 397	P 694	PK 685	K 618	P 548	PK 661	O 587	PK 705	P 779

SYSTEM OF REPLICATION : 4 × 4 Latin Square, with plots sub-divided into 4.
AREA OF EACH WHOLE PLOT : 1/50th acre.
SOIL : Flinty loam on chalk.
VARIETY : Plumage Archer.
TREATMENTS :

- O = No Nitrogen.
- C = Cyanamide.
- N = Nitrate of Soda
- S = Sulphate of Ammonia

C, N, S: At the rate of 0.2 cwt. N per acre.

Plan showing Nitrogenous Treatments applied to whole plots.

O	N	S	C
S	O	C	N
C	S	N	O
N	C	O	S

Plots sub-divided to receive no Potash or Superphosphate (O), Sulphate of Potash (K) at the rate of 0.6 cwt. K_2O per acre, Superphosphate (P) at the rate of 0.4 cwt. P_2O_5 per acre, and Sulphate of Potash and Superphosphate (PK).

Plots harvested by sampling method.

Manures applied : April 17th.
Barley sown : April 17th.
Harvested : August 20th-21st.
Previous crop : Oats and Vetches.

Summary of Results.

Average yield	Cwt. per acre					Per cent.				
	No Nitrogen	Sulph./ Amm.	Nitrate of Soda	Cyana-mide	Mean	No Nitrogen	Sulph./ Amm.	Nitrate of Soda	Cyana-mide	Mean
Grain—										
No Potash or Super	15.6	17.8	16.9	17.0	16.8	90.6	103.5	98.6	99.1	97.9
Sulphate of Potash	17.1	17.7	17.2	17.6	17.4	99.6	103.0	100.4	102.8	101.5
Superphosphate ..	16.2	18.0	17.0	16.3	16.9	94.4	105.2	99.1	95.2	98.4
Potash and Super ..	16.9	17.9	17.5	17.8	17.5	98.6	104.1	102.1	103.6	102.1
Mean	16.4	17.8	17.2	17.2	17.2	95.8	104.0	100.0	100.2	100.0
Straw—										
No Potash or Super	26.8	29.6	28.9	28.2	28.4	94.8	104.7	102.0	99.8	100.3
Sulphate of Potash	25.8	28.1	31.2	28.9	28.5	91.3	99.4	110.4	102.0	100.8
Superphosphate ..	27.1	29.4	28.0	27.0	27.9	95.7	104.0	98.9	95.4	98.5
Potash and Super ..	24.9	29.6	30.1	29.1	28.4	88.0	104.6	106.3	102.9	100.4
Mean	26.2	29.2	29.6	28.3	28.3	92.4	103.2	104.4	100.0	100.0

Standard Errors : comparisons involving :	Grain. cwt. per acre.	Grain. per cent.	Straw. cwt. per acre.	Straw. per cent.
Subtreatments only, over a single main treatment	0.704 or	4.10	2.04 or	7.20
Subtreatments only, over all main treatments	0.352 or	2.05	1.02 or	3.60
Main treatments, over a single sub-treatment	0.789 or	4.60	2.04 or	7.22
Main treatments, over the mean of all sub-treatments	0.501 or	2.92	1.02 or	3.62

The straw, but not the grain, shows a significant response to nitrogen, without any difference between the different forms. The response of the grain to potash is not significant, and there are no superphosphate effects.

Potatoes: Effect of Superphosphate and Sulphate of Ammonia. G. Major, Esq., Newton Farm, Wisbech—1931.

IV.	III.	II.	I.
— 0	— 2½	— 5	10 —
2½ —	— 0	10 —	5 —
— 5	10 —	— 0	2½ —
10 —	5 —	— 2½	— 0

System of Replication: 4×4 Latin Square, with split plots.
Area of Each Whole Plot: 1/35th acre.
Soil: Deep silt.
Variety: Yorkshire King Edwards.
Treatments: Superphosphate at the rate of 0, 2½, 5 and 10 cwt. per acre, and half of each plot received in addition 2 cwt. Sulphate of Ammonia per acre as single and double dressing. Double Sulphate of Ammonia is indicated by the treatment symbol occurring on that half.
All plots received 4 cwt. Sulphate of Potash and 2 cwt. Sulphate of Ammonia per acre.
Manures applied: April 14th.
Land dunged in autumn of 1930.
Potatoes planted: April 16th.
Potatoes lifted: September 22nd.
Previous crop: Wheat.

Actual weights in lb.

Column	Single Sulphate of Ammonia.				Double Sulphate of Ammonia.			
	0	2½	5	10	0	2½	5	10
I.	353	365	405	363	431	392	369	413
II.	332	351	389	385	348	377	333	355
III.	322	366	349	340	312	356	338	285
IV.	397	371	298	362	366	381	363	360

Summary of Results.

Average yield. (Clean Weights.)	Tons per acre.					Per Cent.				
	No Super.	2½ cwt. Super.	5 cwt. Super.	10 cwt. Super.	Mean.	No Super.	2½ cwt. Super.	5 cwt. Super.	10 cwt. Super.	Mean.
Single S/Amm. ..	10.97	11.35	11.26	11.33	11.23	97.4	100.8	100.0	100.6	99.7
Double S/Amm. ..	11.38	11.76	10.96	11.04	11.29	101.1	104.5	97.4	98.1	100.3
Mean	11.18	11.56	11.11	11.18	11.26	99.3	102.7	98.7	99.3	100.0

Standard Error of Single treatments = 0.386 or 3.43 per cent.
Standard Error Mean of Single and Double S/Amm. = 0.192 or 1.70 per cent.

No significant effects.

https://doi.org/10.23637/ERADOC-1-65

Potatoes: Effect of Sulphate of Ammonia, Sulphate of Potash and Superphosphate.

A. W. Oldershaw, Esq., County Organiser, Tunstall, Suffolk, 1931.

N	NK	NPK	I.
ICI	NP	O	
O	NPK	NK	II.
ICI	NP	N	
N	NPK	NK	III.
NP	O	ICI	
NPK	NP	NK	IV.
O	ICI	N	
NPK	NK	O	V.
N	ICI	NP	
NP	O	NPK	VI.
N	ICI	NK	

System of Replication : 6 randomised blocks of 6 plots each.

Area of Each Plot : 1/85th acre.

Soil : Light sand, very poor.

Variety : Great Scott.

Treatments : I.C.I. complete Fertiliser and Sulphate of Ammonia at the rate of 0.6 cwt. N per acre, Sulphate of Potash at the rate of 1.21 cwt. K_2O per acre and Super at the rate of 0.63 cwt. P_2O_5 per acre. The I.C.I. fertiliser contained N, 10.3 per cent. ; P_2O_5, 10.8 per cent. ; K_2O, 20.7 per cent.

Blocks 1-3 are on chalked land, blocks 4-6 on unchalked land. The chalked area received 5 tons per acre of lump chalk during winter 1925-6.

Manures applied : April 21st.

Potatoes planted : April 22nd.

Potatoes lifted : October 7th.

Previous crop : Buck wheat.

Actual weights in lb.

Block.	O	N	NP	NK	NPK	I.C.I.
I.	177	286	311	280	312	331
II.	185	278	294	292	322	323
III.	182	258	266	284	319	313
IV.	172	257	297	219	289	334
V.	193	253	291	233	328	319
VI.	214	218	284	259	313	325

Summary of Results.

Average yield	No Nitrogen	S/Amm.	S/Amm. + S/Potash	S/Amm. + Super.	S/Amm. + Super. + S/Potash	I.C.I. Mixture	Mean	S. Error
Tons per acre ..	7.10	9.80	9.91	11.02	11.91	12.30	10.34	0.286
Per cent. ..	68.7	94.8	95.8	106.6	115.2	118.9	100.0	2.77

Definitely significant response to nitrogen. A significant improvement is produced by superphosphate. The difference between the I.C.I. mixture and the balanced dressing is not significant. The chalked half of the field has not given markedly different results from the unchalked.

https://doi.org/10.23637/ERADOC-1-65

Potatoes: Effect of Sulphate of Ammonia, Sulphate of Potash, and Superphosphate.

H. Inskip, Esq., Stanford, Biggleswade, 1931.

C			A		
2S 1K —	— 2S 2K	— 1S 2K	— 2S 0K	0S 1K —	1S 1K —
1S 0K —	— 1S 1K	0S 0K —	— 0S 0K	— 1S 2K	— 1S 0K
2S 0K —	0S 1K —	0S 2K —	— 2S 2K	— 2S 1K	0S 2K —
— 0S 1K	— 0S 2K	2S 2K —	— 2S 0K	0S 1K —	— 2S 2K
— 1S 2K	— 0S 0K	— 1S 0K	1S 2K —	— 2S 1K	0S 2K —
— 2S 1K	2S 0K —	1S 1K —	0S 0K —	1S 1K —	— 1S 0K
D			B		

System of Replication : 4 randomised blocks, each of 9 plots. split for superphosphate.

Area of Each Plot ; 1/100th acre.

Soil : Light gravel.

Variety : Arran Banner.

Treatments : Sulphate of Ammonia (S) at the rate of 0.3 and 0.6 cwt. N per acre, Sulphate of Potash (K) at the rate of 0.75 and 1.5 cwt. K_2O per acre. Superphosphate at the rate of 0.4 cwt. P_2O_5 per acre applied to one out of each pair of sub-plots (indicated by the treatment symbol occurring on that half).

Manures applied : April 13th.

Potatoes planted : April 14th

Potatoes lifted : September 18th-19th.

Previous crop : Sprouts.

Actual weights in lb. (dirty)

Block.	0-0	0-1	0-2	1-0	1-1	1-2	2-0	2-1	2-2
	With Superphosphate.								
A	256	254	201	266	241	288	280	287	275
B	213	238	177	239	247	236	251	224	246
C	259	252	261	250	271	285	252	292	271
D	211	228	221	217	269	262	272	256	267
	Without Superphosphate.								
A	261	245	207	247	250	286	270	304	282
B	182	219	213	218	220	244	265	280	254
C	255	237	240	246	250	285	274	300	295
D	222	231	248	250	234	273	236	263	248

Summary of Results.

Clean weights		Average yield tons per acre. No Potash.	Single Potash.	Double Potash.	Mean.	Average yield per cent. No Potash.	Single Potash.	Double Potash.	Mean.
Without Super	No S/Am.	9.81	9.94	9.68	9.81	91.8	92.9	90.6	91.8
	Single S/Am.	10.25	10.17	11.60	10.67	95.8	95.1	108.5	99.8
	Double S/Am.	11.14	12.23	11.50	11.63	104.2	114.4	107.6	108.7
	Mean	10.40	10.78	10.93	10.70	97.3	100.8	102.2	100.1
With Super	No S/Am.	10.01	10.36	9.17	9.85	93.6	96.9	85.8	92.1
	Single S/Am.	10.36	10.96	11.42	10.91	96.9	102.5	106.8	102.1
	Double S/Am.	11.25	11.29	11.29	11.28	105.2	105.6	105.6	105.5
	Mean	10.54	10.87	10.63	10.68	98.6	101.7	99.4	99.9

Standard Error = 0.336 tons or 3.14 per cent.

Mean of Superphosphate and No Superphosphate.

Clean weights	Average yield tons per acre. No Potash.	Single Potash.	Double Potash.	Mean.	Average yield per cent. No Potash.	Single Potash.	Double Potash.	Mean.
No S/Amm.	9.91	10.15	9.43	9.83	92.7	94.9	88.2	91.9
Single S/Amm.	10.31	10.57	11.51	10.80	96.4	98.8	107.7	101.0
Double S/Amm.	11.20	11.76	11.40	11.45	104.7	110.0	106.6	107.1

Standard Error = 0.259 tons or 2.42 per cent.

The response to sulphate of ammonia is definitely significant. There is a significant response to sulphate of potash in the presence of sulphate of ammonia. No response to superphosphate. The depression of yield shown by superphosphate at the higher levels of nitrogen and potash is not significant.

M

Potatoes: Effect of Sulphate of Ammonia, Sulphate of Potash, and Superphosphate.

R. Starling, Esq., Northfield Farm, Little Downham, Ely, 1931.

C			A		
1P 2K —	1P 0K —	— 2P 0K	— 0P 0K	— 2P 1K	1P 1K —
— 0P 0K	— 2P 2K	— 0P 2K	2P 2K —	1P 2K —	— 1P 0K
— 0P 1K	2P 1K —	1P 1K —	— 2P 0K	— 0P 2K	— 0P 1K
— 1P 1K	2P 0K —	— 2P 2K	— 0P 1K	1P 0K —	— 2P 2K
0P 0K —	— 1P 2K	2P 1K —	1P 2K —	— 2P 1K	2P 0K —
0P 2K —	0P 1K —	— 1P 0K	— 1P 1K	— 0P 0K	— 0P 2K
D			B		

System of Replication: 4 randomised blocks, each of 9 plots, split for Nitrogen.

Area of Each Sub-Plot: 1/100th acre.

Soil: Black Fen.

Variety: Majestic.

Potatoes planted: April 6th.

Potatoes lifted: October 7th-8th.

Previous crop: Oats.

Treatments: Superphosphate (P) at the rate of 0, 5 and 10 cwt. per acre, Sulphate of Potash (K) at the rate of 0, 2 and 4 cwt. per acre. Sulphate of Ammonia at the rate of 0.4 cwt. N per acre, applied to one out of each pair of sub-plots indicated by the treatment symbol occurring on that half.

Manures applied: April 2nd.

Actual weights in lb.

Block.	0-0	0-1	0-2	1-0	1-1	1-2	2-0	2-1	2-2
	With Sulphate of Ammonia.								
A	175	173	239	205	232	230	224	277	229
B	203	167	170	256	224	208	243	283	252
C	213	217	189	261	201	256	266	254	284
D	144	160	163	210	223	207	258	241	238
	Without Sulphate of Ammonia.								
A	194	146	188	158	176	204	177	263	214
B	196	134	146	213	173	178	196	223	188
C	209	185	171	185	195	231	245	230	241
D	122	101	144	149	211	155	193	242	179

https://doi.org/10.23637/ERADOC-1-65

Summary of Results.

		Average yield in tons per acre.				Average yield per cent.			
		No Super	Single Super	Double Super	Mean.	No Super.	Single Super.	Double Super.	Mean.
Without S/Amm.	No Potash	8.05	7.87	9.05	8.32	88.1	86.2	99.1	91.1
	Single Potash	6.32	8.43	10.69	8.48	69.2	92.3	117.1	92.8
	Double Potash	7.24	8.57	9.17	8.33	79.3	93.8	100.4	91.2
	Mean	7.20	8.29	9.64	8.38	78.9	90.8	105.5	91.7
With S/Amm.	No Potash	8.20	10.40	11.06	9.89	89.8	113.9	121.1	108.3
	Single Potash	8.00	9.82	11.77	9.87	87.6	107.5	128.9	108.0
	Double Potash	8.49	10.06	11.19	9.91	93.0	110.1	122.6	108.6
	Mean	8.23	10.09	11.34	9.89	90.1	110.5	124.2	108.3
Mean of no S/Amm. and S/Amm.		7.72	9.19	10.49	9.13	84.5	100.6	114.9	100.0

Standard Error = 0.512 tons or 5.61 per cent.

The response to superphosphate and to sulphate of ammonia are definitely significant. The lower yields of the plots receiving potash only are statistically significant, and there is some evidence that the sulphate of ammonia is more effective in the presence of superphosphate.

Potatoes: Effect of Sulphate of Potash and Superphosphate.

J. A. Tribe, Esq., Willow Farm, Nr. March, 1931.

N	O	N	O	O	N
0P 1K	2P 0K	0P 0K	1P 0K	1P 1K	2P 1K
1P 1K	0P 0K	2P 1K	2P 0K	1P 0K	0P 1K
1P 0K	0P 1K	2P 0K	2P 1K	0P 0K	1P 1K
2P 1K	1P 1K	1P 0K	0P 1K	2P 0K	0P 0K
2P 0K	2P 1K	1P 1K	0P 0K	0P 1K	1P 0K
0P 0K	1P 0K	0P 1K	1P 1K	2P 1K	2P 0K
1	2	3	4	5	6

SYSTEM OF REPLICATION: 6×6 Latin Square.
AREA OF EACH PLOT: 1/70th acre.
Soil: Poor Fenland.
Variety: Arran Chief.
TREATMENTS: Superphosphate (P) at the rate of 0,5 and 10cwt. per acre, Sulphate of Potash (K) at the rate of 0 and 2 cwt. per acre, Sulphate of Ammonia at the rate of 0.4 cwt. N per acre.
Manures applied: April 9th.
Potatoes planted: April 13th.
Potatoes lifted: October 22nd.
Previous crop: Wheat.

Actual weights in lb.

Column.		0-0	0-1	1-0	1-1	2-0	2-1
1 and 2	No Nitrogen ..	134	155	228	184	187	233
	Nitrogen	196	186	198	213	245	233
3 and 4	No Nitrogen ..	248	234	222	255	265	290
	Nitrogen	208	242	218	282	272	296
5 and 6	No Nitrogen ..	261	247	250	296	248	273
	Nitrogen	239	253	303	310	294	331

Summary of Results.

Average yield corrected for dirt tare.	Tons per acre.				Per cent.			
	No Super.	Single Super.	Double Super.	Mean.	No Super.	Single Super.	Double Super.	Mean.
No Potash ..	6.38	7.04	7.50	6.97	88.4	97.5	103.9	96.6
Potash	6.53	7.64	8.21	7.46	90.5	105.8	113.8	103.4
Mean	6.46	7.34	7.85	7.22	89.5	101.7	108.8	100.0

Standard Error Means of No Nitrogen and Nitrogen = 0.234 or 3.24 per cent.

The improvement due to superphosphate is definitely significant, both with and without potash. Potash produces a significant effect at all levels of superphosphate. The direct effect of nitrogen is not significant, this comparison being based on only three replications.

Potatoes: Effect of Nitrate of Soda in various dressings.
T. H. Ream, Esq., Portobello Farm, Nr. Potton, 1931.
In co-operation with R. S. Brieant, Esq.

I.	E	A	D	C	B
II.	D	E	C	B	A
III.	C	B	A	D	E
IV.	A	D	B	E	C
V.	B	C	E	A	D

SYSTEM OF REPLICATION: 5×5 Latin Square.
AREA OF EACH PLOT: 1/50th acre.
Variety: Ninetyfold.
Soil: Very poor light sand on "Sandy Heath."
TREATMENTS:
A=No Nitrate of Soda.
B=1 cwt. Nitrate before sowing and 1 cwt. top dressed.
C=2 cwt. Nitrate before sowing.
D=3 cwt. Nitrate before sowing.
E=2 cwt. Nitrate before sowing and 1 cwt. top dressed.
Basal manuring: 3 cwt. Superphosphate and 3 cwt. Sulphate of Potash per acre.
Manures applied: March 25th.
Potatoes planted: April 6th.
Potatoes lifted: July 6th.
Previous crop: Dunged early potatoes followed by sprouts.

Actual weights in lb. (Ware).

Row.	A	B	C	D	E
I.	164	200	196	191	172
II. ..	214	227	192	174	194
III. ..	220	200	174	256	261
IV. ..	186	247	264	203	254
V. ..	228	204	185	256	210

Summary of Results.

Average Yield	No Nitrate of Soda	1 cwt. Nitrate before sowing + 1 cwt. T.D.	2 cwt. Nitrate before sowing	3 cwt. Nitrate before sowing	2 cwt. Nitrate before sowing + 1 cwt. T.D.	Mean	Standard Error
Tons per acre	4.52	4.81	4.51	4.82	4.87	4.71	0.120
Per cent.	96.0	102.2	95.9	102.4	103.5	100.0	2.54

The response to Nitrate of Soda is not significant.

N

Potatoes: Effect of Superphosphate.

Comparison of Nitrate of Soda and Sulphate of Ammonia.

T. H. Ream, Esq., Portobello Farm, Nr. Potton, 1931.

IV.	III.	II.	I.
— 0	4 —	— 8	2 —
— 2	8 —	— 4	— 0
— 8	2 —	0 —	4 —
— 4	0 —	2 —	8 —

SYSTEM OF REPLICATION: 4×4 Latin Square with split plots.

AREA OF EACH WHOLE PLOT: 1/30th acre.

Soil: Very poor light sand on "Sandy Heath."

Variety: Ninetyfold.

TREATMENTS: Superphosphate at the rate of 0, 2, 4 and 8 cwt. per acre. Half of each plot received Sulphate of Ammonia and the other half received Nitrate of Soda. Nitrate of Soda equivalent to Sulphate of Ammonia. Sulphate of Ammonia at the rate of 2 cwt. per acre. Nitrate of Soda is indicated by the treatment symbol occurring on that half.

Basal Manuring: 2 cwt. Sulphate of Potash per acre.

Potatoes planted: April 6th.

Potatoes lifted: July 6th.

Previous crop: Dunged early potatoes, followed by sprouts.

Actual Weights in lb. (Ware).

Column	Nitrate of Soda.				Sulphate of Ammonia.			
	O	2	4	8	0	2	4	8
I.	153	143	163	129	131	127	147	126
II.	162	148	167	137	147	135	157	156
III.	152	160	164	178	139	153	163	154
IV.	161	156	176	145	164	135	146	123

Summary of Results.

Average yield.	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre—						
S/Ammonia	3.89	3.68	4.10	3.74	3.86	} 0.125
N/Soda	4.21	4.06	4.49	3.94	4.18	
Mean	4.05	3.87	4.30	3.84	4.02	0.124
Per cent.—						
S/Ammonia	96.9	91.7	102.2	93.2	96.0	} 3.11
N/Soda	104.7	101.2	111.7	98.2	104.0	
Mean	100.8	96.5	107.0	95.7	100.0	3.09

Nitrate of Soda significantly superior to Sulphate of Ammonia. No response to Superphosphate.

Sugar Beet: Effect of Potash Salt, Superphosphate, and Sulphate of Ammonia.

R. Starling, Esq., Northfield Farm, Little Downham, Ely, 1931.

	C			A	
— — 2P 2K	2P 1K — —	1P 1K — —	— — 1P 2K	— — 2P 2K	0P 1K — —
1P 2K — —	— — 1P 0K	— — 0P 0K	— — 0P 2K	— — 1P 1K	— — 2P 1K
— — 2P 0K	0P 1K — —	0P 2K — —	1P 0K — —	0P 0K — —	2P 0K — —
1P 1K — —	— — 0P 2K	— — 1P 2K	0P 2K — —	2P 0K — —	— — 0P 1K
— — 2P 1K	— — 2P 0K	1P 0K — —	2P 2K — —	1P 1K — —	— — 0P 0K
— — 0P 1K	— — 0P 0K	— — 2P 2K	2P 1K — —	1P 2K — —	— — 1P 0K
	D			B	

System of Replication: 4 randomised blocks, each of 9 plots, split for nitrogen.

Area of Each Whole Plot: 1/50th acre.

Soil: Good black fen near the clay.

Variety: Kleinwanzleben E.

Manures applied: April 15th.

Beet sown: April 15th.

Beet lifted: November 5th-6th.

Treatments: Superphosphate (P) at the rate of 0, 3 and 6 cwt. per acre, Potash Salt (K) at the rate of 0, 1½ and 3 cwt. per acre. Sulphate of Ammonia at the rate of 2 cwt. per acre, applied to one out of each pair of sub-plots, indicated by the treatment symbol occurring on that half.

Previous crop: Oats, not dunged:

Actual weights in lb.

Block.	0-0	0-1	0-2	1-0	1-1	1-2	2-0	2-1	2-2
	Without Sulphate of Ammonia.								
Roots (unwashed)—									
A	374	371	378	388	375	386	367	385	372
B	375	379	382	378	371	367	391	403	378
C	411	381	407	381	407	377	376	394	380
D	360	370	370	423	388	408	373	365	402
	With Sulphate of Ammonia.								
A	370	384	395	397	400	385	398	380	399
B	384	392	402	361	387	375	388	411	394
C	390	388	404	385	398	379	391	395	389
D	393	379	372	418	382	404	370	383	413
Tops*—	Without Sulphate of Ammonia.								
A	266	274	268	292	253	264	265	244	251
B	265	183	311	264	287	300	242	274	324
	With Sulphate of Ammonia.								
A	290	230	291	260	274	307	246	258	272
B	312	260	287	292	296	303	267	258	297
Sugar percentage—	Without Sulphate of Ammonia.								
A	17.48	18.30	17.31	17.54	17.48	17.48	18.41	17.48	18.30
B	16.33	18.81	17.43	16.62	17.48	17.48	17.48	16.56	16.50
C	16.50	18.52	18.30	17.42	17.65	17.36	17.36	17.77	18.35
D	18.05	16.45	18.75	17.01	16.84	18.18	17.01	17.43	18.30
	With Sulphate of Ammonia.								
A	16.78	17.70	16.42	16.76	16.93	16.96	17.31	18.25	18.30
B	16.73	17.43	16.44	17.36	16.44	16.96	18.05	17.88	16.16
C	16.21	16.79	16.90	17.54	17.88	16.76	17.59	17.54	18.11
D	17.48	17.25	17.70	16.33	18.86	16.73	17.82	15.86	16.84

* Tops weighed on Block A and B only, on area of half plot = 1/100th acre.

Summary of Results.

Average yield.		Tons per acre. No Super.	Tons per acre. Single Super.	Tons per acre. Double Super.	Tons per acre. Mean.	Per cent. No Super.	Per cent. Single Super.	Per cent. Double Super.	Per cent. Mean.
Roots— (washed) Without S/Amm.	No Potash Salt	15.35	15.86	15.23	15.48	98.3	101.6	97.5	99.1
	Single Potash Salt	15.16	15.57	15.62	15.45	97.1	99.7	100.1	98.9
	Double Potash Salt	15.52	15.53	15.48	15.52	99.4	99.5	99.1	99.3
	Mean	15.35	15.66	15.44	15.48	98.3	100.2	98.9	99.1
With S/Amm.	No Potash Salt	15.52	15.77	15.62	15.64	99.4	101.0	100.1	100.2
	Single Potash Salt	15.59	15.83	15.85	15.76	99.8	101.4	101.5	100.9
	Double Potash Salt	15.90	15.59	16.11	15.87	101.7	99.8	103.2	101.6
	Mean	15.67	15.73	15.87	15.75	100.3	100.7	101.6	100.9
Mean of No S/Amm. & S/Amm.		15.51	15.70	15.65	15.62	99.3	100.5	100.2	100.0
Tops— Without S/Amm.	No Potash Salt	23.70	24.82	22.63	23.72	97.3	101.8	92.9	97.3
	Single Potash Salt	20.40	24.11	23.12	22.54	83.7	98.9	94.9	92.5
	Double Potash Salt	25.85	25.18	25.67	25.56	106.0	103.3	105.3	104.9
	Mean	23.32	24.70	23.81	23.94	95.7	101.4	97.7	98.2
With S/Amm.	No Potash Salt..	26.87	24.64	22.90	24.81	110.3	101.1	94.0	101.8
	Single Potash Salt	21.87	25.45	23.04	23.45	89.8	104.4	94.5	96.2
	Double Potash Salt	25.80	27.23	25.40	26.14	105.9	111.7	104.2	107.3
	Mean	24.85	25.77	23.78	24.80	102.0	105.7	97.6	101.8
Mean of No S/Amm. & S/Amm.		24.08	25.24	23.79	24.37	98.8	103.6	97.6	100.0
Sugar Percentage in Roots— Without S/Amm.	No Potash Salt	17.09	17.15	17.56	17.55				
	Single Potash Salt	18.02	17.36	17.31					
	Double Potash Salt	17.95	17.62	17.86					
With S/Amm.	No Potash Salt	16.80	17.00	17.69	17.19				
	Single Potash Salt	17.29	17.53	17.38					
	Double Potash Salt	16.86	16.85	17.35					

Standard Error : Roots : 0.304 tons or 1.95 per cent.
,, ,, Tops : 1.576 tons or 6.47 per cent.
,, ,, Sugar percentage : 0.348.

The roots show a small but definitely significant response to nitrogen. For the tops the difference, though greater, is not significant owing to the higher standard error. The sugar percentage is significantly depressed by nitrogen. There are no other significant effects.

Sugar Beet: Effect of Potash Salt and Superphosphate.

J. A. Tribe, Esq., Willow Farm, Nr. March, 1931.

	O	N	O	N	N	O
I.	0P 0K	2P 0K	1P 1K	2P 1K	0P 1K	1P 0K
II.	1P 0K	0P 1K	2P 0K	0P 0K	1P 1K	2P 1K
III.	1P 1K	1P 0K	0P 0K	2P 0K	2P 1K	0P 1K
IV.	2P 0K	2P 1K	0P 1K	1P 1K	1P 0K	0P 0K
V.	2P 1K	1P 1K	1P 0K	0P 1K	0P 0K	2P 0K
VI.	0P 1K	0P 0K	2P 1K	1P 0K	2P 0K	1P 1K

System of Replication: 6×6 Latin Square.
Area of Each Plot: 1/60th acre.
Soil: Black Fen, about 1-1½ ft. deep, on clay.
Variety: Shrciber.
Treatments: Superphosphate (P) at the rate of 0, 3 and 6 cwt. per acre, Potash Salt (K) at the rate of 0 and 2½ cwt. per acre, and Sulphate of Ammonia at the rate of 0·4 cwt. N. per acre.
Manures applied: April 23rd.
Beet drilled: May 6th.
Beet lifted: December 7th.
Previous crop: Beet.

Actual weights in lb.

Row.	Roots (unwashed).						Tops.					
	0-0	0-1	1-0	1-1	2-0	2-1	0-0	0-1	1-0	1-1	2-0	2-1
I.	385	329	348	415	383*	388	126	143	96	137	172*	133
II.	425	396*	408	428	389	502	159	191*	138	141	156	163
III.	289	414	382*	446	441	438	153	136	173*	144	174	173
IV.	447	386	454	447	466	375	117	134	145	130	164	155
V.	432	433	431	501	499	503	146	132	121	186	141	178
VI.	477	451	442*	454	452	432*	195	182	132*	115	136	157*

*These plots discarded and values calculated from the remaining plots. Tops were weighed on ¼ plots only. Area 1/240th acre.

https://doi.org/10.23637/ERADOC-1-65

Summary of Results.

Roots (unwashed)—	Average yield tons per acre.				Average yield per cent.			
	Nitrogen and No Nitrogen.				Nitrogen and No Nitrogen.			
	No Super.	Single Super.	Double Super.	Mean.	No Super.	Single Super.	Double Super.	Mean.
No Potash ..	10.96	11.00	11.74	11.24	96.4	96.7	103.2	98.8
Potash	10.75	12.01	11.78	11.51	94.5	105.6	103.5	101.2
Mean	10.86	11.51	11.76	11.38	95.4	101.2	103.4	100.0
Tops—								
No Potash ..	16.00	14.37	16.84	15.74	100.0	89.9	105.3	98.4
Potash	16.39	15.23	17.12	16.25	102.5	95.2	107.1	101.6
Mean	16.20	14.80	16.98	15.99	101.3	92.6	106.2	100.0

Standard Error : Roots : 0.434 tons or 3.82 per cent.
,, ,, Tops : 0.757 tons or 4.73 per cent.

Roots.	tons per acre.	per cent.
Nitrogen ..	11.34	99.7
No Nitrogen ..	11.41	100.3
Mean	11.38	100.0
Tops—		
Nitrogen ..	16.76	104.8
No Nitrogen ..	15.23	95.2
Mean	15.99	100.0

The effect of superphosphate is not significant. There is no evidence of any potash or nitrogen effects. The experiment was marred by the acidity of certain plots.

Sugar Beet: Effect of Sulphate of Ammonia and Superphosphate.

Messrs. C. S. & G. M. Wilson, Stanway Hall Farm, Colchester, 1931.

A			B		
1P 1S	2P 0S	0P 0S	0P 1S	1P 0S	0P 2S
0P 1S	1P 2S	2P 2S	1P 2S	2P 0S	1P 1S
0P 2S	2P 1S	1P 0S	2P 2S	2P 1S	0P 0S
0P 0S	0P 2S	1P 2S	0P 1S	2P 1S	0P 2S
2P 2S	2P 0S	1P 1S	2P 2S	1P 0S	0P 0S
1P 0S	2P 1S	0P 1S	2P 0S	1P 1S	1P 2S
C			D		

System of Replication: 4 randomised blocks of 9 plots each.

Area of Each Plot: 1/60th acre.

Soil: Light sandy gravel.

Variety: Kleinwanzleben

Treatments: Superphosphate (P) at the rate of 0, 2 and 4 cwt. per acre, Sulphate of Ammonia (S) at the rate of 0, $1\frac{1}{2}$ and 3 cwt. per acre.

All plots received 30 per cent. Potash Salt at the rate of $2\frac{1}{2}$ cwt. per acre, and dung, 8 loads per acre.

Manures applied: April 28th.

Beet planted: April 28th.

Beet lifted: November 2nd-4th.

Previous crop: Barley.

Actual weights in lb.

Block.		0-0	0-1	0-2	1-0	1-1	1-2	2-0	2-1	2-2
Roots (unwashed)	A	325	440	463	367	428	424	338	443	460
	B	349	394	334	402	409	459	426	486	458
	C	458	409	447	406	461	454	392	471	471
	D	424	460	444	449	485	498	366	499	477
Tops	A	213	279	360	215	286	327	211	288	310
	B	291	299	396	337	320	381	303	385	400
	C	279	299	390	230	318	372	278	317	367
	D	260	330	421	293	381	431	240	395	367
Sugar percentage	A	19.45	19.92	19.46	19.92	19.68	19.17	19.74	19.92	19.23
	B	19.34	19.00	18.76	19.05	19.28	19.86	19.35	19.51	19.92
	C	19.57	18.64	19.40	19.05	18.76	19.11	19.40	19.12	19.28
	D	19.34	19.74	18.82	18.93	18.47	18.36	19.12	19.05	18.93

https://doi.org/10.23637/ERADOC-1-65

Summary of Results.

Average yield. Roots (clean)—	Tons per acre. No Super.	Single Super.	Double Super.	Mean.	Per cent. No Super.	Single Super.	Double Super.	Mean.
No S/Amm. ..	9.26	9.66	9.05	9.33	90.5	94.4	88.5	91.1
Single S/Amm.	10.13	10.61	11.30	10.68	99.0	103.7	110.4	104.4
Double S/Amm.	10.04	10.92	11.10	10.69	98.2	106.7	108.5	104.5
Mean	9.81	10.39	10.48	10.22	95.9	101.6	102.5	100.0
Tops—								
No S/Amm. ..	6.98	7.20	6.91	7.03	81.1	83.6	80.3	81.7
Single S/Amm. ..	8.08	8.74	9.27	8.70	93.9	101.5	107.7	101.0
Double S/Amm.	10.49	10.12	9.67	10.09	121.9	117.5	112.3	117.3
Mean	8.52	8.68	8.62	8.61	99.0	100.9	100.1	100.0
Sugar percentage—								
No S/Amm. ..	19.42	19.24	19.40	19.36				
Single S/Amm. ..	19.32	19.05	19.40	19.26				
Double S/Amm.	19.11	19.12	19.34	19.19				
Mean	19.29	19.14	19.38	19.27				

Standard Errors : Roots Single treatments : 0.402 tons or 3.92 per cent.
,, Means : 0.232 tons or 2.27 per cent.
Tops Single treatments : 0.330 tons or 3.83 per cent.
,, Means : 0.190 tons or 2.21 per cent.
Sugar percentage Single treatments : 0.187
Means : 0.108.

Definitely significant response to the single dressing of sulphate of ammonia, both for roots and tops, with a further significant response of the tops to the double dressing but no further improvement of the roots. The response to superphosphate for the roots is not significant, and there is no sign of any effect on the tops. No significant effects on sugar percentage.

Experiments at other centres, carried out by the local workers on the lines of those described on the preceding pages.

Potatoes. J. E. Arden, Esq., Owmby Cliff, Lincolnshire, 1931.
J. A. McVicar, Esq., County Organiser.

4 × 4 Latin Square : Plots 1/80th acre. Soil : Limestone.
Basal Manuring : Dung ; 3 cwt. Sulphate of Potash and 4 cwt. Sulphate of Ammonia per acre.
Variety : King Edward. Potatoes planted : April 15th. Lifted : October 6th.
Previous crop : 1 year seeds.

Average yield.	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre	7.01	6.83	6.97	6.60	6.85	0.187
Per cent.	102.3	99.7	101.8	96.3	100.0	2.73

No apparent manurial effects.

Potatoes. Midland Agricultural College, Loughborough, 1931.

4 × 4 Latin Square : Plots 1/60th acre. Soil : Light loam.
Treatments : Fish Manure, I.C.I. Compound Manure, Home-made mixture at the rate of 0.83 cwt. N, 0.83 cwt. P_2O_5, and 1.66 cwt. K_2O per acre.
Variety : King Edward. Potatoes planted : April 17th. Lifted : September 26th.
Previous crop : Seeds hay.

Average Yield.	No Manure	Fish Manure.	I.C.I. Compound Manure.	Home-made Mixture.	Mean.	Standard Error.
Tons per acre	5.68	7.85	8.71	8.26	7.62	0.221
Per cent...	74.5	103.0	114.2	108.3	100.0	2.90

The response to the manures is definitely significant. There is a significant difference between I.C.I. and fish manure, but not between I.C.I. and home-made, or home-made and fish manure. Neither is the difference between the inorganic (taken together) and the fish manures significant.

Potatoes. Midland Agricultural College, Loughborough, 1931.

4 Randomised blocks of 9 plots each. Plots 1/48.8 acre. Soil : Light loam.
Treatments : Sulphate of Ammonia and Sulphate of Potash at the rate of 1½ and 3 cwt. per acre.
Basal Manuring : 3 cwt. Superphosphate per acre. No dung given.
Variety : King Edward. Potatoes planted : April 15th. Lifted : September 24th.
Previous crop : Seeds hay.

Average yield.	tons per acre.			per cent.		
	No Nitrogen.	Single S/Amm.	Double S/Amm.	No Nitrogen.	Single S/Amm.	Double S/Amm.
No Potash	7.55	8.58	10.33	87.0	98.9	119.0
Single Potash	7.86	8.35	9.73	90.6	96.3	112.1
Double Potash ..	7.02	8.69	9.99	80.9	100.1	115.2
Mean	7.48	8.54	10.02	86.2	98.4	115.4
Mean	8.68			100.0		
Standard Error (Single treatments)	0.455			5.24		
,, ,, (means)	0.263			3.02		

The response to Sulphate of Ammonia is definitely significant, the yield being proportional to the quantity of nitrogen supplied. No response to potash.

Potatoes. County School, Welshpool, Montgomeryshire, 1931.

4 Randomised blocks of 4 plots each. Plots 0.00468 acre. Soil: Medium loam (Wenlock shale).
TREATMENTS: Sulphate of Ammonia, Nitrate of Soda and Cyanamide at the rate of 0.6 cwt. N. per acre.
Basal Manuring: 4 cwt. Superphosphate and 3 cwt. Sulphate of Potash per acre.
Variety: Great Scot. Potatoes planted: May 10th. Lifted: September 22nd-25th.
Previous crop: Potatoes.

Average yield.	No Nitrogen.	Cyana-mide.	Nitrate of Soda.	Sulphate of Amm.	Mean.	Standard Error.
Tons per acre	4.75	7.23	7.49	7.92	6.84	0.323
Per cent...	69.3	105.6	109.4	115.7	100.0	4.72

Definitely significant response to nitrogen. No significant difference between types of nitrogen.

Potatoes. Grammar School, Burford, Oxon, 1931.

2 unequal Randomised blocks of 4 and 12 plots each respectively, with split plots. Sub-plots: 1/200th acre. Soil: Limestone loam.
TREATMENTS: Main Tests, Superphosphate at the rate of 0, 0.3, 0.6, 1.2 cwt. P_2O_5 per acre. Sub-plots: Sulphate of Ammonia and Cyanamide at the rate of 0.6 cwt. N. per acre.
Basal Manuring: Sulphate of Potash at the rate of 1.4 cwt. K_2O per acre.
Variety: King George. Potatoes planted: April 27th. Lifted: October 1st.

Average Yield.	Tons per acre.					Per cent.				
	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.
With S/Amm. ..	3.93	5.45	5.89	5.60	5.22	75.6	104.8	113.4	107.8	100.4
With Cyanamide ..	4.33	5.98	5.40	4.98	5.17	83.4	115.1	104.0	95.8	99.6
Mean	4.13	5.71	5.65	5.29	5.20	79.5	110.0	108.7	101.8	100.0

Standard Error single treatment: 0.431 tons or 8.30 per cent.
Standard Error Mean of S/Amm. and Cyan. = 0.353 tons or 6.80 per cent.
Standard Error Mean of all levels of Super. = 0.176 tons or 3.40 per cent.

There is a significant response to the 2 cwt. dressing of superphosphate, but no additional response to the heavier dressings. There are no significant differences between Sulphate of Ammonia and Cyanamide.

Potatoes. Sailors' Orphan Homes School, Hull, 1931.

4×4 Latin Square. Plots 0.00459 acre. Soil: Heavy alluvium.
TREATMENTS: Sulphate of Ammonia, Nitrate of Soda and Cyanamide at the rate of 0.6 cwt. N per acre.
Basal Dressing: 4 cwt. Superphosphate, 3 cwt. Sulphate of Potash per acre.
Variety: Kerr's Pink. Potatoes planted: April 29th. Lifted: Oct. 3rd-7th.

Average yield.	No Nitrogen.	Nitrate of Soda.	Sulphate of Ammonia.	Cyana-mide.*	Mean.	Standard Error.
Tons per acre	7.88	8.46	9.42	7.73	8.37	0.483
Per cent...	94.1	101.1	112.5	92.3	100.0	5.77

The response to treatments is not large enough to be significant.

* One plot of this treatment discarded and a value calculated for it from the remaining plots.

Potatoes: Messrs. Hickman & Co., Wisbech, 1931.
W. F. Cheal, Esq., Horticultural Organiser.

4×4 Latin Square. Plots 0.0207 acre. Soil: Deep silt.
Basal Manuring: 4 cwt. Sulphate of Potash, 4 cwt. Sulphate of Ammonia per acre.
Variety: Baron. Potatoes planted: April 25th. Lifted:
Previous crop - Rhubarb.

Average Yield.	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre ..	12.30	13.16	13.08	13.03	12.90	0.271
Per cent.	95.4	102.1	101.5	101.1	100.0	2.099

The effect of Superphosphate is just significant. No further response to the higher levels of Superphosphate.

Potatoes. Lady Manner's School, Bakewell, 1931.

4×4 Latin Square. Plots 1/120th acre. Soil: Limestone—rather stony.
TREATMENTS: Sulphate of Ammonia, Nitrate of Soda and Cyanamide at the rate of 0.6 cwt. N per acre.
Basal Manuring: 4 cwt. Superphosphate, 3 cwt. Sulphate of Potash per acre.
Variety: King Edward. Potatoes planted: May 8th. Lifted: Sept. 22nd-28th.

Average Yield.	No Nitrogen.	Sulphate of Ammonia.	Cyanamide	Nitrate of Soda.	Mean.	Standard Error.
Tons per acre ..	6.64	8.29	8.04	8.42	7.84	0.196
Per cent.	84.6	105.6	102.4	107.3	100.0	2.50

Definitely significant response to nitrogen. No significant differences between the various forms.

Potatoes: T. Gornall, Esq., Upper Birks Farm, Garstang, Lancs., 1931
J. J. Green, Esq., Director of Agriculture.

4×4 Latin Square. Plots 1/57th acre. Soil: Moss.
Basal Manuring: Sulphate of Ammonia and Sulphate of Potash each at the rate of 2 cwt. per acre, and 10 tons farmyard manure per acre.
Variety: King Edward VII. Potatoes planted: May 11th. Lifted: Sept. 22nd.
Previous crop: Spring oats.

Average Yield.	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre ..	2.69	2.67	2.69	2.60	2.66	0.078
Per cent.	101.0	100.3	101.0	97.7	100.0	2.95

Partial failure of crop; no response to manurial treatment.

Potatoes. J. B. Everatt, Esq., Garthorpe, Lincs., 1931.
J. A. McVicar, Esq., County Organiser.

4×4 Latin Square. Plots 1/80th acre. Soil: Warp.
Basal Manuring: Sulphate of Ammonia and Superphosphate, each at the rate of 4 cwt. per acre.
Variety: King Edward. Potatoes planted: May 4th. Lifted: Oct. 15th.
Previous crop: Sugar Beet.

Average Yield.	No Sul. of Pot.	1 cwt. Sul. of Pot.	2 cwt. Sul. of Pot.	3 cwt. Sul. of Pot.	Mean.	Standard Error.
Tons per acre ..	11.88	12.39	12.84	12.30	12.35	0.350
Per cent.	96.1	100.3	103.9	99.6	100.0	2.83

No significant manurial effects.

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Potatoes. J. W. Halkon, Esq., Garthorpe, Lincs., 1931. J. A. McVicar, Esq., County Organiser.

4 × 4 Latin Square. Plots 1/80th acre. Soil: Warp.
Basal Manuring: Sulphate of Ammonia and Superphosphate, each at the rate of 4 cwt. per acre.
Variety: Majestic. Potatoes planted: April 15th. Lifted: Oct. 6th.
Previous crop: Peas.

Average Yield.	No Sul. of Pot.	1 cwt. Sul. of Pot.	2 cwt. Sul. of Pot.	3 cwt. Sul. of Pot.	Mean.	Standard Error.
Tons per acre ..	10.12	10.54	10.29	10.21	10.29	0.312
Per cent.	98.4	102.4	100.0	99.2	100.0	3.04

No apparent manurial effects.

Sugar Beet. South-Eastern Agricultural College, Wye, Kent, 1931.

4 × 4 Latin Square. Plots 1/40th acre. Soil: Silty loam.
Treatments: Muriate of Potash, at the rate of 1.6 cwt. per acre, and Salt at the rate of 1.14 cwt. per acre.
Basal Manuring: 12 tons dung, Sulphate of Ammonia at the rate of 2 cwt. per acre, and Superphosphate at the rate of 4 cwt. per acre.
Variety: Kleinwanzleben E. Beet sown: May 6th. Lifted: Oct. 13th.
Previous crop: Oats.

Average yield.	No Potash.	Muriate of Potash.	Salt.	Muriate of Potash and Salt.	Mean.	Standard Error.
Roots (clean) tons per acre ..	11.18	10.82	11.31	11.12	11.11	0.169
per cent.	100.7	97.4	101.8	100.1	100.0	1.53
Sugar percentage in Roots	18.43	18.68	18.63	18.99	18.68	0.146

No significant effects. The difference of sugar percentage for the various treatments is not significant.

Sugar Beet. South-Eastern Agricultural College, Wye, Kent, 1931.

4 × 4 Latin Square. Plots 1/40th acre. Soil: Silty loam.
Treatments: Sulphate of Ammonia at the rate of 1.33 cwt. per acre, Nitrate of Soda at the rate of 2.06 cwt. per acre, and Cyanamide at the rate of 1.6 cwt. per acre.
Basal Manuring: 12 tons dung, 4 cwt. Superphosphate, and 2 cwt. Muriate of Potash per acre.
Variety: Kleinwanzleben E. Beet sown: May 6th. Lifted: October 13th.
Previous crop: Oats.

Average Yield.	No Nitrogen.	Sulphate of Ammonia.	Cyana-mide.	Nitrate of Soda.	Mean.	Standard Error.
Roots (clean) Tons per acre ..	11.79	11.89	11.77	11.85	11.83	0.145
Per cent.	99.7	100.6	99.5	100.2	100.0	1.22
Tops Tons per acre ..	12.89	13.63	14.13	14.94	13.90	0.452
Per cent.	92.8	98.1	101.7	107.5	100.0	3.25
Sugar Percentage in Roots	18.93	18.48	18.61	18.39	18.60	0.0872

There is a significant improvement due to nitrogen in the yield of the tops, but no significant difference between the different kinds of nitrogen. The roots did not respond to treatment. Significant depression in sugar percentage by nitrogen, but no significant difference between the various forms of nitrogen.

Sugar Beet. The University of Leeds, Askham Bryan, Yorks, 1931.

4×4 Latin Square. Plots 1/80th acre. Soil: Medium loam on gravel.
TREATMENTS: 2 cwt. Sulphate of Ammonia per acre with seed, Nitrate of Soda with seed, and Nitrate of Soda as top dressing equivalent to 2 cwt. Sulphate of Ammonia.
Basal Manuring: 10 tons Farmyard Manure, 2 cwt. Superphosphate, 1 cwt. Steamed Bone Flour, and 1 cwt. 30 per cent. Potash Salt per acre.
Variety: Kleinwanzleben E. Beet sown: May 6th. Lifted: October 30th.
Previous crop: Oats.

Average yield.	No Nitrogen.	Sulphate of Ammonia.	Nitrate of Soda with seed.	Nitrate of Soda top-dressing.	Mean.	Standard Error.
Roots (clean)—						
Tons per acre ..	7.93	9.04	9.27	9.05	8.82	0.250
Per cent.	89.8	102.5	105.0	102.6	100.0	2.84
Tops—						
Tons per acre	9.78	11.43	11.97	11.41	11.15	0.448
Per cent.	87.8	102.5	107.4	102.3	100.0	4.02
Sugar percentage in Roots	16.90	16.58	16.78	16.78	16.76	0.195

Significant response to nitrogen. The difference between the different forms of nitrogen is not significant. No significant differences in sugar percentage.

Sugar Beet. Gregory's Farm, Watton, 1931.
H. W. Gardner, Esq., Hertfordshire Farm Institute.

4×4 Latin Square. Plots 0.0223 acre. Soil: Gravelly—rather sour.
TREATMENTS: Dung and Sulphate of Ammonia 2 cwt. per acre, Superphosphate 3.57 cwt. per acre, Potash Salt (30 per cent.) at the rate of 2 cwt. per acre. Lime at the rate of 2 tons per acre, Cyanamide at the rate of 2 cwt. per acre and Slag (14 per cent.) at the rate of 3 cwt. per acre.
Variety: Kleinwanzleben E. Beet sown: May 1st. Lifted: September 12th.
Previous crop: Turnips.

Average yield.	Dung only	Dung, S/Amm., Super and Potash Salts.	Dung, S/Amm., Super, Potash Salts and Lime.	Dung, Cyanamide Slag and Potash Salts.	Mean.	Standard Error.
Roots (dirty)—						
Tons per acre ..	10.04	11.39	12.15	11.37	11.24	0.328
Per cent.	89.4	101.3	108.1	101.2	100.0	2.92
Tops—						
Tons per acre ..	9.57	10.86	12.21	11.27	10.98	0.407
Per cent.	87.2	98.9	111.2	102.7	100.0	3.71

Significant improvement by artificials, with further significant improvement by lime. No appreciable difference between sulphate of ammonia and super, and cyanamide and slag.

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Swedes. County School, Welshpool, Montgomeryshire, 1931.

4 × 4 Latin Square. Plots 1/160th acre. Soil : Medium loam (Wenlock shale).
TREATMENTS : Superphosphate, Rock Phosphate and Slag, providing 1 cwt. P_2O_5 per acre.
Basal Manuring : 2 cwt. Sulphate of Ammonia and 1½ cwt. Sulphate of Potash per acre.
Variety : Lord Derby. Swedes sown : May 20th. Lifted : November 1st-4th.
Previous crop : Sugar Beet.

Average yield.	No Phosphate.	Slag.	Rock phosphate.	Super-phosphate.	Mean.	Standard Error.
Roots—						
Tons per acre ..	16.96	18.21	17.20	18.14	17.63	0.261
Per cent. ..	96.2	103.3	97.5	102.9	100.0	1.48
Tops—						
Tons per acre ..	4.80	6.41	4.93	5.41	5.39	0.093
Per cent.	89.1	119.0	91.5	100.4	100.0	1.73

Significant response to slag and to superphosphate, but not to rock phosphate. There is no significant difference between slag and superphosphate in the case of roots, but for the tops slag is significantly superior.

Swedes. County Farm Institute, Moulton, Northampton, 1931.

5 × 5 Latin Square. Plots 0.02 acre. Soil : Sandy loam.
TREATMENTS : Superphosphate, Mineral Phosphate, High and Low soluble Slag, all providing 1 cwt. P_2O_5 per acre.
Basal Manuring : 1½ cwt. Sulphate of Ammonia and 3 cwt. (30 per cent.) Potash Salts per acre.
Variety : Garton's Superlative. Swedes sown : June 9th. Lifted : November 12th.
Previous crop : Wheat.

Average yield.	No Phosphate.	Mineral Phosphate.	Low Slag.	High Slag.	Super-phosphate.	Mean.	Standard Error.
Roots—							
Tons per acre	28.53	29.01	28.99	27.76	27.54	28.37	0.804
Per cent. ..	100.6	102.3	102.2	97.8	97.1	100.0	2.83
Tops—							
Tons per acre	2.52	2.72	2.60	2.57	2.47	2.57	0.089
Per cent. ..	97.8	105.6	100.9	99.7	96.0	100.0	3.45

No significant results.

Swedes. Oundle School, Northamptonshire, 1931.

5 × 5 Latin Square. Plots 1/50th acre. Soil : Heavy loam on Oxford clay.
TREATMENTS : Superphosphate, Mineral Phosphate, High and Low soluble Slag, all providing 1 cwt. P_2O_5 per acre.
Basal Manuring : 1 cwt. Sulphate of Ammonia per acre.
Variety : Purple Top. Swedes sown : May 27th. Lifted : November 23rd.
Previous crop : Grey Winter Oats.

Average yield.	No Phosphate.	Mineral Phosphate.	Low Soluble Slag.	High Soluble Slag.	Super.	Mean.	Standard Error.
Roots (clean)							
Tons per acre	35.53	33.50	33.86	36.21	34.75	34.77	1.20
Per cent. ..	102.2	96.3	97.4	104.1	99.9	100.0	3.46

No significant effects.

Cabbages. T. H. Ream, Esq., Portobello Farm, Nr. Potton, 1931.
J. W. Dallas, Esq., County Organiser.

5 × 5 Latin Square. Plots 1/50th acre. Soil: Very poor light sand on Sandy Heath.
Basal Manuring for Potatoes: 3 cwt. Superphosphate and 3 cwt. Sulphate of Potash per acre.
Variety: Christmas Drumhead. Cabbages planted: July 21st. Counted: December 7th.
Previous crop: Early Potatoes, to which all the manures were applied.

Average	No Nitrate of Soda	1 cwt. N/Soda before sowing + 1 cwt. top dressed	2 cwt. Nitrate of Soda before sowing	3 cwt. Nitrate of Soda before sowing	2 cwt. N/Soda before sowing + 1 cwt. top dressed	Mean	Standard Error
No. per acre	4760	5670	4870	5750	6260	5462	285

There is a significant average response to nitrogen as measured by the number of cabbages cut. There is some indication that the split dressings are superior to single dressings.

Cabbages. T. H. Ream, Esq., Portobello Farm, Nr. Potton, 1931.
J. W. Dallas, Esq., County Organiser.

4 × 4 Latin Square with split plots. Main Plots 1/30th acre. Soil: Very poor, light sand on Sandy Heath.
TREATMENTS: Increasing applications of Superphosphates to previous crop. Plots split for Sulphate of Ammonia at the rate of 2 cwt. per acre, and Nitrate of Soda equivalent to Sulphate of Ammonia.
Basal Manuring: 2 cwt. Sulphate of Potash per acre.
Variety: Christmas Drumhead. Cabbages planted: July 20th. Cut: December 11th—January 11th.
Previous crop: Potatoes, to which all manures were applied.

	Average weight per cabbage.					Average no. of cabbages gathered per acre.				
	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.
S/Amm.	1.18	1.22	1.20	1.24	1.21	2318	2198	2798	2978	2572
N/Soda ..	1.32	1.33	1.30	1.22	1.29	2865	2790	2948	2925	2882
Mean ..	1.25	1.28	1.25	1.23	1.25	2591	2494	2872	2951	2727
Standard Error: single treatment = 0.038.						259				

The weight per cabbage is signficantly higher on the nitrate of soda plots, and the number of cabbages cut is also higher, though not significantly so. There are no other significant effects.

Kale. Midland Agricultural College, Loughborough, 1931.

4 × 4 Latin Square. Plots 1/50th acre. Soil: Light loam.
TREATMENTS: Increasing applications of Nitrate of Soda.
Basal Manuring: 15 tons Farmyard Manure per acre, 3 cwt. Superphosphate and 3 cwt. Potash Salt per acre.
Variety: Marrowstem. Kale sown April 24th. Cut: September 17th-October 3rd.
Previous crop: Oats.

Average yield	No Nitrogen	1 cwt. Nitrate of Soda	2 cwt. Nitrate of Soda	4 cwt. Nitrate of Soda	Mean	Standard Error.
Tons per acre ..	15.31	18.20	19.06	22.42	18.75	0.677
Per cent.	81.7	97.1	101.7	119.6	100.0	3.61

Definitely significant response to nitrogen, with a significant increase in yield at the higher levels.

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Brussel Sprouts. The Horticultural College, Swanley, 1931.

5 × 5 Latin Square. Plots 1/125th acre. Soil : Light calcareous loam.
TREATMENTS : Super and Potash (no Nitrogen), Poultry Manure, Guano, Artificials full N (0.4 cwt.), and Artificials ½ N (0.2 cwt.) at the rate of 0.4 cwt. N per acre.
Basal Manuring : Superphosphate at the rate of 0.8 cwt. P_2O_5, Sulphate of Potash at the rate of 1.0 cwt. K_2O per acre.
Brussels harvested : September 17th, October 12th, October 29th and November 2nd.

Average yield.	No Nitrogen	Artificials ½ N.	Artificials full N.	Guano.	Poultry Manure.	Mean.	Standard Error.
Cwt. per acre.							
1st Harvesting	10.4	9.8	13.9	13.2	15.7	12.6	1.55
2nd Harvesting	23.7	22.8	20.8	25.4	25.5	23.6	1.16
3rd Harvesting	14.0	13.1	12.5	13.2	12.7	13.1	1.09
4th Harvesting*	14.1	17.1	18.6	19.7	20.6	18.0	1.36
Per cent.							
1st Harvesting	82.4	77.6	110.4	104.6	125.0	100.0	12.33
2nd Harvesting	100.3	96.3	87.8	107.6	107.9	100.0	4.93
3rd Harvesting	106.6	99.8	95.6	100.7	97.3	100.0	8.31
4th Harvesting*	78.3	94.7	103.4	109.3	114.2	100.0	7.55

*Blown sprouts.

The response to poultry manure and guano is significant when the fourth harvesting (blown sprouts) is taken into account. The response to these two manures on the first three harvestings is not itself significant. The high standard error prevents any conclusions on the effects of artificials.

Hay. Haileybury College Farm, 1930.
H. W. Gardner, Esq., Agricultural Chemist, Hertfordshire Farm Institute.

5 × 5 Latin Square. Plots 1/50th acre. Soil : Light loam.
TREATMENTS : Top dressings of Sulphate of Ammonia, Cyanamide, Nitrate of Soda and Nitro-chalk equivalent to 1½ cwt. Sulphate of Ammonia per acre.
Hay cut : July 2nd, 1930.

Average yield.	No Nitrogen.	Sulphate of Ammonia.	Cyana-mide.	Nitrate of Soda.	Nitro-Chalk.	Mean.	Standard Error.
Cwt. per acre	60.6	72.1	69.0	66.1	70.8	67.7	1.75
Per cent...	89.4	106.5	101.9	97.6	104.5	100.0	2.58

Definitely significant response to nitrogen. There are no significant differences between the various forms of nitrogen.

Hay. Haileybury College Farm, 1931.
H. W. Gardner, Esq., Agricultural Chemist, Hertfordshire Farm Institute.

5 × 5 Latin Square. Plots 1/50th acre. Soil : Clay.
TREATMENTS : Top dressings of Sulphate of Ammonia, Cyanamide, Nitrate of Soda, Nitro-chalk equivalent to 1½ cwt. Sulphate of Ammonia per acre.
Hay cut : July 4th.

Average yield.	No Nitrogen.	Sulphate of Ammonia.	Cyana-mide.	Nitrate of Soda.	Nitro-chalk.	Mean.	Standard Error.
Cwt. per acre	35.7	44.6	38.3	44.8	42.5	41.2	1.52
Per cent. ..	86.7	108.4	93.1	108.7	103.2	100.0	3.69

Definitely significant response to nitrogen. Cyanamide is significantly inferior to sulphate of ammonia and nitrate of soda, but scarcely to Nitro-chalk.

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Grass. H. W. Gardner, Esq., Agricultural Chemist, Hertfordshire Farm Institute, 1931.

4 × 4 Latin Square. Plots 6 square yards. Soil : Loam.
TREATMENTS : Single (1 cwt. per acre) Sulphate of Ammonia applied early (March 2nd) and after June grazing, and Double Sulphate of Ammonia applied early (March 2nd). Single I.C.I. Fertiliser provided same amount of N. Plots receiving Sulphate of Ammonia also received the same P_2O_5 and K_2O as was provided by the I.C.I. Fertiliser. Sixty per cent. of the N removed in the crop corresponding to each treatment was returned to the land in the form of poultry manure.
Basal Manuring : 1 ton Lime, 4 cwt. Mineral Phosphate, and 2 cwt. Potash Salt (30 per cent.) per acre.
Grass cut : April 23rd, June 5th, July 20th and September 15th.

Average yield.	No Nitrogen.	S/Amm. Single E. and L.	S/Amm. Double E.	I.C.I. Fertiliser E. and L.	Mean.	Standard Error.
Dry matter—						
Cwt. per acre	70.6	81.0	77.8	78.1	76.9	2.60
Per cent.	91.8	105.4	101.2	101.6	100.0	3.38

The response to nitrogen is significant, but there is no difference between the different forms and times of application.

Hay. Lady Manner's School, Bakewell, 1931.

Three randomised blocks of 8 plots each. Plots 1/161 acre. Soil : Limestone.
TREATMENTS : 2 cwt. Nitrate of Soda (N), 3 cwt. Superphosphate (P) and 2 cwt. Kainit (K) per acre.
Manures applied March 20th.
Hay cut : June 30th.

Average yield.	O	N	P	K	NP	NK	PK	NPK	Mean.	S.E.
Cwt. per acre ..	39.3	49.6	41.4	36.4	49.6	43.1	37.8	60.4	44.7	2.82
Per cent.	87.9	110.9	92.7	81.4	110.9	96.5	84.7	135.0	100.0	6.31

Significant response to nitrate of soda, and to superphosphate in the presence of nitrate and kainit.

Hay. Lady Manner's School, Bakewell, 1931.

5 × 5 Latin Square. Plots 1/198th acre. Soil : Limestone.
TREATMENTS : Low and High Soluble Slag, Rock Phosphate and Superphosphate, providing 1.0 cwt. P_2O_5 per acre.
Manures applied : March 27th.
Hay cut : June 30th.

Average yield.	No Phosphate.	Low Soluble Slag.	High Soluble Slag.	Rock Phosphate.	Super.	Mean.	Standard Error.
Cwt. per acre	31.1	29.5	32.4	30.9	34.1	31.6	1.62
Per cent. . .	98.4	93.3	102.6	97.8	107.9	100.0	5.12

No significant response to manures.

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