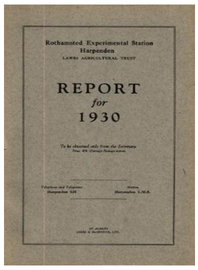
ROTHAMSTED RESEARCH

Report for 1930



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Rothamsted Experimental Station
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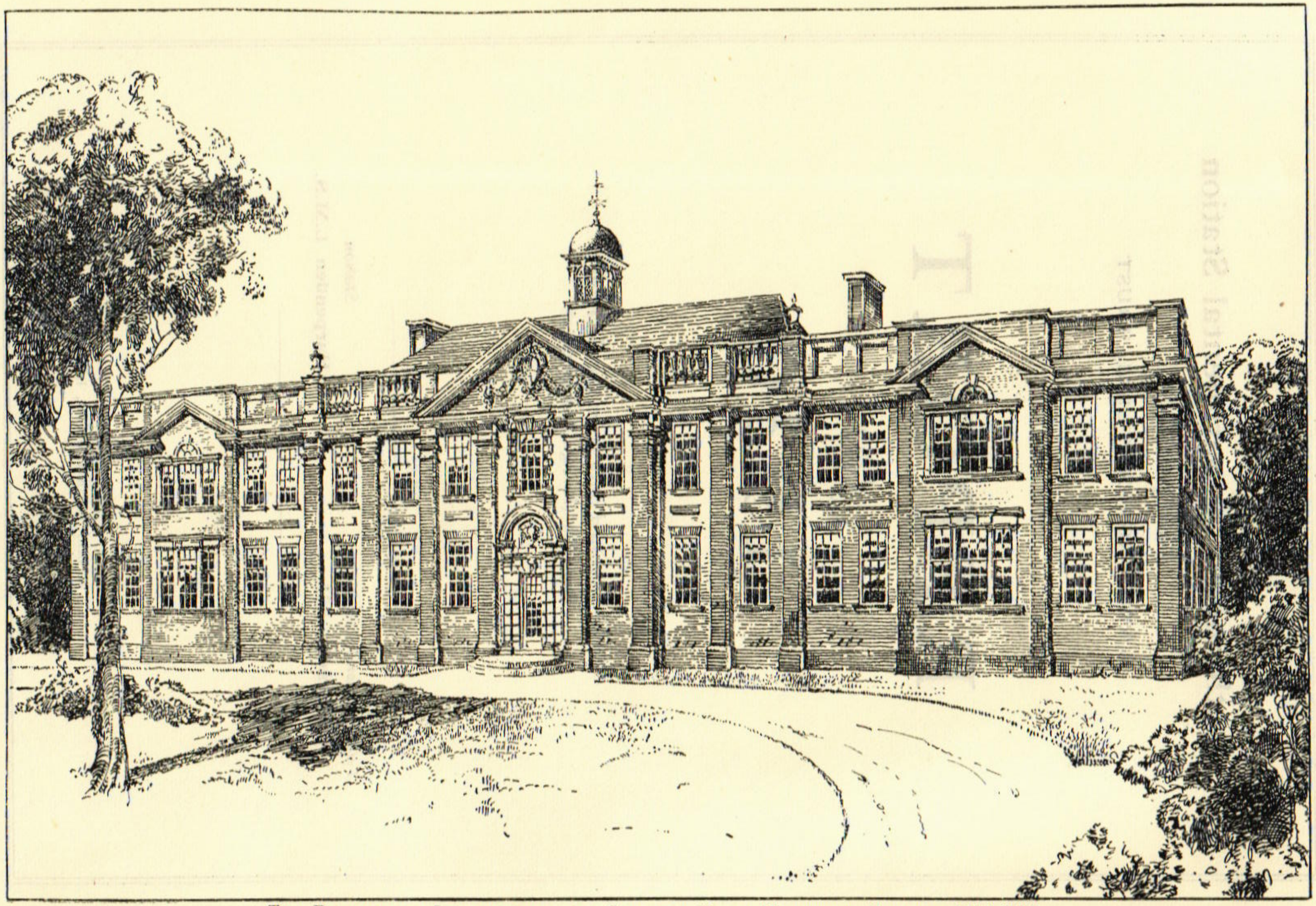

THE ROTHAMSTED LABORATORIES FOR SOIL AND PLANT NUTRITION, ERECTED 1914-1916

REPORT
FOR
1930

https://doi.org/10.23637/ERADOC-1-63

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Experimental Station Staff

Director: SIR E. JOHN RUSSELL, D.Sc., F.R.S.
Assistant Director: D. WARD CUTLER, M.A., F.L.S., F.Z.S.

INSTITUTE of PLANT NUTRITION and SOIL PROBLEMS

The James Mason Bacteriological Laboratory—

Head of Department ..	H. G. THORNTON, B.A., D.Sc.
Assistant Bacteriologist ..	HUGH NICOL, M.Sc., A.I.C.
Post-Graduate Research Workers	EVELYN C. ANDREWS, B.Sc. E. C. TOMMERUP, B.Sc.
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Botanical Laboratory—

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Post-Graduate Research Worker	JOAN E. TAUDEVIN, B.Sc.
Laboratory Assistant ..	ELIZABETH KINGHAM
Laboratory Attendants ..	KATHLEEN DELLAR MAY DOLLIMORE

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Head of Department ..	E. M. CROWTHER, D.Sc., F.I.C.
Assistant Chemists ..	R. G. WARREN, B.Sc. H. L. RICHARDSON, Ph.D., A.I.C. A. J. PUGH, B.Sc. SIGNE G. HEINTZE, Mag. Phil.
Post-Graduate Research Workers	A. WALKLEY, B.A., B.Sc. T. J. MIRCHANDANI, M.Sc.
Barley Investigations (Institute of Brewing Research Scheme) ..	L. R. BISHOP, M.A., Ph.D. F. E. DAY, B.Sc., F.I.C. DORIS R. M. MARX, M.Sc.
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Laboratory Attendants ..	MAUD BRACEY MURIEL RUSSELL

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Assistant Chemist	S. H. JENKINS, Ph.D., A.I.C.
Post - Graduate Research Worker	J. A. DAJI, M.Ag.
Laboratory Attendant ..	MABEL PAYNE.

Laboratory for Insecticides and Fungicides—

Head of Department ..	F. TATTERSFIELD, D.Sc., F.I.C.
Assistant Chemist	J. T. MARTIN, B.Sc., A.I.C.
Laboratory Attendants ..	IRENE RANDALL. MOLLY JOHNSON

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Assistant Microbiologists ..	LETTICE M. CRUMP, M.Sc., F.Z.S. N. W. BARRITT, M.A. ANNIE DIXON, M.Sc., F.R.M.S. JANE MEIKLEJOHN, B.Sc.
Post - Graduate Research Worker	L. DE TELEGDY-KOVATS, D.Sc.
Laboratory Assistant ..	MABEL DUNKLEY.
Laboratory Attendant ..	HILDA PARSONS.

Physical Laboratory—

Head of Department ..	R. K. SCHOFIELD, M.A., Ph.D. (Empire Cotton Growing Corporation Soil Physicist).
Assistant Physicists ..	G. W. SCOTT BLAIR, M.A. (Goldsmiths' Company Physicist). G. H. CASHEN, M.Sc. E. W. RUSSELL, B.A.
Post - Graduate Research Worker	C. G. HAWES, M.C., B.Sc., M.I.C.E.
Assistant	JESSIE WALKER
Laboratory Assistants ..	W. C. GAME R. F. S. HEARMON.
Laboratory Attendants ..	H. GIBSON. MADELEINE COOTE.

Statistical Laboratory—

Head of Department ..	R. A. Fisher, M.A., Sc.D., F.R.S.
Assistant Statisticians ..	J. Wishart, M.A., D.Sc., F.R.S.E. J. O. Irwin, M.A., D.Sc. A. Margaret Webster, B.A.
Post - Graduate Research Workers	R. J. Kalamkar, B.Sc. J. W. Hopkins, M.Sc. A. L. Murray, B.A. F. R. Immer, Ph.D.
Assistant Computers ..	A. D. Dunkley. Florence Pennells. Alice Kingham. Kitty Rolt.

INSTITUTE of PLANT PATHOLOGY

Entomological Laboratory—

Head of Department ..	A. D. Imms, M.A., D.Sc., F.R.S.
Assistant Entomologists ..	H. F. Barnes, B.A., Ph.D. D. M. T. Morland, M.A. H. C. F. Newton, B.Sc., A.R.C.S.
Field Assistant	A. C. Rolt.
Laboratory Attendants ..	Edith Cooper. Elizabeth Sibley.

Mycological Laboratory—

Head of Department ..	W. B. Brierley, D.Sc., F.L.S.
Assistant Mycologist ..	Mary D. Glynne, M.Sc., F.L.S.
Bacterial Diseases ..	R. H. Stoughton, B.Sc., A.R.C.S., F.L.S.
Virus Diseases	J. Henderson Smith, M.B., Ch.B., B.A.
Special Staff — Empire Marketing Board Scheme:	
Physiologist	J. Caldwell, B.Sc., Ph.D.
Cytologist	Frances M. L. Sheffield, Ph.D., F.L.S.
Entomologist	Marion A. Hamilton, Ph.D.
Glasshouse Superintendent	Margaret M. Browne.
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Laboratory Assistant ..	Doris Tuffin.
Laboratory Attendant ..	Edna Evenett.
Glasshouse Attendant ..	Hilda Hale.

FIELD EXPERIMENTS

Guide Demonstrators ..	H. V. Garner, M.A., B.Sc. E. H. Gregory.
Plant Physiologist ..	D. J. Watson, M.A.
Field Superintendent ..	B. Weston.
Assistants	G. F. Cole. S. A. W. French. G. Wilcock.
Plant Physiologists for Special Experiments (Imperial College of Science and Technology) ..	F. G. Gregory, D.Sc. A. T. Legg. F. J. Richards, M.Sc. E. R. Leonard.
Field Assistant	G. W. Messenger.
Laboratory Attendant ..	Kathleen Keys.

FARM

Director	H. G. Miller, B.Sc.
Bailiff	H. Currant.
Ploughmen	F. Stokes. F. A. Lewis.
Stockmen	T. J. Lewis. J. R. Vipond. J. I. Davies.
Tractor Driver	J. Underhill.
Labourer	W. Holland.

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Librarian	Mary S. Aslin.
Assistant Librarian ..	Janet N. Combe.

SECRETARIAL STAFF

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Assistant Secretary ..	Constance K. Catton.
Director's Private Secretary	Annie E. Mackness.
Senior Clerk	Beatrice E. Allard.
Junior Clerks	Nora Leverton. Rose Robinson. Lucy Arnold.

Photographer	V. Stansfield, F.R.P.S.
Laboratory Steward and Storekeeper	A. Oggelsby.
Engineer and Caretaker ..	W. Pearce.
Assistant Caretaker ..	F. K. Hawkins.

Woburn Experimental Farm

Hon. Local Director ..	J. A. VOELCKER, C.I.E., M.A., Ph.D.
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.

FARM STAFF

Assistant Manager ..	T. C. V. BRIGHT.
Ploughmen	G. TYLER J. MCCALLUM.
Stockman	W. MCCALLUM.
Assistant Stockman ..	D. MCCALLUM.
Labourers	K. MCCALLUM. J. TYLER.

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

B. A. KEEN, D.Sc. ..	Director, Imperial Institute, of Agricultural Research, Pusa, India.
A. R. CLAPHAM, Ph.D. ..	Departmental Demonstrator, School of Botany, Oxford University.

TEMPORARY WORKERS, 1930

In addition to those temporary workers recorded in the list of Staff, the following have worked at the Station for various periods during the year 1930 :—

SENT OFFICIALLY BY GOVERNMENTS AND CORPORATIONS :

(1) *Colonial Office Agricultural Officers :* H. C. Arnold (Rhodesia), C. H. N. Jackson (Tanganyika), A. W. R. Joachim (Ceylon).

Colonial Office Scholar : I. R. Black.

Australian Government : Frances E. Allan, N. H. Parbery (Department of Agriculture, New South Wales).

Canadian Government : Miss M. Crawford, C. H. Goulden.

Indian Government : H. E. Castens, Dr. B. K. Mukerji, Dr. J. K. Basu.

Department of Scientific and Industrial Research : Dr. A. G. Norman.

(2) *From Foreign Countries—*

Rockfeller Foundation Fellows : E. Anderson, Dr. Elizabeth F. McCoy.

Brazil : Dr. A. Franco.

Denmark—Farm and Experimental Plots : E. Boserup. H. Branth, H. Hansen, O. Hansen, A. Madsen, N. B. Nikolajsen, H. Petersen.

Egypt : Dr. F. Allam.

Greece : B. G. Christidis.

Holland : Miss H. Van Straaten.

Sweden : K. E. Troell.

United States of America : Prof. H. H. Whetzel.

OTHER WORKERS :

J. R. H. Coutts, V. S. Desai, A. Stuart Miller, Miss M. Roupell, E. E. Skillman, A. Steel.

We regret to announce that Mr. W. D. Christmas, who for thirteen years was Hon. Computer in the Statistical Department, died on January 3rd, 1931.

Imperial Bureau of Soil Science

Director : Sir E. J. Russell, D.Sc., F.R.S.
Deputy Director : A. F. Joseph, D.Sc., F.I.C.
Assistants : A. J. Lloyd Lawrence, M.A., Helen Scherbatoff.
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.

"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.

(1)* "THE GROWING OF LUCERNE." 1/6.

(2) "THE CULTURE AND MANURING OF FODDER CROPS." 1/6.

(3) "GREEN MANURING; ITS POSSIBILITIES AND LIMITATIONS IN PRACTICE." 2/-.

(4) "THE CULTURE AND MANURING of SUGAR BEET." 2/6.

(5) "ART AND SCIENCE OF CULTIVATION." 2/.

(6) "POWER FOR CULTIVATION AND HAULAGE ON THE FARM." 2/6.

(7) "MALTING BARLEY." 2/6.

(8) "RECENT CHANGES IN SYSTEMS OF HUSBANDRY IN ENGLAND." 2/6.

(9) "THE HERTFORDSHIRE AGRICULTURAL SITUATION: CAN IT BE IMPROVED?" 2/-.

(10) "THE GROWTH OF CHEAPER WINTER FOOD FOR LIVE STOCK." 2/6.

(11) "THE MAKING OF NEW GRASSLAND: EXPERIENCES OF PRACTICAL FARMERS." 2/6.

(12) "THE PLACE AND MANAGEMENT OF SHEEP IN MODERN FARMING." 1/6.

(13) "THE TECHNIQUE OF FIELD EXPERIMENTS." 1/6.

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.

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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.

"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) 1931, by B. A. Keen, D.Sc. 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/-.

"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/-.

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

"Agricultural Investigations at Rothamsted, England, during a Period of 50 Years," by Sir Joseph Henry Gilbert, M.A., LL.D., F.R.S., etc. 1895. 3/6.

"Guide to the Experimental Plots, Rothamsted Experimental Station, Harpenden." 1913. John Murray, 50 Albemarle Street, W. 1/-.

"Guide to the Experimental Fields," Rothamsted. 1930.

"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.

The Rothamsted Experimental Station Reports :—

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1918-1920	(triennial).	2/6.
1921-1922	(biennial).	2/6.
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1925-1926	(biennial).	2/6.
1927-1928	(biennial).	2/6.
1929	(annual)	2/6.
1930	(annual)	2/6.

Foreign postage extra.

"Records of the Rothamsted Staff, Harpenden," containing personal notes and accounts of past and present events at Rothamsted and of past members of the Staff. Published annually in June. No. 1, June 1929. No. 2, June, 1930. 2/-. each. Post free. Subscription for first five issues, 7/6, payable in advance.

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. 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.

Mezzotint Engravings

Mezzotint Engravings of Portraits of the Founders of the Station, Sir J. B. Lawes (H. Herkomer) and Sir J. H. Gilbert (F. O. Salisbury), by Julia Clutterbuck, A.R.E.

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To be obtained from the Secretary, Rothamsted Experimental Station, Harpenden, Herts.

Plans and Drawings of the old Rothamsted Laboratory, 1852

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 1930-31, 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. Imperial Chemical Industries, Ltd., and the Fertiliser Manufacturers' Association, jointly defray the cost of a Guide Demonstrator for the field plots and, in addition, provide considerable funds for the extension of the work; the United Potash Company, European Cyanamide Export Company, Beet Sugar Factories (Anglo-Dutch Group) and other firms, also give substantial assistance. 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 laboratories have been entirely rebuilt in recent years.

The main block 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 the house adjoining the laboratories on the North side, the Red Gables, 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.

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Perhaps even more important has been the reorganisation of the work of the Station so as to keep it in touch with modern conditions of agriculture on the one side and of science on the other. This was completed in the laboratories in 1922, on the Farm in 1924, and on the field plots in 1926, when the field laboratory was erected and the new methods of field experiment were adopted. In 1926, the International Education Board, Rockfeller Foundation, generously gave a grant of £2,000 for the extension of the glass-houses on condition that another £1,000 should be obtained; this was done with the help of the Ministry of Agriculture and of the Society for Extending the Rothamsted Experiments. In 1928, the Empire Marketing Board made a grant of £1,835 for the erection of special insect-proof houses, and an annual grant of about £2,200 for the study of virus diseases. The equipment of the Station is now exceptionally good.

The Library is steadily growing, and now contains some 22,000 volumes dealing with agriculture and cognate subjects. The catalogue of the old printed books on agriculture has been published, 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 farmhouses, 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, thanks to the grants of the Royal Agricultural Society and the co-operation of the Institute of Brewing. 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 organisation, 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. Dr. Harold H. Mann, formerly Director of Agriculture, Bombay Presidency, India, and Agricultural Adviser to H.E.H. the Nizam's Government, Hyderabad, India, has been appointed Assistant Director, with Mr. T. W. Barnes as Chemist, and the laboratories, pot-culture station and meteorological station have been re-equipped and reorganised. 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.

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, Canada and Russia to discuss agricultural problems and possibilities of co-operation ; in addition, visits are paid to the United States and to European countries 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 has been inaugurated. 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. Dr. A. F. Joseph, late Chief Chemist to the Sudan Government, was appointed Deputy Director ; Mr. A. J. L. Lawrence, Scientific Assistant ; and Miss H. Scherbatoff, Translator.

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 FOR THE YEAR 1930

The purpose of the Rothamsted work is to discover the principles underlying the facts of agriculture and to put the knowledge thus gained into a form in which it can be used by teachers, experts and farmers for the upraising of country life and the improvement of the standard of farming. This purpose has remained unchanged during the 87 years of life of the Station, a steadfastness which experience has amply justified. A programme drawn up solely to suit a particular set of economic conditions becomes obsolete when the conditions change and the results may then be of little use ; but accurate information properly gained and tested always has value, and with this at his disposal the farmer is better able to adapt himself to new circumstances.

The Rothamsted investigations are concerned mainly with crop production and utilisation ; they involve the growth of the plant in health and disease, its nutrition, its reaction to soil and climatic conditions, and its composition under various conditions. The knowledge thus gained is applied to problems of soil management, the use of fertilisers, the control of plant diseases and the value of the resulting crop. The work involves pure science on the one hand and commercial farming on the other, and it necessitates co-operation with both groups of workers. Happily this is freely given ; on the pure science side valuable help comes from the great scientific institutions, the Botany School of the Imperial College, the Biochemical School at Cambridge and others ; on the practical side help is freely given both by farmers who allow us without cost to make experiments on their farms, and by expert users of the crops who give us or enable us to obtain information about their requirements so that we can try to find ways whereby farmers can produce what buyers most desire.

New Developments on the Farm. Two important new rotation experiments have been started, particulars of which will be found on pp. 125-129.

By the courtesy of Sir John Flett, Director of the Geological Survey, Mr. Henry Dines was enabled to visit Rothamsted and re-examine the geology of the farm. His report is given on p. 59.

During 1930 the equipment of the farm was greatly improved. The Committee spent some £2,000 in purchasing live stock, fencing and equipment to make the fullest use of the new grass land, and the Development Commission generously gave a grant of £1,700 to allow of much needed additions to the farm buildings and the laying on of water to the fields.

Thanks also to the sympathetic co-operation of the North Metropolitan Electric Power Supply Company, the farm is now to be connected up with their system. The buildings lie well off the track of the supply cables, nevertheless the company has been good enough to erect a special line, asking only a nominal guaranteed revenue, in order that we may be able to investigate the possibilities of using electricity in agriculture. The work will fall into three divisions:

(1) Use of appliances already known to be effective, so as to gain experience with them, to record their performance and to see how they compare in convenience, effectiveness, and cost with the older appliances. These will be fully demonstrated to all agriculturists interested.

(2) Tests for electrical engineers and implement makers of promising electrical devices not yet in common use about which more information is wanted.

(3) Investigations of possible new applications of electricity in agriculture.

It is hoped to begin work during the coming season.

The Committee has been fortunate in obtaining much valuable assistance from the General Electric Company and from Mr. R. Borlase Matthews, the well known electrical expert.

THE FIELD EXPERIMENTS.

CEREAL CROPS—BARLEY

An inquiry made in 1930 from the chief barley merchants in England, showed that about 65 per cent of the barley grown in England is sold for malting, a further 20 per cent is sold for seed, chicken mixtures, barley meal, etc., and the remaining 15 per cent is retained on the farm and crushed or ground for the animals.

This 65 per cent of barley sold by the farmer does not completely satisfy the maltsters demands. Only about one half of the barley used for malting is British grown[1]; the remainder comes from overseas. It is obviously important that the farmer should try to supply as much as possible, and with this end in view the Institute of Brewing has since 1922 carried out extensive investigations in co-operation with Rothamsted and the National Institute of Agricultural Botany to furnish all necessary information. The samples of barley grown in the various experiments are malted, and the more promising are brewed, so as to discover the effect of soil, season, manuring and variety on the malting and brewing qualities.

The characteristic of the season 1930 was the large response to nitrogenous manures, and the small returns from potash and phosphate. This held true of all the centres, with minor variations. At Rothamsted the increase was of the order of 4½ cwt. (9 bushels) of grain, and 4½ cwt. straw for 1 cwt. of sulphate of ammonia; at Woburn the return was even higher: over 11 bushels of grain. Phosphatic and potassic fertilisers, on the other hand, gave no

[1] "Report on the Agricultural Output and Food Supplies of Great Britain," 1929, Ministry of Agriculture. The proportions vary as between brewing and distilling; about three-fifths of the malt used in brewing is from British grown barley, as against one-third of the malt used in distilling.

TABLE I.—Highest yields on Experimental Plots at Rothamsted, 1920–1930.
PRODUCE PER ACRE.

Years.	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930
Wheat in cwt.—Grain	20.4	19.9	19.7	16.2	25.7	13.6	25.7	27.3	36.5	21.8*b*	31.2
Ref. in Report ..	p. 79	p. 92	p. 86	p. 102	p. 112	p. 154	p. 137	p. 135	p. 129	p. 95	p. 132
Straw	45.4	37.5	37.4	38.6	39.7	25.0	48.4	55.8	62.0	57.6	81.2
Ref. in Report ..	p. 74	p. 85	p. 86	p. 108	p. 112	p. 132	p. 147	p. 135	p. 129	p. 87	p. 132
Barley in cwt.—Grain	23.4	22.1	19.1	18.6	22.3	23.2	22.3	23.8	20.5	30.5	30.5
Ref. in Report ..	p. 76	p. 90	p. 103	p. 114	p. 117	p. 151	p. 149	p. 132	p. 133	p. 98	p. 132
Straw	29.1	25.9	24.6	21.1	26.1	23.9	40.6	28.3	37.4	44.9	42.5
Ref. in Report ..	p. 81	p. 101	p. 101	p. 117	p. 117	p. 151	p. 149	p. 130	p. 133	p. 98	p. 131
Oats in cwt.—Grain ..		22.0		21.4	17.5	26.0	30.2	22.3	22.0*a*	15.9	16.8*c*
Ref. in Report ..		p. 93		p. 116	p. 128	p. 145	p. 146	p. 153		p. 93	p. 144
Straw		47.0		41.3	33.6	45.5	58.6	22.7		28.7	35.3
Ref. in Report ..		p. 93		p. 116	p. 128	p. 151	p. 146	p. 153		p. 93	p. 144
Hay—Cwt.	88.3	65.9	29.1	132.4	73.4	90.3	86.7	70.7	76.4	50.3	91.4
Ref. in Report ..	p. 70	p. 82	p. 95	p. 104	p. 104	p. 128	p. 128	p. 126	p. 126	p. 86	p. 121
Clover—Cwt.	24.1	54.9	26.4	78.8	72.3		32.2		28.0*a*		73.0*d*
Ref. in Report ..	p. 83	p. 102	p. 98	p. 112	p. 114		p. 125				p. 132
Potatoes—Tons	11.8	4.3	10.7	16.6	11.9	11.0	12.3	8.0	11.1	6.8	11.1
Ref. in Report ..	p. 81	p. 98	p. 94	p. 118	p. 120	p. 139	p. 140	p. 140	p. 142	p. 99	p. 146
Swedes in tons—Roots ..	21.7		32.6	17.1	21.6		21.8	15.2	22.8		
Ref. in Report ..	p. 77		p. 94	p. 119	p. 122		p. 136	p. 150	p. 152		
Tops	4.3			1.8	4.4		3.9	5.3	1.1		
Ref. in Report ..	p. 77			p. 119	p. 122		p. 136	p. 150	p. 152		
Mangolds in tons—Roots.. ..	37.7	31.0	31.6	37.4	34.2	27.1	34.7	17.3	29.3	20.7	30.9
Ref. in Report ..	p. 69	p. 81	p. 81	p. 103	p. 103	p. 127	p. 127	p. 125	p. 125	p. 85	p. 149
Tops	7.3	5.3	6.34	5.2	7.2	7.3	6.1	4.8	6.1	4.2	8.2
Ref. in Report ..	p. 69	p. 81	p. 81	p. 103	p. 103	p. 127	p. 127	p. 125	p. 125	p. 85	p. 149
Sugar Beet in tons—Roots ..							12.1	4.0	9.5	9.2	8.0
Ref. in Report ..							p. 142	p. 146	p. 147	p. 102	p. 132
Tops							26.0	13.0	12.6	6.9	11.7
Ref. in Report ..							p. 142	p. 146	p. 147	p. 102	p. 132

(*a*) Non-experimental.
(*b*) On great Harpenden (non-experimental) the yield was 31½ cwt. per acre of grain as estimated by the sampling method and on Little Hoos it was 29¼ cwt. per acre of grain as measured from the threshing machine.
(*c*) Little Hoos and Long Hoos non-experimental oats yielded 22 cwt. per acre of grain. Yield on p. 132 is dry matter.
The 1926 sugar beet was grown on freshly broken grass land well manured; the others are grown in the rotations.

increases in grain on either farm; indeed heavy dressings of phosphate appeared slightly to depress the yield of grain at Woburn, as had happened in some of the previous years. The straw was increased, though barely significantly, by phosphate, especially at Rothamsted; possibly also, though not significantly, by potash. The figures, set out side by side, are as follows

Varying Nutrient	Rothamsted heavy soil Doses of Nutrient					Woburn light soil Doses of Nutrient				
	0	1	2	3	4	0	1	2	3	4
	Grain : cwt. per acre					Grain : cwt. per acre				
Nitrogen	21	25	27	22	31	13.6	18.9	18.2	20.7	23.0
Phosphate	28	26	27	25	26	22.0	22.1	22.1	19.4	20.5
Potassium	30	33	40	36	33	19.3	20.7	19.6	21.1	20.4
	Straw : cwt. per acre					Straw : cwt. per acre				
Nitrogen	23	27	30	23	35	29	36	37	46	45
Phosphate	30	24	31	39	37	36	38	37	38	39
Potassium	30	33	40	36	33	33	33	33	34	36

In another experiment at Rothamsted (p. 134) the returns from nitrogenous manure were lower, and less than last year.

On the light limestone soil at Wellingore the return from nitrogen was as high as at Woburn and there was a further return from potash, and a still further return from potash and phosphate, though not from phosphate alone. The result is similar to that of 1929, except that the yields are smaller and certain small effects then observed with phosphate alone hardly appeared in 1930. On the light chalk soil of Sparsholt the nitrogen was less effective, giving an additional 4 bushels per cwt. sulphate of ammonia. Phosphate and potash were ineffective excepting only where nitrate of soda had been used. On the light chalk soil at Wye muriate of potash and salt had no effect on yields of grain or of straw.

Of the nitrogenous manures nitrate of soda was most effective, as in 1929, excepting only at Wellingore where it was no better than sulphate of ammonia or cyanamide. At Rothamsted, cyanamide was less effective than in 1929; the difficulty of applying it to barley is that it should be put on the land a few days before seeding, but this proved impossible. A method sometimes advocated on the Continent was therefore used, and the cyanamide was put on three days after the seed was sown. The result showed that this is not the proper way; we should in future put on the cyanamide first, and harrow the soil before drilling the seed. In this way no time would be lost, and the risk of damage to the seed would be minimised. Whenever possible a few days should elapse between harrowing in the cyanamide and sowing the seed.

The effect of the phosphatic fertilisers was tested on the exhausted land of Rotation I (four course): superphosphate proved considerably more effective than rock phosphate.

Behaviour of Different Varieties of Barley. For the past two years Spratt Archer and Plumage Archer have been sown in alternate strips in Hoosfield so as to compare their behaviour towards the different fertilisers. The differences are small, but the experiment is being continued. The method is in 1931 being adopted on the permanent barley plots at Woburn, Plumage and Archer being here compared.

Effect on Quality. The effect of nitrogenous fertilisers on yield and quality of the grain is well illustrated by a series of experiments repeated during the three years 1927 to 1929, comparing the effects of 1 and of 2 cwt. of sulphate of ammonia.

The 1 cwt. dressing raised the yield by 3 to 5 cwt. of grain per acre, and 3.6 to 7.7 cwt. of straw without injury to the nitrogen content, 1,000 corn weight, or malting properties. Two cwt. per acre of sulphate of ammonia, however, added little to the yield, and considerably injured the quality. The figures are given in Table II.

The chemical factors involved in quality are discussed on p. 55

Growing for Quality. The general results of the experiments are as follows :

(1) Early sowing is essential for high quality.

(2) The preceding crop is not of great importance provided the land can be cleared in time. A cereal crop is the most convenient because it allows ample time for preparation. A root crop fed off has the disadvantage that the land may be occupied too long.

(3) Modern varieties of barley stand up to nitrogenous manures better than the older ones. It is therefore quite unnecessary to withhold manure. The farmer should aim at large crops, and so long as the treatment gives a good increase, such as that shown in Table II, by 1 cwt. sulphate of ammonia, no harmful effect on quality need be feared.

(4) When clover is sown in the barley a dressing of muriate of potash (1 cwt. per acre), or 30 per cent potash manure salts (1½–2 cwt. per acre) may benefit the barley and will help the clover in the next year. If the land recently had a dressing of superphosphate none need be given to the barley ; otherwise a dressing of 2 cwt. per acre should be given.

TABLE II.—Effect of Increasing Amounts of Sulphate of Ammonia on the Yield and Quality of Barley at Rothamsted.

Yield.

Sulphate of Ammonia cwt./ac.	Grain : cwt. per acre. 1927	1928	1929	Straw : cwt. per acre. 1927	1928	1929
None	11.8	14.3	20.1	15.4	24.4	20.3
1	17.0	17.8	23.1	20.4	32.1	23.9
2	18.9	17.3	25.2	22.2	34.5	24.9

Quality of Barley.

S/Am.	Nitrogen per cent. on dry matter. 1927—All Plots.	Plots Malted.	1928	1929	1,000 corn weight, dry. 1927—all Plots.	Plots. Malted	1928	1929
None	1.458	1.427	1.928	1.464	36.0	36.3	38.2	39.7
1cwt/ac	1.451	1.470	2.049	1.459	35.6	34.8	38.1	39.6
2cwt/ac	1.488	1.510	2.174	1.482	34.6	34.6	37.2	37.0

Quality of Malt.

S/Am.	Extract, lb. per barrel, on dry matter. 1927 Plots Malted	1928	1929	Diastatic Power, Lintner. 1927 Plots Malted	1928	1929	Colour. 1927	1928	1929
None	(99.6)	95.8	98.8	(43.5)	59.0	38.5	4.2	5.4	4.8
1cwt/ac	(99.1)	95.0	98.7	(39.5)	64.0	38.0	4.0	3.9	4.8
2cwt/ac	(98.1)	94.2	98.8	(41.0)	69.0	41.0	4.7	5.2	4.8

Valuation of Barley and Malt.

S/Am.	Barley. Shillings per qr. of 448lb. 1927.	1928.	1929.	Malt. Shillings per qr. of 336lb. 1927.	1928.	1929.
None	38	37	35	68	(2)	54
1 cwt/ac.	41	37	35	68	(1)	54
2 cwt/ac.	39	37	42	68	(3)	54

Notes.—The bracketed Malt Extracts and Diastatic Powers refer to the results on single plot samples : others are means of replicates.
Diastatic Power is depressed with increasing colour.
The 1928 Malts were noted as "unsaleable" by the valuers, but placed in the relative order given in brackets.

WHEAT

No crop is more discussed than this. It is easy to grow and it is especially suited for the somewhat dry regions which in Australia, Canada and Russia are now being populated ; hence a large increase in the amount grown and sent to these shores.

We could, however, grow much larger quantities ourselves if we desired. The present method of growing wheat gives about 33 bushels to the acre which is quite unprofitable. Considerably higher yields, however, are possible. Recent Rothamsted experiments have shown the remarkable effects of a summer fallow in raising the yield ; where rents are low the cost is small, the necessary cultivations being done entirely by tractor. With the ordinary methods our highest yields, as shown in Table I (p. 22) were usually about 37 bushels per acre from 1920 to 1925 (excluding 1924) ; since then they have been 50 to 55 or more. The 1930 Great Knott crop yielded 27 cwt. of grain (50.5 bushels) per acre, and 54 cwt. of straw on the unmanured land ; nitrogenous top dressings added nothing to the grain and 8 cwt. to the straw, which caused the crop to lodge. The preparation had been a fodder crop folded by sheep, which had paid for itself, then the summer fallow. In these circumstances one might expect damage from the wheat bulbfly (*Hylemya coarctata Fall*), and it was present and destroyed many tillers, but there still remained a good crop.

In another experiment, made in Long Hoos field, the wheat followed a seeds ley. The yield without nitrogen averaged only 15.2 cwt. of grain (28.4 bushels) and 21.9 cwt. of straw. There had been much loss of plant during the winter. Four varieties were tested : Square-Head's Master, Million III, Yeoman II and Swedish Iron ; of these the Square-Head's Master gave the lowest yield, 13.1 cwt. of grain per acre, and Swedish Iron as in 1929 the highest, 18.5 cwt. per acre, but on all alike nitrogenous manuring, whether applied early or late, was almost ineffective. Muriate of ammonia applied late appeared somewhat to reduce the yield both of grain and of straw. Sulphate of ammonia applied late gave a better increase of straw, and possibly of grain, than when applied early, thus agreeing with the results of 1926 and 1928, but opposite to those of 1927 and 1929. In the Great Knott experiment the small differences in result, associated with differences in time of application of the fertilisers, were not in themselves significant but were in the direction of the 1927 and 1929 results.

On another experiment in Hoos field the unmanured wheat gave only 14 cwt. of grain per acre (26 bushels) and 22 cwt. of straw, but there was a considerable response to sulphate of ammonia (1.8 cwt. per acre) the yield rising to 20.5 cwt. of grain (38.2 bushels) and 29 cwt. of straw.

A new experiment in the management of the wheat crop was tried. Now that we have gone in extensively for sheep we are in constant need of fresh grazing land in spring. It is therefore important to know how far one can safely follow the old Hertfordshire custom and graze wheat in March or April. This was tried in 1930 on Long Hoos field; part of the wheat was grazed on, part was left ungrazed. The ungrazed portion yielded 15.7 cwt. of grain per acre (29.3 bushels), and the grazed portion 13.5 cwt. (25.2 bushels), a loss of 4 bushels of grain and 4 cwt. of straw together worth 20s. at selling price; the value as grazing was estimated by the farm manager at about the same price.

The quality of the wheat is assessed by Dr. E. A. Fisher of the Research Association of British Flour Millers, St. Albans. He finds that the Rothamsted wheats are all somewhat poor in quality, the Broadbalk wheats especially so. None of the methods of increasing the yield has improved the quality.

Another important investigation has been begun, thanks to the co-operation of the Dunn Nutritional Laboratory at Cambridge. Dr. Harris and Dr. Moore propose to examine samples of our various wheats for vitamin content. The results promise to be of great interest, and they may open out entirely new lines of work.

THE FALLOWING OF BROADBALK WHEAT FIELD

The year 1929-30 was the first in which the whole of Broadbalk wheat field was again under wheat after the four years in which parts had been fallowed. The crop was harvested in five portions:

1 and 2	The upper two fifths (west end) fallowed 1925-1927, then cropped.
3	The middle fifth, fallowed 1925-1929, then cropped.
4 and 5	The lower two fifths (east end) fallowed 1927-1929, then cropped.

We therefore had in 1930 a crop grown after two years' fallow, another after four years' fallow, and a third after two previous wheat crops. The yields are given on pp. 122-3.

The first crop after the fallow was exceptionally high, with a ratio of grain to straw well up to the average. The effect of the fallow, however, was only transient; both yield and Grain/Straw ratio rapidly fell; in the second year the yield was approximately equal to the average and in the third year after fallow it was well below. The weeds are rapidly coming back. *Alopecurus agrestis* is already established.

Dr. Brenchley's observations show that the value of bare fallowing for weed eradication depends largely upon the species it is desired to eliminate. Some species, as Shepherd's Purse (*Capsella Bursapastoris*), which germinate and flower throughout the year, are not reduced by fallowing, because they grow and form seed so quickly that they re-stock the ground in the interval between autumn ploughing and the first spring cultivation. Others, as Poppy (*Papaver sp.*), have so long a period of natural dormancy, that they leave enough viable seeds in the soil to yield a big crop even after the fallowing. On the other hand, Black Bent (*Alopecurus agrestis*) and others with a short period of dormancy, are so reduced by fallowing that they can be kept within bounds; sufficient viable seeds are, however, left in the ground to recolonise the land rapidly unless adequate cultivation be given.

Fallowing also improves the physical condition of the soil. It had so marked an effect on the tilth that we were able in the first year of cropping to obtain a seed-bed with no more cultivation than harrowing. However this effect soon passed away, and in the second year the seed-bed was no more easy to obtain than usual; it was less fine than in the first year.

It is proposed in future to continue the separate harvestings and to continue the fallowing indefinitely but in a somewhat different way. In 1930-31 Strip 1 is being fallowed (the west end); in 1931-32 Strip 2 will be fallowed, and so throughout. In each year, therefore, one-fifth of the field will be under fallow and four-fifths under crop, of which one-fifth is in the first year after fallow, another in the second year, and the others in the third and fourth years respectively. This will give opportunities of studying the effects of fallowing and also of keeping the field clean.

POTATOES

The variety planted was again Ally. It yields less on our land than Kerr's Pink, which we grew from 1921 till 1926, but it matures earlier and fits in better with our programme of autumn work.

There were two sets of experiments, both in the same field and with the same variety; in one the maximum yield was 11 tons, in the other with equally efficient mixtures of artificial fertilisers, it was 7 tons only. The heavy yielding crop had had farmyard manure, the other had not. In general one would not have expected so marked a difference[1], but in 1930 the crop receiving farmyard manure continued growing well throughout the latter part of the season, while the crop without it weakened early and became smothered in weeds, mainly chickweed (*Stellaria media*); no fertiliser scheme helped much, although no fewer than 13 were tried; the yield without nitrogen, like that without potash, was 4 tons per acre; this was raised to 7 by the heaviest dressings of artificials. The number of plants per acre averaged 14,760. In the other set the crop gave a yield of 7.5 tons from farmyard manure without any artificials. One cwt. sulphate of ammonia gave an additional 30 cwt. of potatoes as also did 1.6 cwt. sulphate of potash so long as sufficient superphosphate was given, otherwise the increase was only 24 cwt. Superphosphate (3 cwt. per acre)

[1] See Report for1923-24, pp. 120, 121, for and 1921-22, p. 98

gave the very satisfactory increase of 36 cwt. of potatoes per acre so long as there was sufficient nitrogen and potash ; with insufficient quantities the increase was only 11 cwt. The results are as follows :

Average yield in tons per acre.

Sulphate of Ammonia, cwt. per acre.		Without Phosphate. 0	1	2	With Phosphate. 0	1	2
Sulphate of	0	7.55	8.12	8.78	7.89	8.32	9.75
Potash, or	1	7.64	9.29	9.00	8.30	9.84	10.16
equivalent cwt.	2	8.01	9.53	9.22	8.85	10.25	11.00
per acre			Mean 8.57 tons.			Mean 9.37 tons.	

General mean — 8.97 tons. Standard error for above table —0.215 tons or 2.40 per cent.

Mean number of plants per acre, 14,341.

All plots received farmyard manure.

As betweeen the various potassic fertilisers sulphate of potash, muriate of potash and potash manure salts all gave approximately equal yields when used with a complete fertiliser. When, however, superphosphate was omitted the muriate and the manure salts were less effective than the sulphate suggesting that the potato needs sulphate as well as nitrogen, potassium, and phosphorus ; a result also obtained at Woburn (p. 152).

The maximum yield was 11 tons per acre ; it is remarkable how often this figure has been attained as the highest on our farm. The number of plants per acre was about 14,500.

No quality determinations were made this year, but chemical analyses were made of the tubers of the heavier crop. The percentage of dry matter in the tubers was about 23 ; it was not affected by nitrogenous, or phosphatic manuring, or by sulphate of potash ; it was, however, lowered by chlorides ; thus potash manure salts in the larger dressing lowered it from 23.3 per cent to 22.1 per cent. The nitrogen content of the tubers was about 0.3 per cent ; it was raised by nitrogenous but lowered by phosphatic and potassic manuring, and by the chlorides ; it was, however, least affected by sulphate of potash. The figures are given in Table III.

TABLE III.—Composition of Potatoes as influenced by Manuring.
Potatoes, Long Hoos, 1930.
Percentage of Dry Matter.

		No Superphosphate given. No S/Amm.	Single S/Amm.	Double S/Amm.	Superphosphate given. No S/Amm.	Single S/Amm.	Double S/Amm.
	No Potash	22.94	23.37	22.94	22.83	23.14	23.54
Single Potash	Sulphate	23.25	22.66	23.87	23.26	22.95	22.97
	Muriate	22.95	23.25	22.98	23.32	23.04	22.56
	Potash Salts	22.82	22.72	23.22	22.35	23.15	22.59
Double Potash	Sulphate	23.39	23.56	23.28	22.61	23.68	23.47
	Muriate	22.29	22.94	22.51	22.42	23.03	22.81
	Potash Salts	22.43	21.99	22.05	22.32	21.99	21.73
Mean		22.87	22.93	22.98	22.73	23.00	22.81
General Mean			22.92			22.85	

Potatoes, Long Hoos, 1930.

Percentage of Nitrogen.

		No Superphosphate given			Superphosphate given		
		No S/Amm.	Single S/Amm.	Double S/Amm.	No S/Amm.	Single S/Amm.	Double S/Amm.
	No Potash	.320	.342	.354	.298	.320	.342
Single Potash	Sulphate	.313	.331	.350	.297	.318	.288
	Muriate	.318	.317	.335	.293	.298	.333
	Potash Salts	.321	.327	.359	.295	.322	.322
Double Potash	Sulphate	.316	.334	.358	.330	.324	.338
	Muriate	.286	.331	.322	.286	.311	.323
	Potash Salts	.294	.310	.334	.295	.292	.318
	Mean	.310	.327	.345	.299	.312	.323
General Mean			.327			.312	
In dry matter— Means		1.316	1.426	1.501	1.315	1.357	1.416
General Mean			1.427			1.365	

Summary of Potassic Manures : Mean of all.

Amount of K_2O cwt. per acre.	Dry matter : per cent. in tubers.	Nitrogen per cent. in fresh tubers.	Nitrogen per cent. in dry matter.
None	23.1	0.329	1.42
0.4	23.0	0.319	1.38
0.8	22.7	0.317	1.39
Standard error	0.10	0.0028	

Effect of Different Salts.

	Dry matter per cent. in tubers.		Nitrogen per cent. in fresh tubers.		Nitrogen per cent. in dry matter.	
Amount of K_2O cwt. per acre	0.4	0.8	0.4	0.8	0.4	0.8
As Sulphate	23.2	23.3	0.316	0.334	1.36	1.43
As Muriate	23.0	22.7	0.316	0.310	1.37	1.36
As 30 per cent. P.M.S.	22.8	22.1	0.324	0.307	1.47	1.39
Standard errors	0.17		0.0049			

The potatoes at Woburn (also Ally) yielded even better than at Rothamsted giving up to 13 tons per acre. The most marked effects were from nitrogenous manuring ; phosphatic and potassic fertilisers had less effect, contrary to expectation on this light soil. In another experiment cyanamide and sulphate of ammonia were found equally effective, as also were superphosphate and basic slag, compared on the basis of equal amounts of nitrogen and of phosphoric acid respectively. Another experiment indicated, like the one at Rothamsted, that a certain amount of sulphate, in the forms of sulphates of magnesium, potassium and calcium, had been beneficial ; larger amounts, however, were not (p. 152).

In our Rothamsted and Woburn experiments we have commonly obtained very satisfactory yields from the following mixture of fertilisers :

10 tons farmyard manure ploughed under in autumn or winter.
3 or 4 cwt. sulphate of ammonia.
3 or 4 cwt. sulphate of potash.
4 cwt. super. (17 per cent P_2O_5)

applied in the drills at the time of setting the seed ; the 3, 3, 4 mixture correspond to the proportions 1N : $2.5K_2O$: $1P_2O_5$. Where muriate of potash or potash manure salts are used instead of the sulphate the amount of chlorine (Cl) should not be more than double the nitrogen (N).

Experiments were also made at other centres in various parts of England. The most striking result has been the marked benefit from superphosphate, the average increase at the seven responsive centres per cwt. of 36 per cent super. (17 per cent P_2O_5) having been 12 cwt. per acre ; the same figure as is obtained at Rothamsted. The actual increase varied ; at one of the centres the response was only 3 cwt., at another it was 24 cwt. ; at three centres there was no response. The average increases for the past three seasons per cwt. of 36 per cent superphosphate (17 per cent P_2O_5) are given in Table IV.

TABLE IV.—Increases in Yield of Potatoes per cwt. of 36 per cent. super.

	1928 cwt.	1929 cwt.	1930 cwt.
Wisbech	2	6	10*
Stowbridge	19	—	—
Woburn	9	−2	—
Rothamsted	6	6	12
Owmby Cliff	−14	Nil	8
Bangor	−2	−4	—
Midland Agric. College ..	—	−2	10
Haverfordwest	—	—	13
Nateby	—	—	3
Welshpool	—	—	24

* British Queen : King Edward gave no increase.
Details are given on p. 00.

The result at Owmby Cliff is especially interesting because it was here that super. had apparently depressed the yield in 1928, a result similar to that at Kirton. In 1929 it had no effect, and in 1930 it has increased the yield. However the depression may have been caused, it is obviously only an exceptional occurrence and we are not yet prepared to account for it.

A number of experiments have now been made to ascertain how heavily a crop can advantageously be fertilised with superphosphate. In general the effect depends on the level of nitrogen and of potash given, and the broad results are (1) that these two fertilisers can act well only when the crops are sufficiently well supplied with phosphate ; and (2) that superphosphate is effective even in large dressings where the level of crop production varies from 9 to 14 tons per acre—the usual case in good potato districts—but it had little action where the yields without it, or with only a small dressing, were below 8 tons or above 14 tons per acre :

Yield of potatoes when only one dose of superphosphate was given.	No. of experiments.	Average yield, tons per acre.			
		No Super.	Super. given.		
			Single dose.	Double dose.	Quadruple dose.
Below 8 tons ..	4	6.92	6.54	6.66	6.65
9–14 tons	8	9.97	11.19	11.40	11.77
Above 14 tons	5	15.37	15.39	15.80	15.80

The details are given in Table V the " dose " is usually 2 cwt. 36 per cent. super. per acre.

TABLE V.—Effect of Superphosphate on Yield of Potatoes: Tons per acre.

Year	Centre.	Soil.	No Super.	Single dose[1]	Double dose.	Quadruple dose.
1927	Woburn[3]	Light sand	4.06	4.10	3.96	4.08
1928	Woburn[3]	,,	12.25	13.43	14.00	14.69
1928	Stowbridge, Norfolk ..	Black fen	8.10	10.05	10.97	12.57
1928	Owmby Cliff, Lincs. ..	Oolitic limestone	8.18	6.79	7.73	7.25
1929	Owmby Cliff ..	,, ,,	7.42	7.44	7.34	7.30
1928	Bangor	Light gravelly	15.78	15.62	16.12	16.03
1929	Bangor	loam	14.66	14.25	14.53	14.66
1929	Midland Agric. Coll...	Light loam	8.00	7.82	7.63	7.97
1928	Wisbech[4]	Deep silt	16.98	17.32	17.55	17.75
1929	Wisbech[2]	,, ,,	11.67	12.48	12.82	13.11
1930	Owmby Cliff ..		11.37	12.19	11.85	12.34
1930	Midland Agric. Coll. ..		10.03	10.98	9.05	9.70
1930	Wisbech[4]		13.18	14.14	14.42	14.62
1930	Wisbech[2]		16.27	15.60	16.39	15.93
1930	Haverfordwest ..	Hungry sand	7.94	9.21	9.68	9.96
1930	Nateby (Lancs.) ..	Moss soil in deep peat	9.24	9.54	9.50	9.44
1930	Welshpool	County School garden	9.18	11.64	13.29	12.36
1930	Bourne[5]	Light black fen	10.22	—	12.07	12.18

[1] Single dose usually 2 cwt. superphosphate per acre.
[2] King Edward. Single dose 2½ cwt.
[3] Single, double and treble doses, unit 3 cwt. in this case.
[4] British Queen. Single dose 2½ cwt.
[5] Single dose 2½ cwt.

Both at Bourne and at Wisbech 5 cwt. of super. gave profitable returns: 1.85 tons of potatoes at the former, and 1.24 at the latter centre; at Wisbech, however, the response was confined to British Queen and there was no gain with King Edward. These differences in behaviour of different varieties are now being studied.

At Bourne the first 2 cwt. of sulphate of potash increased the yield of potatoes by 1 ton per acre, and the second 2 cwt. gave a further increase of 16 cwt. per acre, both profitable.

Perhaps the most dramatic result at the outside centres is that obtained at Tunstall by Mr. A. W. Oldershaw on a light sandy soil in Suffolk, reckoned as hopelessly bad, which yet when chalked and given a dressing of 3½ cwt. superphosphate and 4 cwt. nitrate of soda per acre, yielded over 13 tons of potatoes per acre.

Finally, in experiments on light land at Biggleswade and at Burford, and on heavy land at Hull, we this year compared inor-

TABLE VI.—Comparison of Artificial Manures with Organic Manures.
Outside Centres, 1930.
Potatoes, tons per acre.

Locality.	Soil.	Sulphate of Ammonia. Super.	Dried Blood. Steamed bone flour.	Sulphate of Ammonia. Steamed bone flour.	Dried Blood. Super.	Standard error.	Significant results.
Sailors' Orphan Home Hull	Heavy alluvium	11.69	9.01	9.86	10.88	0.425	Super. better than bone flour. Sulphate of Ammonia better than blood.
Grammar School, Burford.	Light loam on lime-stone	9.05	8.82	9.03	9.91	0.554	No difference.
Mr. H. Inskip, Stanford, Beds.	Light sand	5.52	5.06	5.31	5.28	0.127	No difference. No significant effect was produced by potassic fertilisers. With potash 5.44 Without potash 5.14 Standard error—0.124
Ditto.	Heavy clay	15.03	14.50	14.55	14.84	0.311	No difference.
Mr. H. Inskip, Stanford, Beds.	Heavy clay	16.09	Fish Meal. 16.11			0.346	No difference.

All plots had potassic fertiliser unless otherwise stated.

The comparison between artificial and organic nutrients was on the basis of equal amounts of nitrogen and equal amounts of phosphoric acid per acre.

No farmyard manure was given.

ganic with organic manuring for potatoes, testing dried blood against sulphate of ammonia and steamed bone flour against superphosphate. On the light land there was no difference in effect, on the heavy soil the organic fertilisers were distinctly inferior, super. giving 1.85 tons more than steamed bone flour, and sulphate of ammonia 0.83 tons more than blood on yields of about 10 tons (Table VI). The organic fertilisers certainly require little knowledge for handling, and they are convenient for garden use, but we have no evidence that they ever act better than, or even as well as, the artificial fertilisers.

The effect of the bulky organic manures, farmyard manure and rotted straw, is shown on pp. 130-1.

SUGAR BEET

The variety grown was again Kuhn (Johnson's Perfection). The average yield of washed roots was the same as last year; the percentage of sugar was slightly higher while the yield of tops was considerably higher. It was a good growing season and the leaves did well but the roots could not keep pace. The results bring out strikingly the variation in efficiency of the tops from season to season, and their low efficiency as compared with that of the mangold. The results of recent years have been :

	Sugar Beet. (washed)			*Mangolds.*[1] *(scraped)*		
Year.	Yield of tops in tons per acre.	Yield of roots in tons per acre.	1 part of top makes of root	Yield of tops in tons per acre.	Yield of roots in tons per acre.	1 part of top makes of root
1926	25.23	12.10*a*	0.48	6.05	22.43	6.25
1927	10.82	3.38	0.31	3.89	13.42	3.45
1928	11.43	9.15	0.80	5.01	29.22	5.83
1929	5.41	7.43	1.37	3.94	20.67	5.25
1930	9.15	7.44	0.81	6.23	26.78	4.30
Mean	12.41	7.85	0.75	5.02	22.50	5.02

(*a*) The figures given in the 1926 Report on p. 142 are for unwashed beet.
[1] Barnfield, Plot 4 A.C.

The yields of tops vary a good deal according to season and manuring, but the yields of roots vary much less.[1] The root is able to keep pace with the top up to a certain stage, but then it can do no more, no matter how much the top grows. Mangold roots, on the other hand, can continue growth much further and so keep pace with the better leaf growth of good seasons. This restriction or congestion of the root of the sugar beet may result from its constitution; its sap is so highly concentrated that new soluble material from the leaf may not readily enter so that the process of translocation from leaf to root may be considerably retarded. Increased concentration of the leaf sap might improve matters; this may explain the special value of salt as a fertiliser.

The manurial results show that the leaves behave normally giving their full increase with fertilisers, but the roots do not. Thus in Rotation II the yields for varying dressings of nitrogen were :

[1] Excluding 1927 ,where the failure was due to very late sowing.

C

Cwt. N per acre applied as Sulphate of ammonia	0	0.15	0.30	0.45	0.60
Tops, tons per acre	7.3	9.3	7.8	10.5	11.7
Roots, tons per acre	6.3	7.1	6.0	8.0	7.0

Neither phosphate not potash had any important effects on the roots or tops either at Rothamsted or at Woburn. One general result up to the present is that sulphate of ammonia applied with the seed usually gives an increased yield of root which is still further increased by potash manure salts or by muriate of potash and salt (Table VII). Nitrate of soda usually gives a greater increased yield of root, but there is not always a further gain by adding potassic fertiliser and salt ; apparently its soda exerts some beneficial effect. The effects at Rothamsted are not very great ; a dressing of 23 lb. of nitrogen, the equivalent of 1 cwt. of sulphate of ammonia, or 1⅛ cwt. nitrate of soda, has usually given an additional 6 to 9 cwt. of roots, and 12 to 17 cwt. of tops per acre. At the outside centres the figures are better, the roots having been increased on the average by 12.3 cwt., and the leaves by 23.9 cwt. per acre by a dressing containing 23 lb. nitrogen :

Mean of 17 comparisons at Outside Centres, 1929–30.
Effect of Nitrogenous Manures.
Calculated to basis of 23lb. N. per acre.*

Yield without added Nitrogen.			Increase per 23lb. N.		
Roots, Tons.	Tops, Tons.	Sugar, per cent.	Roots, cwt.	Tops, cwt.	Sugar, per cent.
9.66	11.29	17.87	12.3	23.9	0.05

* The actual rates of application were either 46 or 69lb. N. per acre.

TABLE VII.—The Effect of Potassic Fertilisers and of Salt on Sugar Beet at the outside centres in 1929 and 1930.

	Average Increase per 1 cwt. potash or salt fertilisers.		
(*a*) No potash or salt in basal dressing :	Roots, cwt.	Tops, cwt.	Sugar, per cent.
Mean of 4 expts. [1]Muriate of potash ..	9.5	7.5	0.10
„ „ 3 expts. [2]Salt	14.0	8.5	0.27
„ „ 3 expts. [1]Muriate and Salt Mixture	6.5	9.5	0.14
1 expt. 20 per cent. Potash Salts	9.5	—	0.10
(*b*) Salt in basal dressing : Mean of 2 expts. [2]Muriate of potash ..	0	0	0.10
(*c*) Muriate of potash in basal dressing : Mean of 3 expts. [1]Salt	2.0	12.0	0.17

[1]Two only for tops.
[2]One only for tops.

These various points are well illustrated in the experiment made on Messrs. Wilson's farm at Colchester on a good sugar beet soil (pp. 166-7).

It does not always happen, however, that nitrate of soda is superior to sulphate of ammonia ; at the County School, Welshpool, in 1930, in one of the most accurate experiments yet made, the sulphate of ammonia came out superior (p. 169) as it had done at Rothamsted in 1929, when muriate of potash, salt, and super. were also given. We are not yet in a position to put forward a general recommendation for the manuring of sugar beet. As a basis for experiment we should suggest, per acre :

10 tons farmyard manure applied in autumn.
2 cwt. nitrate of soda.
3 cwt. super.
3 cwt. potash salt all applied at or before seeding.

The effect of 2 cwt. salt should also be tried instead of the potash manure salts. Possibly new varieties will be more responsive than the present ones, but our whole scheme of management may be unsuitable for the crop. It is possible that the additional saline material taken up by the root from the fertilisers, and remaining in solution in the juices of the root, adds to the difficulty of entry of sugar from the leaf, and that the proper way of fertilising sugar beet would be from the exchangeable bases in the soil and not from soluble salts ; this may explain the continental preference for putting on the manures some long time before the seed is sown so that all unwanted ions can be washed away.

The average percentages of sugar at Rothamsted and Woburn have been :

	1926.	1928.	1929.	1930.	Mean.
Rothamsted ..	17.4	17.6	18.4	17.6	17.8
Woburn ..	16.7	18.0	17.1	19.4	17.8

No determinations were made in 1927 owing to lowness of yield.

The sugar content is only slightly affected by phosphatic or potassic manuring ; superphosphate, however, slightly raised it at Woburn, both in 1929 and in 1930, while potassic fertiliser had no effect. At Rothamsted superphosphate did not alter the sugar content in 1929 ; potassic fertilisers slightly raised it except where nitrate of soda was given.

The one result that almost always emerges is the lowering of the percentage of sugar by nitrogenous manures. It is not necessarily large ; in the preceding years the reduction has averaged 0.15 per cent ; in 1930 it was 0.05 per cent only.

The loss of plant was not heavy ; the proportion actually obtained was on the average 98 per cent of the number expected at Rothamsted as compared with 84 per cent of those expected at Woburn.

The figures are, per acre :

	Rothamsted.	Woburn.
Number of plants expected	35,280	32,000
Number of plants harvested	34,534	26,795
Plants obtained as percentage of those expected	98	84

FORAGE MIXTURE CROPS

Forage mixture crops have the great advantage that they can be grazed in May or June, cut green in June or July, made into silage or hay in July, or left to ripen, cut in August and threshed, when the straw can be chaffed and the grain crushed. No other crop, not even grass, is so elastic in its uses. Being sown annually the early grazing, if it is used, is always clean ; the land can never become " sheep sick."

The mixtures at present in use at Rothamsted are made up of :

	Bushels per acre.
Wheat, Oats or Barley	2
Peas or Vetches	2
Beans	1

Other proportions are being tested.

The vetches, wheat, winter oats and beans are sown in autumn. The peas have to be drilled in spring in an autumn sown oat or wheat and bean mixture ; the barley and spring oat mixtures are entirely sown in spring.

In 1930, the first year of the trial, the barley mixtures did better than the oat mixtures in yield both of hay and of grain, though not of straw, but there was little difference between peas and vetches. The barley mixtures gave, without manure, good hay, containing 26½ cwt. of dry matter per acre when cut early, or 22 cwt. of grain and 24 cwt. of straw when left to ripen ; the advantage of leaving the crop to finish its growth is considerable, but not quite as great as it looks, for after cutting the hay there still comes up an aftermath which gives clean fresh grazing, or the land can be summer fallowed for a winter crop.

The manuring of the fodder mixtures, however, is difficult, because it involves some entirely new principles. Any fertiliser that is added is likely to benefit one constituent more than the others, increasing its growth and also its power of competition with the others ; the favoured plants tend to crowd out the rest exactly as has happened on the Park grass plots. This is well illustrated by the effect of sulphate of ammonia. Applied at the rates of 1 and of 2 cwt. per acre it greatly increased the growth, especially of the barley mixtures ; with these the larger dressing gave a fine looking crop of 38 cwt. of hay or 24 cwt. grain and 32 cwt. straw. But analyses showed that the gain was entirely on the barley or the oats ; not at all on the peas, vetches and beans ; indeed these had been actually depressed by the manuring. This change affected the feeding value of the product. In place of a foodstuff having nearly the same protein value as good meadow hay, we obtained one of much lower value, though it was better than poor hay or straw. The results are given in Table VIII.

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TABLE VIII.—Yield and composition of mixed crops grown for fodder and cut as hay.

Nitrogen added in manure, cwt. per acre.	0	0.2	0.4
Yield of dry matter, cwt. per acre—			
Oats—Vetches	21.9	32.1	32.4
Oats—Peas	26.0	31.3	34.1
Barley—Vetches	27.3	30.7	37.6
Barley—Peas	26.1	33.0	38.9
Mean	25.3	31.8	35.8
Percentage composition of dry matter of all mixture—			
Protein	11.7	9.6	8.6
Soluble carbohydrates	46.2	48.8	49.1
Crude Fibre	32.9	32.5	33.4
Oil	2.4	2.6	2.5
Ash	6.8	6.5	6.4
Percentage by weight of leguminous plants in hay	41	27	20
Leguminous plants, cwt. of dry matter per acre	10.3	8.7	7.2
Cereals, cwt. of dry matter per acre ..	15.1	23.1	28.6
Nitrogen in crop cwt. per acre	0.42	0.44	0.44

Composition of Meadow Hay (T. B. Wood).

	Very good	Good	Poor.
Protein	16.1	11.3	8.8
Soluble carbohydrates	48.2	47.9	44.6
Crude Fibre	23.0	30.7	39.1
Oil	3.6	2.9	1.8
Ash	9.2	7.2	5.8

In yield of grain the barley mixtures responded somewhat to potassic fertilisers, but the oat mixtures did not, and there was little if any response to superphosphate. Different combinations of manures are being tested this season; there is clearly much to be learned about the manuring of these important crops.

A second forage mixture of rye, beans and vetches in Pastures Field cut as hay gave substantial increases, up to 20 cwt. per acre but not beyond, to sulphate of ammonia, and increases up to 10 cwt. per acre but not beyond, to potash. There were no increases, however, to phosphate. The yields were, in cwt. of hay per acre:

Rothamsted

Varying Nutrient.	Hay: cwt. per acre Doses of Nutrient.				
	0	1	2	3	4
Nitrogen ..	56	66	74	75	72
Phosphate ..	71	66	69	69	65
Potassium ..	59	69	68	61	64

SEEDS HAY

The "seeds ley" sown at Rothamsted is pure clover without admixture of grasses; the reason being that under our conditions of farming, the fritfly (*Oscinella* (*Oscinis*) *frit* L.) and other insects may winter on the grasses and pass over to the cereals as soon as spring appears ; they do not survive on clover, however. Usually the seeds ley receives no manure except what may be given to the barley. Our general experience has been that a dressing of sulphate of ammonia may depress the clover while potash may help it. In the Long Hoos experiment (Rotation II) fertiliser is given to the clover itself as a top dressing in spring, and here quite a different result was obtained ; nitrogen greatly increased the yield, potash slightly increased it, but phosphate had no effect. The yields of dry matter were, in cwt. per acre :

Rothamsted heavy soil.

Varying Nutrient.	Dry matter cwt. per acre Doses of Nutrient.				
	0	1	2	3	4
Nitrogen ..	22	33	34	42	47
Phosphate ..	36	35	36	36	39
Potassium ..	33	37	36	37	36

To convert these figures into hay they should be raised by about one-fifth.

In another experiment on Hoos Field the unmanured clover yielded 12 cwt. dry matter per acre (equal to about 15 cwt. hay), while a dressing of superphosphate, muriate of potash, and 2 cwt. sulphate of ammonia raised it to 22 cwt. dry matter or about 26 cwt. hay and heavier dressings yielded as much as 42 cwt. dry matter or 50 cwt. hay per acre.

Evidently if ever hay were needed there would be great scope for manuring the seeds ley.

These results appear to be contradictory to those given by the earlier experiments where the manuring was given to the barley. There is, however, no contradiction. A mixture of barley and clover responds very differently from pure barley or pure clover to manures. Sulphate of ammonia favours the barley more than it does the clover, so causing the young barley to make more vigorous growth and to crowd out the clover. With the pure clover this element of competition is absent, and so long as the crop is not too weedy there seems the possibility that it could advantageously receive nitrogenous manure. Possibly there would be less fixation of nitrogen from a manured crop than from one receiving no nitrogen, but in these days of cheap nitrogenous fertiliers that point is of less importance than it was.

EFFECTS OF FARMYARD MANURE: HOW LONG DO THEY LAST ?

Two sets of experiments, one at Rothamsted and one at Woburn, give useful information on this subject. The remarkable result is the persistence of the effect when the farmyard manure has been given sufficiently often. Of three plots of barley on Hoos Field, two had farmyard manure every year from 1852 to 1871, both being treated exactly alike, the third had no manure. This unmanured plot and one of the manured plots have remained under the same

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treatment down to the present day. In 1872, however, one of the manured plots ceased to receive its farmyard manure and it has been unmanured ever since. That was nearly 60 years ago, and yet this plot gives a 50 per cent higher yield than the one which had had no farmyard manure during those early years. The results in bushels of grain per acre are given in Table IX.

TABLE IX.—Hoos Field permanent Barley: average yields of dressed corn, bushels per acre.

Years	20 years 1852-1871	5 years 1872-1876	5 years 1877-1881	10 years 1882-1891	10 years 1892-1901	10 years 1902-1911	10 years 1913-1922	8 years 1923-1930
Farmyard manure each year, 1852–1931		49.6	50.8	47.6	44.3	44.3	39.2	25.1
Farmyard manure each year, 1852–1871	48.3							
Unmanured since 1872		39.1	29.2	26.5	20.3	18.3	21.0	9.4
Unmanured all the time	22.0	13.5	14.4	15.8	10.4	9.7	14.3	5.3

For 1929 and 1930 the yields are total corn in 56lb. bushels.

There is no evidence, however, that applications of farmyard manure made only once in four or five years persist for any length of time.

Comparison of Farmyard Manure with Artificials. It is much more difficult from the Rothamsted and Woburn data to compare the values of nitrogen in farmyard manure with that in the artificial fertilisers. Over the early period in the Broadbalk wheat field (1852-1864) before the weed complication became serious, a dressing of farmyard manure containing 200 lb. nitrogen per acre gave a greater yield of wheat than 43 lb. of nitrogen in sulphate of ammonia, but a little less than 86 lb., and distinctly less than 129 lb.; the equivalent values seem to be 80 in sulphate of ammonia and 200 in farmyard manure, *i.e.*, 1 in sulphate of ammonia to 2.5 in farmyard manure.

On Barnfield mangolds the equivalents are 125 in sulphate of ammonia and 200 in farmyard manure, *i.e.*, 1 in sulphate of ammonia to 1.6 in farmyard manure.

ORGANIC MATTER AND SOIL FERTILITY: A NEW CONTINUOUS EXPERIMENT. ROTATION I. FOUR COURSE ROTATION

It has long been recognised that the return of straw to the soil in the form of farmyard manure is a most valuable method of maintaining and increasing soil fertility, while straw ploughed under the soil without previous rotting is harmful.

Investigations in the Bacteriological Department described in previous reports, have shown that the harmful effect results from an absorption of soil nitrate and ammonia by the organisms decomposing the straw, and can therefore be avoided by decomposing the straw before ploughing it under.

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Where farmyard manure is easily and cheaply made it affords the best method of doing this, but increasing numbers of farmers, especially overseas in British Africa, Australia, the West Indies, and elsewhere, cannot make enough of it and need some other way of converting straw into manure. The method of artificial rotting was worked out in the Rothamsted laboratory by Messrs. Hutchinson and Richards, and was applied on the large scale by the Adco Syndicate ; it is proving very successful, requiring only a cheap nitrogen compound and water. Straw so treated has lost all its harmful effects and possesses high fertiliser value.

After various preliminary trials a rotation experiment (Rotation I) was started at Rothamsted in 1929 to compare farmyard manure with straw rotted artificially, with straw ploughed in along with the necessary nitrogenous compounds to promote decomposition, and with artificial manures.

The rotation consists of four crops : Barley, Clover and Italian Ryegrass, Wheat, Swedes.

The ryegrass is included to lessen the risk of clover sickness which on the Agdell Rotation Field has sometimes caused the crop to fail altogether. The ryegrass will, however, provide a host plant for Frit fly (*Oscinella* (*Oscinis*) *frit* L.) ; to mitigate this danger the crop will be ploughed in after the first cut of hay and before the middle of August.

There are five treatments :

1. Farmyard manure.

2. Straw decomposed artificially before being ploughed in (Adco compost).

3. Straw ploughed in without preliminary decomposition, artificial manures, however, being applied.

4. No organic matter ; artificial manures only, the phosphate being superphosphate.

5. As 4, but the phosphate is ground mineral phosphate.

Each crop is grown every year, and each is followed by the next in the rotation. The field thus is divided into four sections each at a different stage in the rotation.

Each section is divided into five blocks of five plots each. Each plot receives one of the five treatments once in five years. Once it has had this treatment it receives no more for the next four years,* when the original treatment is repeated. In any one year only one plot in each block, five in all, are treated, and each of these receives one of the five treatments ; thus all five treatments are represented each year. In the course of the five years the whole rotation has passed over the plot, and when the fifth year comes and the treatment has to be renewed, the crop to receive it is not the one that had it before, but the next in the rotation. Each plot has the same crop in every fourth year, and the same manurial treatment every fifth year ; it thus has the same crop and the same manure only once in 20 years.

Five blocks of five plots each give 25 plots for each crop, and for the four crops there are 100 plots in all.

* This is modified so far as concerns the sulphate of ammonia and muriate of potash given to the plots receiving phosphatic fertilisers (see page 125).

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In any one year there is no replication of the plots, but at the end of 20 years there will be a five-fold replication for the five four-course crop cycles, and the four fivecourse manurial treatments will then be completed.

Useful information will be forthcoming each year, but a particularly valuable lot of data susceptible of full statistical treatment will be available in 1949.

The cost of the experiment is being generously defrayed by Earl Iveagh. Full details, and the first year's results are given on pp. 125-7 and 130-1.

THE EFFECT OF WEATHER CONDITIONS ON FERTILISER EFFICIENCY

The effect of weather on fertiliser efficiency and crop yield is studied in the Statistical Department. The rainfall at Rothamsted is lowest in spring and highest in late autumn; the peak of the curve is in November, but it has not always been so; forty years ago it was at the end of September, and seventy years ago at the beginning of September. The peak is possibly now moving backwards again and we may be reverting to a period of wetter early autumns and drier late autumns; a movement like this has apparently happened before; the somewhat scanty records suggest that it happened in the eighteenth century, and again in the middle of the nineteenth century.

A detailed study of the effect of rain, inch by inch and month by month, on the Rothamsted wheat under different schemes of fertiliser treatment, has already been made, and now the same methods have been applied to the Rothamsted barley. The rain falling in the six months when barley is not in the ground is just as important as that falling while the barley is growing, but the effects of rain in different months vary with the manurial treatment. The plants on potash starved plots 2 O and 2 A seem specially to suffer after a wet winter.

Temperature is less important than rainfall, but it plays a great part in the early days of the plant life. On the average a rise in soil temperature of 1°F shortens the time between sowing the seed and appearance of the plant above ground by one day for spring sown cereals and by 1½ to 2 days for autumn sown cereals at Rothamsted. Swedes and turnips, however, are not affected by soil temperature, it being usually sufficiently high by the time they are sown. In order to obtain further information on these weather relationships, and also on the very important problem of the relation between quantity of fertiliser and crop growth, a second rotation experiment has been set up. The rotation consists of six courses: (1) Barley; (2) Clover hay; (3) Wheat; (4) Potatoes; (5) Forage crops (rye, beans and vetches), followed by mustard and then rye, both of which are ploughed in; and (6) Sugar Beet. The area under each crop is divided into fifteen plots. Of these, five, chosen at random, receive nitrogenous fertiliser in varying amounts, one plot receiving none, one receiving one unit dressing, a third receiving two unit dressings and the fourth and fifth receiving three and four dressings respectively. Another five plots also chosen at random receive potassic fertiliser in varying amounts, and the remaining five receive varying quantities of phosphatic fertiliser, the dressing for both sets being 0, 1, 2, 3 and 4 units as for the nitrogen group. A basal dressing is given to each group of plots. Each year each plot receives one dose less of the same manure as in the preceding year, then it receives none, after which it receives the full quantity of one of the other fertilisers, and then proceeds to receive one dose less, as before; after another five years it receives the third fertiliser. This procedure avoids the disturbances caused by cumulative effects. Thus in the first year the five plots of the nitrogen group receive respectively:

4 3 2 1 0 doses of N with 2 K and 2 P.

In the second year the treatment of the first four is:

3 2 1 0 doses of N with 2 K and 2 P,

while that of the fifth is 4 doses of K or P with 2 doses of the other two fertilisers. At the end of the fifteenth year the manurial cycle is complete and each plot is back to its original manurial treatment.

By the fifteenth year, however, the third rotation is half way through its course. After thirty years the second manurial cycle and the fifth rotation are both completed, and the whole begins again, with the difference that one stage in the rotation is omitted before proceeding as before.

As in Rotation 1 there is no replication of plots but the error can be estimated by comparing the yields for different quantities of each fertiliser with a smooth curve.

The data will give valuable information each year, but a specially full and detailed investigation will be possible after thirty years, when an exceptionally complete set of data should have accumulated. The details are given on pp. 128-9.

GRASSLAND

Manuring of Grassland. Fertilisers produce three distinct effects on grassland; up to a certain point they increase the quantity of their particular nutritive element in the plant (*e.g.*, nitrogenous fertilisers increase the nitrogen, phosphatic fertilisers increase the phosphorus, and potassic fertilisers increase the potassium); they may and often do increase the growth and they usually alter the herbage, encouraging some kinds of plants more than others.

Nitrogenous manures have their greatest effect when applied in spring; they suffer considerable loss when used in autumn. Given in February or March they cause a rapid uptake of nitrogen in the plant shown by a darkening of the green colour; if the soil and other conditions permit this is followed by an increased growth of young grass valuable for early grazing. Sulphate of ammonia used alone, however, while increasing the early growth, greatly reduced the wild white clover, and so reduced the later growth of herbage.

Phosphatic manures have the opposite effect on the herbage; they tend to increase the clover, and therefore the amount of protein in the herbage. They increase also the amount of phosphorus taken up by the plant; usually there is no visible sign of the additional phosphorus except on starved soils; the grazing animal, however, can usually detect it and chooses the phosphate treated land.

In all the tests so far made superphosphate has put more phosphorus into the herbage in the first year after application than any other phosphatic fertiliser ; the next in order has been high soluble basic slag, and the least effective low soluble slag and mineral phosphate. In no case however, is much of the added phosphate recovered ; so far not more than 10 per cent at best. Up to a certain point the increased uptake of phosphorus goes on whether the yield increases or not.

The yields of hay and of protein per acre come out in the same order as phosphorus uptake, superphosphate being best, high soluble slag next, then low soluble slag and mineral phosphate.

Certain new basic slags have recently been produced which, although of low solubility, were said to be more effective than the old ones. Pot and field experiments have not supported this claim ; the new slags seem little better than the old ones. Like them they have a certain lime value on acid soils, being in our tests as effective as their own weight of calcium carbonate. On certain soils, however, they may, like other slags, so much stimulate the decomposition of the organic matter that the carbonic acid produced more than balances their lime effects on the soil reaction.

No new areas were sown down to grass during 1930, nor is it at present proposed to lay down any more. The characteristic feature of the year was the filling up of the bare space which in 1929 amounted to about 30 per cent, and is now down to 5 or 10 per cent, the steady increase in the amount of wild white clover as the season advanced, the very high proportion of rye grass in the spring falling off later as the wild white clover increased, and the steadiness of the cocksfoot which neither increased nor decreased.

These three plants now dominate Sawyers pasture, and the timothy and rough stalked meadow grass are much reduced, even allowing for the fact that some of the identifications are uncertain. The results of the survey are given in Table IV ; the method of survey is being improved this year. Of the other fields laid down in 1928, those sown on a fallow in August without a nurse crop (Sawyers and Harpenden) have given the best result, having now nearly caught up to Little Knott, and those sown in September immediately after a cereal crop (New Zealand, West Barnfield) are the worst ; some of the spring sown seeds in cereals have also done badly (Great Knott and Stackyard). All, however, are improving and clover is increasing. Details of seeding are given in the 1928 Report, p. 101.

USE OF THE GRASSLAND

Having obtained the grass, the next problem is to use it efficiently and economically. It has arrived at its present good state largely as a result of good grazing which has kept down all flower heads, stems and rough patches. Sheep have been much used, with a small number of calves and bullocks ; it is hoped to extend this work considerably.

Phosphatic Fertilisers for Grassland. For several years the Chemistry Department has been engaged in conjunction with the Permanent Basic Slag Committee of the Ministry of Agriculture in an examination of the chemical nature and fertiliser value of the different types of basic slag available to the British farmer. The results have shown that there are two main types which may be

TABLE X.

Percentage Area covered by various species of plants, 1930.
Sawyer's Pasture, sown April 25th, 1928.

Name of Species.	Plot 1. Mixture I. May.	Plot 1. Mixture I. Oct.	Plot 2 Mixture VI. May.	Plot 2 Mixture VI. Oct.	Plot 3. Mixture VIII. May.	Plot 3. Mixture VIII. Oct.	Plot 4. Mixture VII. May.	Plot 4. Mixture VII. Oct.	Plot 5. Mixture IV. May.	Plot 5. Mixture IV. Oct.	Plot 6. Mixture V. May.	Plot 6. Mixture V. Oct.
Perennial Rye Grass (*Lolium perenne*) ..	77.5	44.6	—	—	53.7	30.1	—	—	57.4	35.3	61.7	43.4
Italian Rye Grass (*Lolium italicum*) ..	—	—	49.2	23.8			57.5	25.9	—	—	—	—
Cocksfoot (*Dactylis glomerata*)	3.3	8.4	15.5	19.9	18.7	21.7	12.6	16.2	13.4	21.1	17.3	18.6
Timothy (*Phleum pratense*)	4.9	2.1	4.8	1.5	5.1	4.7	9.4	7.5	8.8	4.2	0.7	0.5
Tall Fescue (*Festuca elatior*)	—	—	3.2	8.6	—	—	—	—	—	—	—	—
Meadow Fescue (*Festuca pratensis*) ..	0.3	0.2	—	—	2.7	0.9	1.4	—	—	—	—	0.1
Red Clover, late and early flowering (*Trifolium pratense*)	2.1	8.1	5.2	8.9	6.6	14.1	6.4	7.7	6.6	12.2	0.2	0.7
Wild White Clover (*Trifolium repens*) ..	6.5	28.6	11.2	31.1	5.4	22.6	5.5	35.5	5.6	22.0	2.9	29.5
Trefoil (*Medicago lupulina*)	—	—	—	—	—	0.7	0.7	—	—	—	—	—
Chicory (*Cichorium intybus*)	1.4	3.4	5.3	2.6	—	—	—	—	0.3	—	—	—
Weeds	1.4	1.2	1.7	0.6	2.7	0.3	1.0	0.2	3.2	0.1	2.2	0.4
Bent Grass (*Agrostis alba*)..	0.2	1.3	—	0.1	—	—	—	0.1	—	—	—	—
Covered with vegetation	97.6	97.9	96.1	97.1	94.9	95.1	94.5	93.1	95.3	94.9	85.0	93.2
Bare Patches	2.4	2.1	3.9	2.9	5.1	4.9	5.5	6.9	4.7	5.1	15.0	6.8

Average of ten samples each of area 1 square foot. For previous figures see 1929 Report, p. 24; for Mixtures see 1928 Report, p.101.

discriminated with sufficient accuracy by the old and conventional citric acid test. In 1930 the work was extended so as to test over a period of years not only the two main types of basic slag but the two alternative phosphatic fertilisers, superphosphate and ground mineral phosphate (Gafsa passing 120 mesh sieve). The tests are conducted in the laboratory, in the pot culture house, and in the field, on both grassland and arable land. Preliminary results on a series of hay experiments are given below to illustrate the extent to which moderate grassland may be improved not merely in the quantity of the hay but in its quality or feeding value. The results of other experiments under conditions more nearly approaching those of pastures are not yet complete.

Seven centres distributed throughout the country were selected and Latin square experiments with 25 plots were laid down in the spring of 1930. Some of them were conducted by the local agricultural authorities and others by the Rothamsted staff. The fertilisers were from single well mixed batches, and were added at the rate of 1 cwt. of phosphoric acid (P_2O_5) per acre. Samples of the produce from individual plots were analysed at Rothamsted for dry matter, nitrogen and phosphoric acid. The results for six centres are given in Table XI.

As only a few months elapsed between the application of the fertilisers and haymaking, little immediate benefit was to be expected from the less soluble and more slowly acting fertilisers. The first year results show only the effect of rapidly available phosphoric acid, and the results in the following years will probably differ considerably from these preliminary ones.

On the average of six centres superphosphate alone showed an appreciable increase in dry matter, though there was a slight benefit from the less soluble phosphates at some of the centres. The effects on the composition of the hay were, however, more striking and more consistent than those on yield. At four centres the average protein content of the dry matter was raised from 9 to 11 per cent by superphosphate, and at six centres the average phosphoric acid content of the dry matter was increased by 50 per cent. At one centre the total phosphoric acid content of the hay per acre was doubled. The hay was thus not merely increased in amount but also in protein and mineral content. In the two Essex centres the improvement in quality was particularly great even though at one of them nearly 3 tons of hay per acre were obtained on the unmanured land. The average gain from superphosphate at the two Essex centres was 6 cwt. of dry matter per acre, but at the same time the protein content of the hay per acre was raised by 1.5 cwt., an amount contained in about 18 cwt. of the unmanured hay. The increase was not merely hay but a richer material with a feeding value comparable with that of dried young grass, and approaching that of a concentrated feeding stuff.

This result illustrates the well known discrepancy between practical experience on the improvement of pastures and stock by slag or other phosphates, and the disappointing results often given by fertiliser trials when similar land is laid up for hay, and the experiment confined to the measurement of yield of hay.

In spite of the great improvement produced at some of these centres the actual recovery of the phosphoric acid added was small ;

for superphosphate the maximum was 12 per cent and the average 6 per cent. Less than 3 per cent of the phosphoric acid added in high soluble slag was recovered and still smaller amounts were taken from the low soluble slag and mineral phosphate. The immediate availability of the phosphoric acid was closely related to its solubility.

TABLE XI.—Effect of Phosphatic Fertilisers on yield and composition of hay, 1930.

	No Phosphate.	Mineral Phosphate.	Low Soluble Slag.	High Soluble Slag.	Super.
Yield of Hay (as cwts. of dry matter per acre)—					
Purleigh, Essex	50.4	50.8	53.5	52.0	54.7
Braintree, Essex	19.3	20.1	20.2	23.5	27.3
Badminton, Glos.	28.5	28.5	28.5	28.8	30.6
Lydbury, Salop	28.7	31.1	29.7	29.6	31.3
Chesterfield, Derby ..	19.3	18.2	19.4	19.1	20.9
Wetherby, Yorks	28.8	31.2	32.4	31.1	28.0
Mean ..	29.2	30.0	30.4	30.7	32.1
Nitrogen as per cent. of dry matter—					
Purleigh ..	1.31	1.29	1.30	1.47	1.57
Braintree ..	1.55	1.72	1.69	1.70	2.21
Badminton ..	1.61	1.58	1.58	1.56	1.66
Chesterfield ..	1.42	1.48	1.38	1.47	1.49
Mean ..	1.47	1.52	1.49	1.55	1.73
Protein in hay in cwts. per acre—					
Purleigh ..	4.13	4.09	4.35	4.78	5.36
Braintree ..	1.87	2.16	2.14	2.50	3.77
Badminton ..	2.86	2.81	2.82	2.80	3.17
Chesterfield ..	1.72	1.68	1.67	1.75	1.95
Mean ..	2.64	2.68	2.74	2.96	3.56
P_2O_5 *as per cent. of dry matter*—					
Purleigh ..	0.46	0.46	0.50	0.51	0.62
Braintree ..	0.48	0.49	0.51	0.52	0.67
Badminton ..	0.43	0.46	0.44	0.54	0.60
Lydbury ..	0.52	0.60	0.59	0.61	0.71
Chesterfield ..	0.36	0.40	0.36	0.43	0.49
Wetherby ..	0.53	0.52	0.52	0.57	0.59
Mean ..	0.464	0.490	0.485	0.530	0.616
Phosphoric Acid in hay in cwts. per acre—					
Purleigh ..	0.23	0.24	0.27	0.27	0.34
Braintree ..	0.09	0.10	0.10	0.12	0.18
Badminton ..	0.12	0.13	0.13	0.16	0.19
Lydbury ..	0.15	0.19	0.18	0.18	0.19
Chesterfield ..	0.07	0.07	0.07	0.08	0.10
Wetherby ..	0.15	0.16	0.17	0.18	0.17
Mean ..	0.136	0.148	0.151	0.164	0.194
Mean percentage recovery of added P_2O_5 ..	—	1.2	1.5	2.8	5.8

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How much of the added phosphoric acid is taken up by the plant? The few experiments that have been made do not indicate a high percentage utilisation of the added phosphoric acid under normal conditions, even when the necessary nitrogen and potassium are supplied. Some of the results are given in Table XII.

TABLE XII.—Recovery of Phosphoric Acid (P_2O_5) from Phosphatic Fertilisers.

Normal Conditions.	Reference	P_2O_5 applied per acre.	P_2O_5 taken up by crop lb. per acre. No Phosphate.	Phosphate.	Difference.	Percentage recovery.
Superphosphate—						
Swedes, 1st year	Little Hoos, Rothamsted	70	28.5	18.7	10	14
2nd, 3rd and 4th year after application ..					17	24
Barley, 1st year	Little Hoos	70	22	17	5	7
Hay, 1st year ..	Essex	112	26	38	12	11
1st year ..	All centres	112	15	21.6	6.6	6
Basic Slag—						
(1) Hay, 1st year		100	10.2	14.8	4.6	3
1st 4 years			23.2	38.0	14.8	15
(2) Hay, 1st year	Essex	112	26	30	4	3.6
1st year ..	All centres	112	15	18.4	3.4	3
	Conditions of phosphatic starvation:					
Superphosphate—						
Hay	Park Grass	64	10	26	16	25
Barley	Hoosfield	64	10.4	22.4	12	19
Wheat	Broadbalk	64	14.4	23.4	9.0	14

THE ACCURACY OF THE FIELD EXPERIMENTS

The average "standard error" per plot for the different crops at Rothamsted, Woburn, and the various other centres are given in Table XIII; they were in 1930 of the same order as in previous years. At Rothamsted the error per plot varies round about 5 per cent of the total yield for Latin squares, and about 10 per cent for randomised blocks; it tends to be lower for potatoes and higher for wheat. Expressed as weights per acre the "standard error" for Latin squares is about 0.5 tons of roots and 1.3 cwt. of grain; for randomised blocks it is about 0.7 tons of roots and 1.5 to 3 cwt. of grain. At Woburn and the outside centres the figures are as usual somewhat higher, but again the Latin square is the more accurate. Even on commercial farms the "error" per plot amounts only to about 0.5 tons of potatoes in Latin squares and 1 ton or less in randomised blocks; with good yields this gives the same percentage error as at Rothamsted. The Latin square is thus the more accurate and we recommend its use wherever practicable. It is used for manurial trials at our outside centres on commercial farms without difficulty. Its range of usefulness has been still further increased in recent years by splitting each plot so as to test some other treatment superimposed on the entire series, *e.g.*, phosphate or no phosphate on each of a set of plots receiving various nitrogenous manures. For cultivation and variety trials involving a large number of comparisons the Latin square is not always practicable and then the randomised blocks can be used.

The fact that the size of the standard error remains approximately the same from year to year, suggests that our present appliances and our methods have reached their limit of accuracy; new and more accurate ones are now being sought. None of the various devices so far tried has constituted any real improvement, and so far as we can see the limit is set by the implements. Both seed and manure drills are admittedly defective; we have had to return to the old Coulter drill as the best we could find. Application of manures to the replicated plots is always by hand, but we urgently need better seed drills and better methods of distributing the fertiliser so that it shall act most effectively.

The sampling method continues to be useful. It is liable to be less accurate than the older method of harvesting the entire plot, but it saves a great amount of labour, and it allows of many more comparisons than would otherwise be possible.

TABLE XIII.—Standard Errors per Plot, 1930.

Weight per acre.

Rothamsted.

	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	—	—
1930	—	0.3	0.3	1.1	1.6	—	—
Randomised Blocks—							
Average 1925–1930 ..	0.7	0.3†	1.2†	1.5	1.9	2.9	4.3
1930	0.6	—	—	—	—	1.5 } 3.7 }	0.8 } 7.1 }

† Single figure.

Woburn.

	Potatoes.	*Sugar Beet.*	
	tons.	Roots. tons.	Tops. tons.
Latin Squares—			
Average 1926–1930	0.5	1.3	1.1
1930	0.5 } 0.8 }	0.8	0.7
Randomised Blocks—			
Average 1926–1930	0.7	1.0	1.5
1930	—	—	—

Outside Centres.

Potatoes—tons

	Wisbech.	Tunstall. Ipswich.	Bourne.	Biggleswade.	Ownby	Midland Ag. Col.	Welshpool.	Burford	Nateby.	Great Nash.	Hull.
Latin Squares—											
Average 1927–30 ..	0.6*	—	—	—	0.4*	0.4†	—	—	—	—	—
1930 ..	0.8	—	—	0.6 0.3	0.3	—	—	1.1	0.5	0.4	0.9
Randomised Blocks—	No previous experiments in many of these cases.										
Average 1927–30 ..	—	—	—	—	—	—	—	—	—	—	—
1930 ..	—	1.1	1.3	0.7	—	0.9	0.7	—	—	—	—

† Mean of 2. * Single figure.

Outside Centres (cont.)

	Sugar Beet—tons.										*Barley* ‡	
	Colchester Roots	Colchester Tops	Welshpool		Wye		Moulton		Askham Bryan		Wye Grain cwt.	Wye Straw cwt.
Latin Squares—												
Average 1927–1930	0.5	0.3*	—	—		—	—	—	—	—	—	—
1930	—	—	—	—	0.6 0.4 0.3	0.8	1.0	1.7	0.5	0.4	1.5	1.4
Randomised Blocks												
Average 1927–1930	0.9†	—	0.7	1.4	—	—	—	—	—	—	—	—
1930	1.2	1.0	0.3	0.5	—	—	—	—	—	—	—	—

* Single figure.
† Mean of 2.
‡ Expts. harvested by sampling method excluded.

TABLE XIII. (continued)—Standard Errors per Plot.

Per cent. of yield.

Rothamsted.

	Potatoes.	*Sugar Beet.* Roots.	*Sugar Beet.* Tops.	*Barley.* Grain.	*Barley.* Straw.	*Wheat.* Grain.	*Wheat.* Straw.
Latin Squares—							
Average 1925–30 ..	4.4	5.7	5.6	5.6	7.4	—	—
1930 ..	—	3.5	3.1	4.5	6.0	—	—
Randomised Blocks—							
Average 1925–1930	8.4	10.2*	10.9*	9.1	7.2	14.0	10.8
1930 ..	7.2	—	—	—	—	9.6 13.8	3.2 11.9

* Single figure.

D

Woburn.

	Potatoes.	*Sugar Beet.* Roots.	Tops.
Latin Squares—			
Average 1926–1930	5.1	9.1	11.0
1930	4.7 7.0	8.6	9.4
Randomised Blocks—			
Average 1926–1930	8.7	12.5	19.1
1930	—	—	—

Outside Centres.

Potatoes.

	Wisbech	Tunstall. Ipswich.	Bourne.	Biggleswade.	Ownby	Midland College.	Welshpool.	Burford	Nateby.	Great Nash.	Hull.
Latin Squares—											
Average 1927–30 ..	3.9*	—	—	—	4.5*	5.6†	—	—	—	—	—
1930 ..	5.0	—	—	4.2 4.8	2.8	—	—	12.0	5.7	4.7	8.2
Randomised Blocks—	No previous experiments in many of these cases.										
Average 1927–30 ..	—	—	—	—	—	—	—	—	—	—	—
1930 ..	—	8.2	11.3	4.3	—	9.0	5.8	—	—	—	—

	Sugar Beet. Colchester. Roots	Colchester. Tops	Welshpool.	Welshpool.	Wye.	Wye.	Moulton.	Moulton.	Leeds.	Leeds.	*Barley* ‡ Wye. Grain	Wye. Straw
Latin Squares—												
Average 1927–30	7.2	5.3†	—	—	5.2	—	—	—	—	—	—	—
1930	—	—	—	—	3.1 2.1	5.2 —	8.5	12.2	5.0	4.1	7.8	8.3
Randomised Blocks—												
Average 1927–30	10.1*	—	5.3	6.9								
1930 ..	12.8	12.2	2.2	2 8								

* Mean of 2.
† Single figure.
‡ Expts. harvested by sampling method excluded.

SOIL MICRO-ORGANISMS

Lucerne. The arrangements for supplying farmers with cultures of the necessary organisms are working smoothly and Messrs. Allen and Hanburys report that the demand during 1930 was more than three times that of the previous year, enough cultures being distributed to inoculate between 4,000 and 4,500 acres. The Ministry's return show that the acreage of lucerne in the country increased by over 4,000 acres in spite of the fall in acreage of arable land. Experiments are in hand to see whether seedsmen can inoculate the seed before sale ; this will save much trouble both in distribution and on the farm.

Meanwhile, scientific work has continued on the relation between the organism and the plant. It was shown in a previous Report that nodules do not appear on the roots of the young plant till the first leaf appears; as soon as that opens a substance is extruded from the root which enables the bacteria to attack and enter. The first visible sign of attack is the curling of the root hairs, this also is determined in part by a root excretion and, like the entry of the bacteria, it can be brought about before the true leaf appears if the seedling is growing among rather older plants on which the leaves have opened. Thus it appears that the excretion from one plant can serve for others as well as for itself. The curling, however, is also determined by an excretion from the bacteria, though the relations between the excretions from the plants and the bacteria cannot yet be stated. The bacterial excretion is effective on plants other than those which the bacteria can enter, *e.g.*, lucerne bacteriaocan curl the root hairs of peas but they cannot enter. The varius leguminous bacteria do not live at peace with each other in the soil; lucerne bacteria reduce the number of nodules formed on clover roots by clover bacteria though they cannot themselves enter the clover root. Something happens to the organisms in the soil after the soil has been cropped with the leguminous plant for a time; clover growing on a soil that had carried clover every fourth year had fewer nodules than clover growing on adjacent soil where no clover had been grown for 80 years, and this held true whether there was inoculation or not.

Purification of Sugar Beet Effluent. The microbiological process developed at Rothamsted has now been so far perfected that it gives a purification of 95 per cent when working at the rate of 50 gallons of liquid per cubic yard of filter per day. This is satisfactory in practise and accordingly the factory work at Colwich has been temporarily discontinued in favour of further laboratory investigation of the various outstanding microbiological difficulties which sooner or later will give trouble unless they are definitely dealt with at the outset. The chemical and microbiological changes are being studied in detail.

The Decomposition of Straw by Micro-organisms. Dr. Norman finds that the most striking change is the rapid decomposition of the cellulose; this accounts for most of the total loss. At first some of the hemicelluloses (unfortunately named since they are entirely different from cellulose) decompose rapidly, but some of them remain with the lignin as the undecomposed residue. The decomposition is brought about mainly by fungi, not, however, by one organism alone but by many acting together. Much heat is evolved during the process but this is associated with the decomposition of hemicellulose especially its pentose units and possibly the uronic units, rather than of cellulose. A supply of easily available nitrogen is essential to the nutrition and the functioning of the organisms; usually there is insufficient in the straw so that a further supply is necessary and this becomes immobilised in the tissues of the organisms. The actual quantity immobilised depends on the reaction, being greater in alkaline than in neutral or acid conditions. Microbial protein is apparently a suitable source of nitrogen.

The Production of Ammonia from Peptone in Culture Soluiont *and its Oxidation by Bacteria.* The production of ammonia from peptone did not increase as the bacterial numbers increased, but beyond a certain point fell off. Introduction of a protozoan Hartmanella lowered the bacterial numbers but seemed to increase the rate of ammonia production.

During the work on sugar beet effluent a number of organisms were discovered which oxidise ammonia to nitrite; critical examinations have already revealed 42 distinct strains of these organisms in addition to the nitrosomonas and nitrococcus previously known. Four distinct species have been isolated from the Rothamsted soil which, while agreeing physiologically with some of those from the filters, are morphologically different.

CULTIVATION OF THE SOIL

Cultivation is one of the costliest items in the arable farmer's programme; its high cost, indeed, is sending many of them into grass farming. It is not yet reduced to a science and consequently cannot be treated by advisors with the same confidence as manuring.

The Physics Department at Rothamsted is endeavouring to work out a science of cultivation, and it is proceeding in two ways. Experiments are made in the field to try and discover by dynamometer and other tests what cultivation does to the soil, and to see what other methods have the same effect. Other studies are made in the laboratory to explain the field measurements and observations, and to work out the physical properties of the soil, especially those related to cultivation such as stickiness, friction, plasticity and permeability; to discover also what is meant by tilth and crumb structure. The physical properties under investigation for the purpose of explaining tilth and crumb structure include the plasticity of the soil, the electrical conductivity and dielectric constants of soil suspensions, the specific gravity in the crumb and finely powdered states before and after pumping out all air. Cultivation with a rotary implement, the Simar, which makes a seed bed in one operation, has for the past five years been compared with the normal cultivation which requires two or three processes to do the same thing.

The Simar has consistently given a better seed bed, so that there has always been better germination and early growth; more plants, and on wheat more tillers. This, however, has applied to the weeds as well as the sown crop, and the "Simared" plots have always been the more weedy. The final yields have been much the same as with the ordinary cultivation, the advantage of the early growth not having been maintained—perhaps the result of the weed growth.

The Simar appears to be admirable for inducing germination of weeds and cleaning land.

The effect of sheep folding on light land has been studied at Woburn. The compacting of light soil obtained by sheep is different from that given by implements; it extends to a greater depth and it lasts longer; the top three inches of the soil is mainly affected. It gives also a coarser tilth. In this year's tests it did not increase the water holding power of the soil, on the contrary the trodden part was, if anything, somewhat the drier; but a fuller investigation is being made.

THE UTILISATION OF RESULTS OF AGRICULTURAL EXPERIMENTS

Agricultural problems rarely present clear cut simple issues; they are usually complicated by a number of factors, some of which are themselves highly complex; in experimental work there is always, therefore, an element of doubt whether the result is obtained because of the treatment or in spite of it. Experimenters in the past have got round the difficulty by repeating the experiment a number of times, and if they frequently obtain the same result they have felt justified in attributing it to the treatment and not to some other and unknown cause. In the original Rothamsted experiments Lawes and Gilbert repeated their field trials for twenty years before publishing much about them; they then could speak with considerable certainty.

It is not practicable in modern conditions to use this long time method, and another was introduced at Rothamsted in 1919. Mathematicians have developed methods for studying figures and tracing any relationships that may exist between one set of observations and another; the result can be expressed as the odds in favour of one result being related to another. Dr. R. A. Fisher was appointed to apply these methods at Rothamsted, and he has designed arrangements for field experiments which allow of the valid calculation of the odds in favour of the result being due to the treatment and not to chance. These field methods have been in use for several years, and have proved easily workable and a great advance on the old ones.

Dr. Fisher has also improved the methods for studying masses of data such as agricultural experimental farms and stations have accumulated. It is now possible, for example, to trace the effect of rain week by week, on crops grown under different manurial or cultural conditions, and so to learn definitely how crops and manures behave in different seasons. Great masses of data that have accumulated at the various experimental farms in the country, and have not hitherto been used, can now be examined with a high degree of assurance that any information concealed therein will soon be discovered. In recent years Dr. Fisher has developed a new method, the Analysis of Variance, which is of special value in agricultural and biological research. It is used at Rothamsted for the most diverse purposes; in the bacteriological work for the study of the hourly fluctuations of the numbers of bacteria in the soil, in the entomological department for studying bees and other insects, in the field work for assessing the trustworthiness of the results, and in the chemical department for extracting information from the masses of figures accumulated by a succession of industrious analysts.

THE COMPOSITION OF THE SOIL: SOIL ANALYSIS

For many years past, chemists have been analysing soils, and the work has now been systematised by the setting up of soil surveys in different parts of the country. Great quantities of analytical data have accumulated which, however, are difficult to interpret by the older methods. Statistical methods have been used by Dr. Crowther, and he has extracted from the figures some highly interesting and valuable results. He has begun on the many analyses of clay fraction of the soil that have been made. The molecular ratio of silica to alumina (SiO_2/Al_2O_3) has been recognised as an important soil character, but it varies a good deal from soil to soil with little or no apparent regularity. Dr. Crowther now shows that the ratio is determined partly by the geological history of the parent material of the soil, and partly by the rainfall and temperature conditions under which it now stands, and further, he has been able to assess the relative effects of these different factors. As the rainfall increases the clay becomes less siliceous (*i.e.*, the ratio SiO_2/Al_2O_3 decreases); as temperature increases the clay becomes more siliceous (*i.e.*, the ratio SiO_2/Al_2O_3 increases); in the clays examined a rise of 1°F had about the same effect as a reduction by 1 inch of the annual rainfall, when both temperature and rainfall increase the composition remains constant if 1°F rise of temperature is accompanied by 1 inch (more accurately 0.97 inches) of rain. This close connection between rainfall and low temperature arises because the effective agent is not the amount of rain, but the quantity of water leaching through the soil, and this falls off as the temperature rises because a larger proportion evaporates. The relation of rainfall and temperature with the amount of drainage through the Rothamsted drain gauge is almost identical with that of rainfall and temperature with the SiO_2/Al_2O_3 ratio.

The ratio also depends on the geological history of the soil. Soils which have been little disturbed during their lifetime, *e.g.*, soils derived from igneous rocks which have not been moved far have a low SiO_2/Al_2O_3 ratio; soils that have been much reworked (*e.g.*, the soils of the south east of England) have a high SiO_2/Al_2O_3 ratio. Much reworking in water therefore has the opposite effect from high rainfall; apparently silica is returned to the clay during this process.

Dr. Crowther has further studied the relationship between soil type and climate. Rainfall is the more important factor in dry conditions, and temperature the more important in humid conditions. The difference between the various soils in the highly leached group, with the exception of the extreme podsol, does not lie in the alumino-silicates of their clay fraction, but in the distribution of the iron oxide in the various layers of the soil; in high temperature weathering this is deposited near to the surface giving red soils, in low temperature its solution or suspension is more stable and is leached down to lower depths.

This work is being continued and will, it is hoped, systematise and make useful a large mass of data which at present has little value.

Another important contribution from the chemical department has cleared up some difficult problems in connection with compensation for unexhausted value of lime. Estimates so far made of the time that lime might be expected to last in the soil do not agree well. Dr. Crowther now finds that the rate of loss of lime and the extent of the loss depend not only on the amount of leaching, but also on the amount of exchangeable calcium in the soil; if this is high the whole of the added lime is soon lost; if it is low the lime remains in the soil and is a permanent improvement. A uniform scale of compensation which takes no account of this soil character therefore operates unfairly, and a better one could now be drawn up.

Considerable progress has now been made with the solution of the difficult green manuring problem at Woburn. The tares and

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mustard ploughed into the soil, decompose with formation of nitrate, which is rapidly washed out, especially from the tares, leaving only little for the wheat, and in consequence it starves for want of nitrogen.

THE COMPOSITION OF CROPS

Dr. Bishop's work on the composition of barley grain, carried out under the Institute of Brewing scheme, shows that the composition and amounts of the various proteins in the grain depend only on the total amount of nitrogen present, and not at all on how it got there—whether as the result of manuring, of soil properties, or weather conditions. The simplest connection is shown by hordein ; all varieties of two rowed barleys so far examined contain the same amount of hordein for any given total weight of nitrogen per grain ; for a nitrogen percentage N in the dry matter the weight of hordein in the dry matter of 1,000 grains of barley is : $0.089+0.422\ N+0.0727\ N^2$ grams.

The other nitrogen compounds, the salt soluble compounds and the glutelin differ in their proportions according to the variety. In the fully mature grain these proportions depend only on the total nitrogen content and the variety ; they are independent of soil, season and manuring.

Dr. Bishop further shows how from a knowledge of the percentage of nitrogen in the barley grain, and of the thousand corn weight, it is possible to calculate the amount of malt extract obtainable after malting, a figure of great importance to maltsters. He has constructed a slide rule which shows this figure at a glance, and thus furnishes information which hitherto could be obtained only after a long, difficult and expensive analysis. Another simple calculation shows also from the barley figures the diastatic power to be expected in the malt cured at any given temperature ; the closeness of agreement between the values expected and those found can be used as a measure of the efficiency of the malting process. The equations are for Plumage-Archer barleys :—

(1) For extract, E :
$E=110.1-11.2N + 0.18G.$

(2) For diastatic power, D.P. :
$D.P.=29N + 0.4\,G-21.$

(3) For permanently soluble nitrogen :
$P.S.N.=0.33\ N.$

Where

N is the total nitrogen percentage on dry barley.

G the dry weight in grams of 1,000 grains.

The D.P. is given for a " kilning temperature " of 180°F.*

* For full accounts of this work see:

Proteins—
Journ. Inst. Brewing, Vol. 34, p. 101, 1928.
" " " Vol. 35, p. 316 and 323, 1929.
" " " Vol. 36, p. 336, 1930.

Prediction Methods—
Extract. Ibid. Vol. 36, p. 421, 1930.

The papers relating to permanently soluble nitrogen and diastatic power are in preparation.

These results are proving of great importance to maltsters and brewers. English brewers require a barley containing about 1.3 to 1.4 per cent of nitrogen ; this seems to represent good normal barley in our conditions.

A survey is in hand of the malting barley production in Britain, showing the yields and qualities that can be expected in different parts of the country, and the comparison of quality of British and foreign barleys.

THE PLANT IN DISEASE. INSECT PESTS AND THEIR CONTROL. INSECTICIDES

Pyrethrum flowers contain substances highly poisonous to certain insects and quite harmless to plants and animals. Since pyrethrum is easily grown in this country there is the possibility that its cultivation may prove of considerable commercial interest. Dr. Tattersfield and his colleagues have studied the active principles ; they find that the maximum yield is obtained when the flowers are fully opened, *i.e.*, when the disc florets are opening ; they should be harvested at this stage and not later, otherwise there is risk that the achenes, which contain most of the poison, may be lost. Flowers differ considerably in their pyrethrin content, however, the range has been from 0.4 to 2.0 per cent. A method has been worked out for determining the quantity in a single flower head, and this can be used in plant breeding experiments to try and raise a strain of plants of high toxic value.

THE INSECT PESTS

In agriculture as distinct from horticulture a direct attack on the insect by sprays and other methods is not always possible, and for the insect pests of ordinary farms it is necessary to rely on some other means.

The natural control of insect pests is by their parasites, and this is being studied by Dr. Imms and Dr. Barnes. The Frit fly of oats is usually parasitised to the extent of about 30 to 35 per cent, the range during the past four seasons has been 27 to 37 per cent ; parasitism becoming heavier as the season advances. There has been no severe attack during this period.

Willow midges during the last three years have also been well parasitised, the range being from 51 to 64 per cent, but foxtail midges have been more variable ; there was 38 per cent parasitism in 1928, only 3 per cent in 1929, and 19 per cent in 1930 ; it is not yet known why the parasites did so badly in 1929.

Immune Varieties. The simplest way of dealing with the Willow midges, however, is to grow varieties of willow immune to its attacks. Unfortunately the most desirable commercial species, *Salix triandra*, is susceptible, as are all its varieties. On the other hand, *S. purpurea*, *S. alba* var. *vitellina* and *S. viminalis*, and their varieties, also the cross *S. viminalis* x *S. purpurea*, are immune. It should not be impossible to cross *S. triandra* with one of these immune varieties, and so finally obtain a new variety, immune to the midge, but with the commercial value of the old *triandra*.

It remains to discover why some varieties are immune and others are not. There is evidence that the immune varieties contain a chemical substance which keeps off the midges ; when an extract of an immune variety is painted on the susceptible varieties they cease to be so attractive. Further work is being done in the hope of discovering the substance and studying it in detail.

Problems of great biological interest, though not of obvious agricultural significance, are suggested by Dr. Barnes' discovery that the midge *Rhabdophaga heterobia* produces families of one sex only ; some mothers producing males only, and others females only. Apparently it is the mother, not the father, that determines the sex of the offspring. The investigation has necessitated breeding lines of pedigree male and female midges, studying and rearing their progeny for successive generations.

Bees. In drawing up the programme of the Bee Research the department is assisted by a committee of practical bee keepers who report from time to time the problems which are of special concern to them. In the main their difficulties arise from diseases which from the outset the Bee Research Staff were, by the terms of the grant, precluded from studying. In consequence the work has been confined to questions of management which are not only difficult, but completely lacking in interest to the non-technical person. The chief problem has been the study of the differences between the "warm way" and the "cold way" of arranging the frames in the hive ; the warm way being the one in which the frames are placed parallel to the front so that the first frame acts as a kind of door shutting off the rest, while in the cold way the frames are placed at right angles to the front. The differences were only slight, but by taking numerous observations continuously for several years, certain conclusions have been reached.

(1) In *summer* the temperature inside the hive is almost entirely independent of the temperature outside, and completely independent in the brood chambers.

(2) In *winter* the temperature inside is affected by that outside ; it changes by 0.6° to 1° for each 1° change outside, and the change was greater in the "warm way" hives than in the "cold way" hives, especially on the north and east aspects.

(3) In spring and winter the inside temperature seems to vary with the outside temperature.

A second question asked by the practical keepers was whether cane sugar or beet sugar is the more suitable winter food ; there is a strong feeling in favour of cane sugar. Prolonged trials, however, failed to reveal any difference.

The work at present is concerned mainly with the study of brood food in relation to swarming and other activities of the bee.

MYCOLOGY

A fundamental difficulty in mycological work is that some of the most serious fungus pests are not simple species which are sharply distinct and easily characterised, but groups consisting of numerous races which are so like each other as to be distinguishable only with great difficulty if at all on the attacked plant. Some races, however, may be almost harmless while others may be very injurious. Dr. Brierley is investigating one of the most important fungi, *Botrytis cinerea*, of which he has already found over 200 races, some of which are apparently saprophytic, others parasitic on a limited range of plants, others again parasitic on a wide range of hosts. Even the parasitism, however, is not simple but depends upon the condition of the host and its environment. Further it is sometimes easy to infect a plant with a race which under natural conditions, does not seem to attack it, while on the other hand, a race which in nature has virulently attacked a plant may fail to attack it in the experimental house. The various races, the question of their permanence in relation to external and other conditions, and their relation to the host plant are being studied by Dr. Brierley, and the investigation is cast on broad lines so that the results are significant for other phases of plant pathology.

Miss Glynne has developed a method of testing potatoes for immunity or susceptibility to wart diseases so that it is now more sensitive than the ordinary field test besides being more rapid, needing only a few weeks, instead of two or three years. The practical question has arisen and needs settling whether a variety in order to be classed as immune, needs to pass the Glynne test in its most severe form, or to pass the field test that corresponds in severity with ordinary field conditions.

The liability of a plant to disease may be affected by the conditions in which it is grown, and it has been found by L. M. Kramer that dressing with phosphate reduced, and dressing with nitrogenous fertiliser increased, the liability of potatoes to the fungus *Corticium solani*. In practice, however, the position of the potatoes in the clamp may be the more important factor.

Bacterial Diseases. Mr. Stoughton is continuing the investigation on the angular leaf spot disease of cotton caused by *Bacterium malvacearum*. The disease organism may be carried on the seed coat and in the fuzz, but only rarely within the seed coat. Thorough disinfection of the exterior of the seed almost eliminates disease of the seedling, but if contaminated seed is not disinfected it produces diseased seedlings. The amount of infection decreases as the soil temperature rises above 30°C though infection may still occur at 40°C. Later on the plants grow out of the disease. They may, however, again become infected, and the progress of the disease is not affected by the soil temperature but by the air temperature, being at a maximum between 30°C and 35°C.

Virus Diseases. Dr. Henderson Smith is in charge of this work and is aided by Drs. Caldwell, Hamilton and Sheffield.

Up to the present most of the work has as a matter of convenience been done with the Aucuba Mosaic of tomato plants. It has suffered from the disadvantage that the winter grown plants are very different from those of the summer—as is well known to all practical growers—and, although they take the disease, they do so only slowly and with abnormal symptoms. The difference between summer and winter results has been traced to the difference in the hours of light ; when the winter day is extended by five hours of good artificial light (from 4.30 p.m. to 9.30 p.m.) the summer disease symptoms are produced and, conversely, when the summer day is shortened by cutting off the light, the plants take the disease only slowly and abnormally, while in complete darkness, the plants fail to develop symptoms of the disease.

Dr. Caldwell has shown that the virus cannot travel across dead tissue, nor can it enter the living cells of the plant from the xylem unless some rupture has occurred. Where a leaf is inoculated the virus travels to the stem and then moves up and down at approximately the same rate.

Dr. Sheffield has studied the mode of formation of the intracellular inclusions found in cells of the diseased plants. Small particles carried in the streaming protoplasm coalesce to form larger masses and ultimately unite to form a spherical mass which becomes vacuolate and may take on an amoeboid appearance which caused them to be regarded at first as parasitic organisms. The process has been photographed cinematographically and the film has attracted much attention.

Dr. Hamilton has devised new and better methods for the study of the insect transference of virus diseases.

THE FARM

During the year the farm and laboratories were visited by over 2,000 agricultural and scientific visitors, some of whom stayed for an extended period. Members of the staff gave over 79 lectures to farmers, students and others, these being arranged either by the County Organiser, or by the National Farmers' Union in collaboration with the organiser, or by a college or university.

GEOLOGY OF THE ROTHAMSTED EXPERIMENTAL FIELDS
REPORT BY MR. H. G. DINES, GEOLOGICAL SURVEY

The Rothamsted Experimental Fields were surveyed in 1903 by H. B. Woodward, and the result of his work was published,[1] together with a map, which, it was claimed, showed "the distribution of the subsoils and soils" of the area. In February, 1930, the Geological Survey undertook a re-examination of the farm for the purpose of bringing Woodward's map up to date. No alteration was found necessary and, apart from the additional survey of some fields that had been added to the farm since 1903, no changes of any importance were made.

In the light of present knowledge of soils and subsoils, Woodward's map cannot be regarded as a soil map, but only as a geological map showing divisions of the clay-with-flints which are usually unnecessary from a geological point of view.

The farm is situated on a dip-slope of the chalk area of the Chiltern Hills, and the fields, for the most part, are on high ground, which is covered with an irregular accumulation of clay and loam with abundant flints, known as clay-with-flints. This was originally considered to be derived, in great part, from slow decomposition of the chalk under atmospheric action. This view was later disputed by various writers on the grounds that the constituents were not present in such ratios as would result from simple solution of the calcareous portion of chalk ; the clay proportion is far too high as compared with that of the flints. Close examination of the deposit also reveals that a considerable part is composed of remnants of Tertiary Beds. Flint pebbles, blocks of pudding-stone, masses of bright red clay and sarsen stones from Eocene formations, and

1 Summary of Progress' for 1903 (Mem. Geol. Surv.), 1904, Appendix I, pp. 142-150

ironstone fragments from Pliocene beds are present in various localities, sometimes to the exclusion of angular flints such as would result from the weathering down of the chalk alone. This irregularity of the clay-with-flints led Dr. R. L. Sherlock and Mr. A. H. Noble to regard it as of glacial origin,[2] a view which is widely accepted. At the beginning of glacial times the chalk outcrop was apparently covered with remnants of various Tertiary formations as outliers, and in some areas where bare chalk had been exposed to the atmosphere for a considerable period, some clay-with-flints (using the term in its original sense) may have formed, but the superficial deposits on the chalk to-day present the appearance of having been mixed up by disturbance such as would result from an ice sheet moving from the north or north-west over the area of the Chilterns.

The clay-with-flints of the Rothamsted area is composed almost entirely of disturbed local rocks. The angular flints showing no sign of abrasion come direct from the chalk, the subangular and generally ochreous flints from old gravels once resting on the chalk, and the black flint-pebbles and blocks of Hertfordshire pudding-stone from the Reading beds or other lower Tertiary deposits. Fragments of iron cemented sandstone from a Pliocene deposit are also present ; these are fossiliferous, and are especially well seen in the subsoil of West Barn, Sawyers and Long Hoos fields. The bulk of the matrics is red-brown clay with varying degrees of loaminess, which apparently is derived mainly from Reading beds. In places where the clay is heavy it presents a grey mottling due to alteration of the iron oxide which produces the colouring. Manganese oxide occurs as a black stain in some fissures in the clay, and as a coating to some of the stones. The mass of clay is scattered sporadically with the various kinds of stones, which occur sometimes mixed and sometimes exclusively in bunches or pockets. It presents every appearance of having been formed under glacial conditions, the various constituents having been mixed during a slow passage southwards in a frozen or partly frozen state.

The thickness of the clay-with-flints is variable. Generally speaking, it may be from 5 to 10 ft., but in swallow holes, which occur frequently in the underlying chalk surface, it may reach much greater thicknesses.

According to Woodward the clay-with-flints of this area can be separated into three classes, namely :

(1) Loamy clay with few stones.
(2) Heavy clay, more or less stony.
(3) Light clay, more or less stony.

These variations are shown upon his map.

The downwash that occurs on the slopes of the clay-with-flints plateau is a mixed lighter soil—more or less stony. This clothes the more gentle slopes towards the Harpenden Valley, but does not extend down the steeper slopes to the west. The edge of the clay-with-flints passes through Great Knott and Little Knott, and to the south west of the line the chalk is free from drift. The down-slipping of the drift into the Harpenden Valley probably

2 *Quart. Journ. Geol. Soc.* vol. lxviii 1912 ,pp. 199-208.

covers a larger area than is shown on the geological map; for instance, although the lane running from north of Red Gables to Ninnings Field is sunk to a depth of at least 4 ft. near the main road, no chalk is visible, but only material that is obviously downwash from the clay-with-flints plateau. It is not possible for the geologist, however, to map this part as anything but bare chalk since the downwash is obviously of recent date.

FIELD EXPERIMENTS AT OUTSIDE CENTRES

The outside experiments began in 1922 with a series of trials under the Institute of Brewing Research Scheme on good barley growing farms in various parts of the country to test the effects of fertilisers on the yield and quality of barley. The same scheme was used throughout and the same stock of seed. In the first four years, 1922-1925, single plots were used, and 225 plots were harvested. In 1926 the scheme was modified and curtailed and 48 plots only were used, but the experiments were in duplicate. In 1924 laboratory work on the inoculation of lucerne was sufficiently advanced to justify extended field trials. The Royal Agricultural Society provided the necessary funds. Some 39 centres were chosen in various parts of Great Britain, and eleven strips were drilled at each centre, five with inoculated seed alternating with six with uninoculated seed. These experiments have continued, and at 21 centres the plots were still in existence in 1930.

By 1926 the new methods of field experimentation had been tested on the Rothamsted farm and they were then used on commercial farms to test the value of various types of basic slags on grass and arable land. Four by four and five by five Latin squares proved entirely successful, and they were continued till 1929, when the effect of the initial dressing of phosphate had almost disappeared. A new series was laid down in 1930. The cost of these experiments was defrayed by the Basic Slag Committee of the Ministry of Agriculture.

In the meantime interest in the level of phosphatic manuring for potatoes had been aroused by Mr. J. C. Wallace's results at Kirton, and a series of experiments was arranged on a number of potato growing farms using four by four Latin squares. The first tests were made on Mr. George Major's farm at Wisbech in 1928 and at Mr. J. C. Luddington's farm at Stowbridge; several other centres have been arranged since.

Up to this point the experiments and much of the work had been done by the Rothamsted Staff, T. Eden being in charge till 1927, and H. J. G. Hines in 1928. In 1929 H. V. Garner took charge, and immediately widened the scope of the work by enlisting the co-operation of agricultural colleges, county organisers, and certain schools which possessed the necessary facilities for small plot work. This has proved very successful; it has enabled us to carry out uniform schemes of experiment over widely different types of soil and climatic conditions. The statistical staff at Rothamsted supplies the form of Latin square and works up the yield data, and the chemical staff examines the produce. Mr. Garner and other members of the field staff maintain personal touch with the workers at the various centres, but are relieved of the detailed work involved in the experiments.

More elaborate experiments are made at some of the centres under the direct supervision of the Rothamsted staff, and in 1929 the new sampling technique for cereal crops was successfully used on barley at Wellingore. In 1930 still higher replication was adopted. The new phosphatic series of the Basic Slag Committee has five by five instead of four by four Latin squares; experiments of 32 plots or 36 plots were put down at several centres on potatoes and sugar beet, and two barley experiments of 64 plots each were carried through by the sampling method. The following table summarises the number of outside centres and plots.

Replicated Trials at Outside Centres, 1926–30.

	Conducted by Rothamsted Staff.		Conducted by Other Workers.		Total.	
	No. of Centres.	No. of Plots.	No. of Centres.	No. of Plots.	Centres.	Plots.
1926	4	73	—	—	4	73
1927	5	85	—	—	5	85
1928	7	186	3	41	10	227
1929	5	112	5	76	10	188
1930	7	234	10	160	17	394

OBSERVATIONS ON FUNGOUS DISEASES IN CROPS ON EXPERIMENTAL PLOTS AT ROTHAMSTED AND WOBURN MAY—SEPTEMBER, 1930

By Mary D. Glynne

WHEAT

Take-all or Whiteheads. (*Ophiobolus graminis Sacc.*) was prevalent on Broadbalk particularly on the unfallowed plots. It appeared to cause serious damage on Great Knott; on Fosters it was only occasional and on Long Hoos Dicyanamide Grazing Experiment, 1929-30, none was found.

Leaf Spot. (*Septoria tritici, Desm.*) was common on Broadbalk, Fosters and Long Hoos Dicyanamide Grazing Experiment, and was present on Great Knott.

Yellow Rust. (*Puccinia glumarum* (*Schm.*) *Erikss. and Henn.*) was slight on Broadbalk and Long Hoos, moderate on Fosters and common on Great Knott.

BARLEY

Leaf Stripe. (*Helminthosporium gramineum* Rabenh.) was very common both at Rothamsted and Woburn. The distribution of the disease appeared to vary little from plot to plot of the same experiment, but showed very striking differences in intensity in different fields. At Rothamsted in Great Harpenden Forage Experiment it was very prevalent, but in Hoos Permanent Barley the infection was slight; at Woburn in Stackyard Permanent Barley almost every plant was affected to some extent; in the Rotation Barley on the same field fewer plants were affected, but actually more were killed. There was some evidence to suggest two kinds of attack in one of which most plants were affected slightly, and in the other fewer plants were affected, but scattered plants were killed.

NET BLOTCH. [(*Pyrenophora teres* (*Died*) *Drechsler*. (*Helminthosporium teres*. *Sacc.*)] was present in varying amount on the barley fields at Rothamsted and Woburn.

LEAF BLOTCH. (*Rhynchosporium secalis* (*Oud*) *Davis*) varied very much in intensity from field to field. At Rothamsted on Long Hoos Rotation II, none was found, but on the Commercial Barley in the same field it was very common. On Hoos Permanent Barley it was very common, and on the Rotation Barley uncommon. At Woburn none was found on the Permanent Barley in Stackyard, but in Butt Furlong field it appeared to be present on nearly every plant.

YELLOW RUST. (*Puccinia glumarum*, (*Schm.*) *Erikss. and Henn*) varied in intensity from field to field, and was on the whole fairly common.

MILDEW. (*Erysiphe graminis, DC.*) was observed at Rothamsted, but was more common at Woburn, especially on the Rotation Barley in Stackyard.

RYE—ROTATION II

LEAF BLOTCH. (*Rhynchosporium secalis* (*Oud*) *Davis*) was very common on every plot.

BROWN RUST. (*Puccinia secalina, Grove*) was present but slight on every plot.

GRASS PLOTS

CHOKE. (*Epichloe typhina*) (*Fr.*) *Tul.* was very prevalent. It was found generally on Agrostis, but was also found on two plants only of Dactylis glomerata. The fungus was much more abundant on the unlimed than on the limed half of the plots, but this may be connected with the more frequent occurrence of Agrostis on the unlimed parts. The distribution of Epichloe, however, is not entirely dependent on the presence of Agrostis because on Plot 2 (unmanured after dung for the first eight years) Agrostis was plentiful and no Epichloe was found.

The fungus was most abundant on Plot 10 where potash is deficient, and on Plot 1, which receives ammonium salts alone.

OBSERVATIONS ON INSECTS ATTACKING THE FARM CROPS

MAY—SEPTEMBER, 1930

By H. C. F. NEWTON

WHEAT

THE WHEAT BULB FLY (*Hylemyia coarctata*, Fall*). Present on all plots on Broadbalk—worse after fallow, but damage estimated as small. Generally present on Fosters, Great Knott, Hoos Field alternate wheat and spring wheat plots, Long Hoos, variety trials, and at Woburn on Stackyard.

* (Note. Field inspections began after attack had been in progress 2 or 3 months.)

THE WHEAT MIDGES (*Sitodiplosis mosellana*, Géhin. *Contarinia tritici*, Kirby). Present on all plots on Broadbalk (attack estimated to be the worst in the last four years) and on all other wheat. Attack judged less on Hoos Field spring wheat, but heavy on Lansome at Woburn.

THE WHEAT LEAF MINER (*Agromyza* sp.). Attack rather severe on Broadbalk, especially at edges of plots and on Hoos Field alternate wheat ; attack smaller on Great Knott, Fosters and Hoos Field spring wheat and Long Hoos variety trials ; more severe at Woburn, on Lansome and Stackyard.

THE WHEAT STEM SAW-FLY (*Cephus pigmeus*, Linn). Generally present but damage insignificant.

BARLEY

THE GOUT FLY (*Chlorops taeniopus*, Meig). Attack very marked on all phosphate deficient plots on Hoosfield, but present on all plots. On the no nitrogen and no phosphate and unmanured plots, practically every plant was attacked, and in many cases to the extent of six or seven tillers. On the other plots attack was of the usual summer type present, but damage small. Attack general on Long Hoos barley plots, but not serious ; rather severe at Woburn (examined July 2nd) on Stackyard field.

THE SADDLE MIDGE (*Haplodiplosis equestris*, Wagn). Slight attack noticed on Long Hoos and Stackyard (Woburn)—damage insignificant.

WIREWORMS (*Agriotes* spp.). During latter half of May slight attack on Long Hoos barley plots.

OATS

THE FRIT FLY (*Oscinella* (*Oscinis*) *frit*, Linn). General attack on Long Hoos variety trials ; on entomology oat plots sown Feb. 29th., 22 per cent shoot attack ; sown Mar. 30th., 37 per cent shoot attack ; sown Apr. 29th., 30 per cent shoot attack.

WIREWORM. Patches rather badly attacked on two northern plots, Long Hoos, early in season (21.5 per cent).

THRIPS. Slight attack.

FORAGE MIXTURES

WHEAT BULB FLY. Slight but general attack on rye on pastures—damage small.

PEA AND BEAN WEEVIL (*Sitona lineata*, Linn, etc.). Small attack on pastures, rather severe in Great Harpenden where it was noticed that the nitrogen plots outgrew damage the best.

FRIT FLY. General attack on Great Harpenden—not severe.

MANGOLDS

THE PIGMY MANGOLD BEETLE (*Atomaria linearis*, Steph.). This beetle was generally present on Barnfield, and to some extent responsible for the gappy plant. It was less frequently found on the dunged plots. The Black Spring-tail (*Bourletiella hortensis*, Fitch) was also present, but there was no attack by the Mangold Fly (*Pegomyia hyocyami*, Panz.), or the Mangold Flea-beetle (*Plectroscelis concinna*, Marsh). At Woburn on July 2nd, the mangolds were well grown and except for the Black Spring-tail no other pests were noticed.

SUGAR BEET

There was no significant insect attack on Long Hoos. At Woburn (July 2nd.) there was on Stackyard a poor plant made up by transplanting. Though the Black Spring-tail was present there was no evidence of attacks by the Pigmy Mangold Beetle, the Mangold Flea-beetle or the Mangold Fly. On Lansome there was a good plant ; here the Black Spring-tail was frequent, and an occasional plant was attacked by the Mangold Fly.

CRUCIFEROUS ROOT CROPS

Attack by Flea-beetles (*Phyllotreta*, spp.) necessitated re-sowings both here and at Woburn.

POTATOES

No significant insect attack.

THE FARM REPORT

I. Weather.

The weather during the season 1929-30 was generally favourable to farm operations. The autumn was wet. After January, however, drier conditions enabled spring work to start early. The rainfall for October, 1929, to January, 1930, as compared with the 77 year average, was :

	October	November	December	January
1929–30	4.51	6.56	6.01	3.24
1853–4—1929–30	3.11	2.66	2.65	2.42

For the remaining months, however, the rainfall was not far from the 77 year average. Frost was rare, the average temperature for January, 41.3°F, being 3.9° above the 57 year average, but this did not prevent a good spring tilth, because all the land had been ploughed in good order during the early autumn. During the spring and early summer the rain was sufficient to encourage vigorous growth, and excellent hay crops were favourably secured during a spell of hot, dry weather. Immediately afterwards the weather broke, and several heavy thunderstorms laid most of our heaviest grain crops. The broken weather continued during the first fortnight of harvest and aroused some anxiety ; later there was a marked improvement which lasted until after the winter oats and some of the wheat had been sown. The total sunshine for the year was very close to the 37 year average.

II. Farm Policy and Developments.

The laying down to grass was completed in 1929. In 1930 water was laid on from the old supply, which had to be enlarged for this purpose, and the fields were divided into fenced areas of 6 to 9 acres, each with water and some with shelters. In addition there are a few small paddocks.

The buildings were next improved and extended so as to bring them all, including the Dutch Barn, under one roof. The extension includes two cart sheds and one storage shed, two covered cattle

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courts, capable of holding nearly thirty-six fattening cattle or other stock, and accommodation for a large quantity of dung.

It is proposed shortly to erect a demonstration room, a farm office and work room for experimental staff and equipment, and to install throughout electricity for power and light ; this will complete the present scheme.

The work on the arable land in recent months has been affected by the following new factors :

(1) Corn crops have become so unprofitable that no more can be grown than will provide the minimum of straw required for litter.

(2) There has been a marked increase in the experimental programme ; the new experiments including :

- (*a*) Two new long term rotation experiments, one in Great Hoos, the other in Long Hoos, Section IV.
- (*b*) A set involving three crops in succession—barley, hay and wheat.
- (*c*) Forage mixtures and other crops.

These factors have made it necessary to introduce various changes ; they prevent strict adherence to any one cropping system. The classical fields and Long Hoos IV to VI alone are reserved exclusively for experiments, but any of the remaining arable land is so used when necessary. On the commercial farm two new crops showed promise : winter rye after farmyard manure in early autumn, and kale. The rye provides, at a cost of less than £2 per acre for seed and cultivation, useful green food for ewes, lambs and cows from the middle of March onwards ; it helps to prevent loss of nitrate from the soil by winter leaching ; it effectively controls black bent and other winter weeds, all of which are destroyed in the spring cultivation after the rye is ploughed up ; and its roots facilitate the production of a spring tilth, a matter of great importance on this sticky soil. This use of rye as a catch crop would be impossible without a tractor to carry out the autumn ploughing.

Kale is the second new crop in the commercial farming. It has the advantages of a root crop without the high labour costs. We have still to discover the best following crop. Barley is almost certain to go down, potatoes and other roots would be very suitable, but soil and other considerations rule them out. This year we are trying barley mixed with beans, and also spring sown (Marvellous) oats. Maize, for green food, and linseed for seed are also possible.

The policy for livestock is to make them as self-contained as possible. Store cattle and store sheep are so dear that purchases are reduced to a minimum. As many polled black calves as possible are raised and suckled by a few cows. A flock of nearly 200 half-bred breeding ewes is kept, these are crossed with Suffolk and other rams, and are timed to lamb from about the middle of March. After lambing they are put on rye and on grass that receives a nitrogenous top dressing early in February. Lambs are sold throughout the year. Young cattle are outwintered as far as possible for sale either fat off the grass during early summer, or as strong stores when the demand is greatest, according as prices move.

III. Cropping, 1929–30. (For dates, yields and other information, see Table on pp. 112-5.)

All winter corn was sown in September, 1929, on a very dusty tilth, except Broadbalk sown on October 16th. The plant was thick and appeared to suffer no harm from the fine tilth. It was in unusually forward condition by the spring and looked promising throughout the season. Winter oats in Little Hoos, and wheat in Fosters, just resisted lodging, and were cut a few days early to secure them against storm damage. Most of Great Knott wheat was hopelessly laid, the damage commencing as early as June, with consequent loss of yield ; on some of the plots where there was little lodging the unmanured wheat gave the remarkable yield of 27 cwt. (50.4 bushels) per acre.

The Broadbalk wheat, on the three-fifths which had been fallowed in the previous years, was completely laid, except for the unmanured plot. The yields were, in consequence, considerably less than the record figures obtained from the top two-fifths in 1928. In 1930 the top two-fifths were not laid but gave poor yields, with much black bent (see pp. 122-3). Barley was grown on the experimental fields only.

Potatoes were planted earlier this year on Long Hoos (April 2nd–3rd), and the yields were considerably better than last year. The crop was again lifted under excellent conditions. Sugar beet, sown alongside on May 9th, was again disappointing. This occurs so frequently at Rothamsted, though not at Woburn with its lighter soil, that in 1931 we are comparing very intensive cultivation and manurial treatments. Barn Field mangolds sown on May 10th, gave better crops than in 1929.

A heavy crop of seeds hay (some 40 cwt. per acre) was cut from Great Harpenden and Long Hoos IV. The aftermath in Great Harpenden was left for sheep, part being ploughed up in time for sowing winter oats, and the rest for spring oats. Long Hoos IV, however, was ploughed up at once and prepared for the second long period Rotation Experiment (pp. 128-9). Immediately after harvest, Sections I and III in Long Hoos were dunged, the mustard on II was folded off with sheep, and all three sections were sown with rye, on September 26th–30th.

Little Hoos was also dunged after harvest, having given heavy crops for several years without dung, and was then laid out for certain of the 1931 experiments. The winter rye in Pastures proved most useful for the ewes and lambs in spring. It is frequently objected that this crop grows so quickly that it soon becomes coarse and unpalatable ; efficient stocking, however, prevents this, and its quick growth is one of its great virtues. When grass sufficed for the ewes and lambs the rye was ploughed up, by sections, and sown with kale from May 17th. The crop suffered much from the turnip flea beetle ; the whole field had to be sown a second time, and parts of it a third time. This trouble would be reduced by earlier ploughing of the rye and earlier sowing of the kale, but as against this early sown kale is apt to be too mature by the time it is most wanted.

Fosters Field was undersown with Italian Rye Grass and Broad Red Clover. Part was drilled, part broadcast ; the latter method was good, but the former was better, as usual in this district. By

September there was an excellent bite of young grass in this field, which was admirable for flushing our ewes.

III. Stock.

A start was made this year in trying to raise sufficient calves to supplement the sheep stocking of our grassland. Four in-calf heifers were purchased, and after calving they are given bought-in calves to rear in addition to their own. Lambing commenced on February 1st, possibly rather early under our conditions. We have not yet been able to wean a 150 per cent crop of lambs, because of the addition of gimmers[1] to the flock. A few of the ewe lambs, purchased in August, 1929, produced lambs, but neither lambs nor mothers did particularly well. More ewe lambs were purchased in September, 1930, thus raising the number of our potential ewe flock to nearly 200.

IV. Grass.

Favoured with a good season for grass in 1930, all the grass on the farm has shown a steady and, in some cases, a surprising improvement. Summer growth was so good that much hay had to be cut, and all fields were, as usual, topped. There was an abundance of aftermath on all fields in the autumn. Little Knott which has had pride of place for the last two years, has now serious rivals. Next to it, and equal to each other come Great Harpenden and Sawyers (next West Barn) ; both these were sown in August, 1928, and despite the very severe frost that followed, the wild white clover survived and now forms a dense mat. This early autumn sowing was a distinct success.

New Zealand is also improving. It has filled up remarkably, clover is becoming prominent and weeds have been largely suppressed.

Great Knott looked very brown by the end of 1930, due possibly, to the strength of the cocksfoot. Parts of it are still somewhat thin and weed grasses are still too prominent, but it has been heavily trampled with stock during the winter of 1930-31.

Great Field continues its steady improvement, and has been very severely grazed with sheep throughout the winter of 1930–31.

The worst grass now on the farm is in West Barn and Stackyard, but the former has improved considerably, and the latter is benefiting from heavy winter treading.

One of the outstanding demonstrations on our young grass is the injurious effect of sulphate of ammonia on the young developing plants of wild white clover, even though the grass be well and thoroughly grazed. This fertiliser should not be used on a permanent grazing pasture while it is becoming established ; whether or not other nitrogenous manures are safer we cannot yet say.

VI. Implements.

Through the kindness of some of the leading implement manufacturers, we have a large variety of implements at our two farms, either presented or on loan, the value of which exceeds £1,000. These are among the most useful of our farm demonstrations, and are a never failing source of interest to farmers. One reason why

1 A gimmer is a young ewe that has not yet borne lambs.

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we desire to improve our demonstration accommodation at the farm is to extend the opportunities for showing and describing the implements. Among firms to whom we are indebted we wish especially to mention the following :

Ruston, Hornby, Ltd. (Grain drill, binder and trusser).
Ransomes, Sims & Jefferies (ploughs and cultivators).
J. & F. Howard, Ltd. (ploughs, potato lifter).
Ford Motor Co., Ltd. (tractor).
International Harvester Co. (manure distributor and grain drill).
Wallace & Sons, Ltd. (potato implements).
Jack & Sons, Ltd. (turnip implements).
Massey, Harris, Ltd. (dung-spreader, pulverator).
W. A. Wood & Co. (mower and harrows).
J. Wilder, Ltd. (Pitch-pole harrows).
Bamfords, Ltd. (hay machinery).
Blackstone & Co., Ltd. (hay machinery).
Simar Rototillers.
Geo. Henderson (manure distributor).
Harrison, McGregor & Co., Ltd. (root pulper, manure distributor).
E. H. Bentall & Co., Ltd. (cake breaker, etc.).
Cooper Stewart Engineering Co. (sheep-shearing machine).
R. A. Lister & Co., Ltd. (oil engine).
Cooper, McDougall & Robertson, Ltd. (sheep dipper).
Cooper-Pegler & Co., Ltd. (spraying machines).
George Monro, Ltd. (motor-hoe).
Allen & Simmonds (motor-hoe).
Parmiter & Sons, Ltd. (chain-harrows).
Garvie & Sons (grass-seed broadcaster).
Dawe-wave Wheel Co. (tractor wheels).

VII. Staff.

Mr. C. Frith, as voluntary student assistant, is collecting data on the commercial farming side, particularly relating to the livestock. At both farms our herds of pigs and flocks of ewes are completely recorded, and as the farms develop it is hoped to extend this branch of the work and to study various management and other problems.

A constant stream of Danish students now come to our farms for varying periods to study field experimental methods and to gain experience of English farming. In return we are hoping to send members of our farm staff from time to time over to Denmark ; the first will, we hope, go out in the summer of 1931.

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 Agricultural in 1926, and possesses all the equipment required of a Crop-Weather Station. The observations taken under this scheme include :

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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 : recording anemobiograph).

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 received on two blackened platinum foils 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.

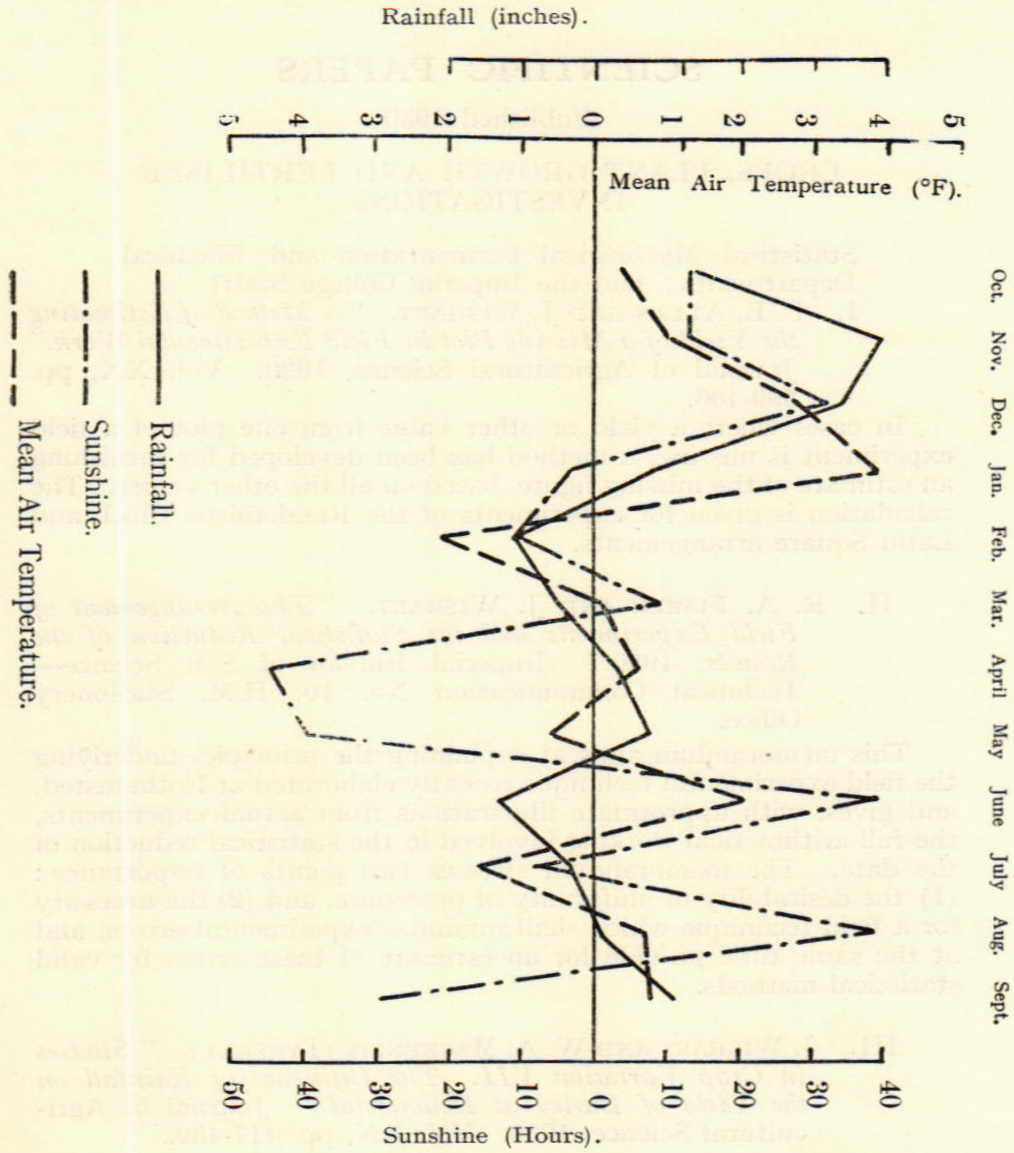
RAINFALL AND DRAINAGE.—The rain falling on one thousandth of an acre is collected in the big gauge erected by Lawes in 1871. Samples of the water are analysed in order to ascertain its nutrient value.

Three drain gauges, each of one thousandth of an acre, originally installed by Lawes in 1870, and fitted with continuous recorders in 1926, give the drainage through 20 inches, 40 inches and 60 inches of uncropped and undisturbed soil. A small continuously recording rain gauge is used in connection with these.

On June 18th, 1930, 0.62 inches of rain fell in twelve minutes, and a further 0.08 inches within the next half hour. Drainage at 20 inches ceased on June 21st, and at 60 inches on June 24th ; in both cases only 0.06 inches had percolated. More than 0.6 inches had been needed, therefore, to make good the loss from evaporation which had occurred during a fortnight of fine weather which preceeded June 18th.

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, 1929-30.

SCIENTIFIC PAPERS

Published 1930

CROPS, PLANT GROWTH AND FERTILISER INVESTIGATIONS

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

I. F. E. ALLAN AND J. WISHART. "*A Method of Estimating the Yield of a Missing Plot in Field Experimental Work.*" Journal of Agricultural Science, 1930. Vol. XX, pp. 399-406.

In cases where a yield or other value from one plot of a field experiment is missing, a method has been developed for furnishing an estimate of the missing figure, based on all the other values. The calculation is given for experiments of the Randomised Block and Latin Square arrangements.

II. R. A. FISHER AND J. WISHART. "*The Arrangement of Field Experiments and the Statistical Reduction of the Results*, 1930." Imperial Bureau of Soil Science—Technical Communication No. 10, H.M. Stationery Office.

This memorandum aims at explaining the principles underlying the field experimental technique recently elaborated at Rothamsted, and gives, with appropriate illustrations from actual experiments, the full arithmetical working involved in the statistical reduction of the data. The memorandum stresses two points of importance : (1) the desirability of uniformity of procedure, and (2) the necessity for a field technique which shall minimize experimental errors, and at the same time provide for an estimate of these errors by valid statistical methods.

III. J. WISHART AND W. A. MACKENZIE (TYRRELL). "*Studies in Crop Variation VII. The Influence of Rainfall on the Yield of Barley at Rothamsted.*" Journal of Agricultural Science, 1930. Vol. XX, pp. 417-439.

The method elaborated by R. A. Fisher in his study of the effect of rainfall on wheat is here applied to the barley crop in Hoos Field, and curves are published showing for thirteen plots the benefit or loss to the final yield in bushels per acre due to an additional inch of rain over the average at any given period of the year. The main effects noted are these : (1) Excess of rain is beneficial to the barley crop for a short period in summer and, in the case of certain plots, over the autumn and winter period. (2) Rainfall over the six months when the barley is not in the ground is just as important as rainfall in spring and summer, and the time at which the rain falls in winter is important. (3) The curves for 2-O and 2-A are essentially different in character from those of the other plots, and point to the important effect of excess of winter rain in reducing the yield of the plots having phosphate but no alkali salts (*i.e.*, no potash, soda or magnesia). (4) Excess of rain at time of sowing is harmful in all cases. (5) The curves of the "O" series (without nitrogen) are much flatter than those of the "A" series, which have a nitrogenous dressing in addition. (6) The indication of summer benefit is not inconsistent with the conclusions of Hooker that a cool summer is desirable for barley. (7) The farmyard manure plot 7–2 bears certain resemblances to the curve for the corresponding plot 2b on Broadbalk.

IV. R. J. Kalamkar. "*Studies in Crop Variation VIII. An Application of the Resistance Formula to Potato Data.*" Journal of Agricultural Science, 1930. Vol. XX, pp. 440-454.

In this paper a further test is made of the validity of the Resistance Formula suggested by Maskell to formulate the yield—nutrient relation in a crop. The material investigated consists of the results of the Rothamsted Potato experiment of 1929, designed to give information as to the effect on yield of applying nitrogenous, potassic and phosphatic fertilisers in various quantities. The experiment confirms the conclusions of Balmukand's paper as to the possibility of fitting the Resistance Formula to experimental data. The nitrogen constants are of the same magnitude as before, but the corresponding constants for potash cannot yet be regarded as well determined.

V. J. Wishart. "*On the Secular Variation of Rainfall at Rothamsted.*" Memoirs of the Royal Meteorological Society, 1930. Vol. III, No. 27, pp. 127-137.

A detailed study of the rainfall at Rothamsted over the 76 harvest years, 1854-1929, has revealed the fact that not only have there been sensible changes in the average yearly rainfall of a similar character to those observed at other stations in England and Wales, but the distribution of rainfall throughout the year has changed. The maximum in autumn (and equally the minimum in spring) occurs significantly later to-day than was the case 76 years ago, but there is some sign that this movement is now reversing its direction, as appeared to have happened towards the end of the eighteenth and again in the middle of the nineteenth centuries, as judged from early records at a number of other stations.

VI. S. H. Jenkins. "*The Determination of Cellulose in Straws.*" Biochemical Journal, 1930. Vol. XXIV, 1429-1432.

Cellulose in straws may be readily determined by treating the straw with hot dilute alkali and mineral acid, and then with cold alkaline hypochlorite solution. The new method gives results which are practically idential with those obtained by the Cross and Bevan procedure. The advantages of the hypochlorite method are that 12 to 16 determinations per day can be carried out by one worker, and large scale preparations of the cellulose in straws may be made without inconvenience.

VII. A. G. NORMAN. "*The Biological Decomposition of Plant Materials. I. The Nature and Quantity of the Furfuraldehyde-yielding Substances in Straw.*" Biochemical Journal, 1929. Vol. XXIII, pp. 1353-1366.

A method is given for determining the content of hemicelluloses in a plant tissue. Figures quoted for "pentosan" obtained by use of the Krober factor are unreliable because of the hexose and uronic acid groups in the hemicelluloses, and the furfuraldehyde-yielding groups intimately associated with the cellulose. If allowance be made for these and for the pectin present, a valid figure may be obtained for the pentose units of the hemicelluloses. A preparation is then made of the hemicellulose of any tissue and its pentose content determined, thus giving a factor for that material. The nature of the hemicelluloses of oat and rye straws is described and the furfuraldehyde-yielding substance associated with the cellulose in each case, shown to be xylan.

VIII. A. G. NORMAN. "*The Biological Decomposition of Plant Materials. II. The Role of the Furfuraldehyde-yielding Substances in the Decomposition of Straws.*" Biochemical Journal, 1929. Vol. XXIII, 1367-1384.

The course of the decomposition of straws is followed by frequent analyses. The most prominent feature is the rapid loss of cellulose, accounting for the major part of the lost organic matter. There is a marked early loss of hemicelluloses, which is by no means complete, as certain groups are biologically less available. Subject to structural and physical variations, it is agreed that the decomposition of mature plant materials in the presence of assimilable nitrogen depends on the balance between cellulose and the available hemicelluloses on the one hand, and the resistant materials, chiefly lignin, on the other. No evidence exists for stating that the hemicelluloses are of pre-eminent importance as satisfactory decompositions have been observed in the case of straws extracted to be practically hemicellulose-free.

IX. A. G. NORMAN. "*The Biological Decomposition of Plant Materials. Part III. Physiological Studies in some Cellulose-Decomposing Fungi.*" Annals of Applied Biology, 1930. Vol. XVII, pp. 575-613.

Certain fungi were isolated which, though actively attacking cellulose in straws, make only a meagre growth on cellulose agar plates. All had their optimum temperature above that usual for fungal growth; three, indeed, could develop at 50°C. The thermogenic power of the organisms individually was tested on sterile straw. A considerable and rapid rise in temperature was observed in most cases, and some rise in all. The highest temperature attained was 49°C due to *Trichoderma sp.* The period of maximum heat production was shown to correspond closely with that of rapid loss of hemicelluloses. Cellulose decomposition does not appear to result in the production of much heat. Certain combinations of organisms were tested and the theoretical differences between competitive and co-operative association defined.

X. A. G. Norman and F. W. Norris. "*Studies on Pectin. Part IV. The Oxidation of Pectin by Fenton's Reagent and its Bearing on the Genesis of the Hemicelluloses.*" Biochemical Journal, 1930. Vol. XXIV, pp. 402-409.

Pectin readily undergoes oxidation by Fenton's reagent at 30°C, yielding products giving on hydrolysis, galactose and galacturonic acid. These are probably polymers containing mainly galactose-monogalacturonic acid and galactose-digalacturonic acid. The products resemble in appearance and general properties the structural hemicelluloses, and some support is lent to the view that the hemicelluloses may be formed in nature by the protracted mild oxidation of pectin.

XI. A. G. Norman and J. T. Martin. "*Studies on Pectin. Part V. The Hydrolysis of Pectin.*" Biochemical Journal, 1930. Vol. XXIV, pp. 649-660.

Hydrolyses of pectin were carried out with hot dilute alkali and acid, and the rate of hydrolysis followed by analyses. The pectin ring seems peculiarly susceptible to the former and is very rapidly destroyed. Certain dienolic fission products of sugars are formed, and render the determination of the uronic acid content unreliable. In the course of mild acid hydrolysis there is firstly a production of pentose by simple decarboxylation of the uronic groups. Later, degradation products probably of a furan type are formed.

No conclusions as to the arrangement of the units in the pectin molecule, or as to the type of linkage involved can be drawn from hydrolytic studies owing to the production of degradation compounds interfering with analyses.

XII. L. R. Bishop. "*The Proteins of Barley during Development and Storage and in the Mature Grain.*" Journal of the Institute of Brewing, 1930. Vol. XXXVI, pp. 336-349.

The proteins of all varieties of barley behave in a similar regular manner. For each variety studied, the proteins all increase regularly with the total nitrogen content. The rates of increase of the different proteins differ—calculated as a percentage on total nitrogen the percentage of hordein nitrogen increases regularly with increasing total nitrogen content, the percentage of salt-soluble nitrogen decreases correspondingly while the percentage of glutelin nitrogen remains constant. The actual quantities of salt-soluble nitrogen and glutelin nitrogen for any given total nitrogen content differ between different varieties which consequently are characterised by them. This applies only to mature grain. In immature grain the salt-soluble nitrogen is high and the glutelin nitrogen low, a condition which has also been found to occur in partly developed grain.

The formation of the separate proteins has been followed in barley grain as it develops on the plant, and it is concluded that development of the proteins in the barley grain is essentially a synthesis of the simple compounds which enter it up to a definite equilibrium point controlled only by the total nitrogen content and the variety.

XIII. L. R. Bishop. "*The Nitrogen Content and 'Quality' of Barley.*" Journal of the Institute of Brewing, 1930. Vol. XXXVI, pp. 352-364.

An attempt has been made to summarise the factors and properties which are of value in guiding anticipations of the brewing quality of the barley in each season and district.

Soil and season are the most important factors governing yield and quality. Variety and artificial nitrogenous manures have less effect. It is suggested that the most important aspect of soil composition is the absence or presence of organic nitrogenous matter which is regarded as resulting in nitrification in summer which supplies nitrogen late in the plant's life with resultant high nitrogen grain.

These considerations and previously published statistical work on weather effects could be used to guide anticipations of yield and quality of harvest in any district and season.

After harvest judgment of yield and quality can be assisted by a knowledge of the nitrogen content and thousand corn weight from which can be predicted the amount of "extract" on malt acid "permanently soluble" nitrogen in the wort.

XIV. L. R. Bishop. "*The Prediction of Extract.*" Journal of the Institute of Brewing, 1930. Vol. XXXVI, pp. 421-434.

By a statistical study it is established beyond doubt that there is an inverse relation between the nitrogen content of barley of one variety and the extract yield of the resulting malt. An increase of extract with increase of grain size is demonstrated almost as conclusively.

The use of this relation is in assisting the valuation of barley, and in the control of malting operations, for which it is accurate enough to be of considerable value in practice.

XV. E. M. Crowther. "*Note on the Phosphoric Acid of Barley Grain.*" Journal of the Institute of Brewing, 1930. Vol. XXXVI, pp. 349-351.

Determinations of phosphoric acid in barley grain from experimental plots conducted in connection with the Institute of Brewing Research Scheme, showed that the total range of values was rather narrow (0.74 to 1.18 per cent P_2O_5 in dry matter) and not closely connected with other analytical data from the samples. There was evidence that it was slightly increased by phosphatic and slightly decreased by nitrogenous manuring.

XVI. A. W. Greenhill. "*The Availability of Phosphatic Fertilisers as shown by an Examination of the Soil Solution and Plant Growth.*" Journal of Agricultural Science, 1930. Vol. XX, pp. 559-572.

The rate of growth of barley and changes in the phosphate concentration of the soil solution were followed in pots containing an acid soil limed at two rates and comparing slag, superphosphate, and no phosphate treatment. Liming increased the phosphate concentration. The effects of phosphatic fertilisers were somewhat variable; on lightly limed soil they reduced the phosphate concentration. There was no correlation between crop growth and phosphate concentration. It is suggested that barley can take up phosphoric acid directly from the solid particles of soil or fertiliser.

XVII. J. Caldwell. "*A Note on the Dichotomous Branching of the Main Stem of the Tomato* (*Lycopersicum esculentum*)." Annals of Botany, 1930. Vol. XLIV, pp. 495-498.

Occasionally in the experimental material it was noticed that plants appeared having dichotomously branched stems. One of these is described in this note. It is shown that the arrangement of the leaves indicates that the bifurcation is of the main stem and not axillary in origin. The stelar tissue divides exactly into two—one half going to each of the limits of the fork.

STATISTICAL METHODS AND RESULTS

(Statistical Departments)

(*a*) General

XVIII. F. E. Allan. "*The General Form of the Orthogonal Polynomials for Simple Series, with Proofs of their Simple Properties*." Proceedings of the Royal Society of Edinburgh, 1930. Vol. L, pp. 310-320.

In "Statistical Methods for Research Workers." R. A. Fisher has given a numerical method of polynomial fitting by means of orthogonal functions, developed from their terminal differences. It is shown here that the use of terminal differences may be made to supply direct and simple proofs of the algebraic properties of these polynomials, and a general formula for them.

XIX. F. E. Allan. "*A Percentile Table of the Relation between the True and the Observed Correlation Coefficient from a Sample of Four*." Proceedings of the Cambridge Philosophical Society, 1930. Vol. XXVI, pp. 536-537.

In this paper a table is furnished, for samples of four, of the 95 per cent values of the transformed correlation, z, for different values of the correlation ζ in the population sampled. The table is based on the distribution of the correlation coefficient given by R. A. Fisher in 1915.

XX. R. A. Fisher. "*Moments and Product Moments of Sampling Distributions*." Proceedings of the London Mathematical Society, 1929. Vol. XXX, Series 2, pp. 199-238.

Much previous work has been expended in studying the distributions of various symmetric functions of the sample values of a variate having a known distribution, and it has been recognised that the moment functions of such statistics must be expressible in terms of the moment functions of the distribution sampled.

Only a few such expressions had, however, been obtained with exactitude, and the great complexity of these gave little promise of a solution of the general problem. It is here shown that, when the Pearsonian moments are replaced by more suitable statistics, the expressions are greatly simplified and may be obtained by a direct algebraic method. Further their general form may be derived in terms of combinatorial analysis by the use of two-way partitions, and certain pattern formulae which are the same alike for uni-variate and multi-variate problems. Rules are given, with a general demonstration, by which any particular term of any of these formulae may be obtained independently. The paper contains a table of the pattern formulae of most frequent occurrence, and a table of all the uni-variate formulae required up to the 10th degree, together with a few others of special importance. From these all the corresponding multi-variate formulae may readily be derived.

XXI. R. A. FISHER. "*The Sieve of Eratosthenes.*" The Mathematical Gazette, 1929. Vol. XIV, pp. 564-566.

The note suggests that the celebrated sieve of Eratosthenes has been misunderstood through lack of recognition of the fact that its author probably had in mind not a method of testing whether any particular number is a prime, but a labour-saving device for finding all the primes in a given range of natural numbers.

It is pointed out that a very simple diagrammatic method of doing this has in fact much the appearance of a wicker sieve, and it is suggested that the sieve connected with Eratosthenes' name was in fact a wall diagram of this sort.

XXII. R. A. FISHER. "*Inverse Probability.*" Proceedings of the Cambridge Philosophical Society, 1930. Vol. XXVI, pp. 528-535.

That the principle of inverse probability includes an arbitrary and unsatisfactory element has been recognised by many writers; but their criticism has failed to settle the controversy, since they have supplied no alternative account in mathematical terms of the process of learning by experience.

This paper briefly summarises the author's view that confusion has arisen through assuming that mathematical probability is the only measure of rational belief, and is applicable to all kinds of uncertain knowledge. It is suggested that from knowledge of a population we can express our incomplete knowledge of a sample in terms of probability, whereas knowing a sample we must express our incomplete knowledge of the population in terms of a different mathematical quantity, termed *likelihood*, which does not obey the laws of probability.

There are, however, certain cases in which statements in terms of probability can be made with respect to unknown populations. These are the typical statements of tests of significance, and the logical distinction between these and the statements of inverse probability, to which they bear a superficial resemblance, is examined.

XXIII. J. O. IRWIN. "*On the Frequency Distribution of the Means of Samples from Populations of Certain of Pearson's Types.*" Metron, 1930. Vol. VIII, pp. 1-55.

In a previous paper the author has given a general solution for the frequency distribution of the means of samples of any size, drawn at random from any population whatever, expressed as a definite integral. The present paper applies this solution to the particular cases of Pearsonian Type I and Type VII curves for integral values of the exponents p and q, which enter into the equation of the Type I curve, and of the exponent m which enters into the equation of the Type VII curve.

The cases $p = 1, 2, 3, 4, q = 1, 2, 3, 4$ are discussed in detail for samples of size 2, 3 and 4 from Type I populations, as are the cases $m = 2, 3, 4$ from samples of size 2, 3 and 4 from Type VII populations. For the Type VII populations the cases $m = 1$ for any size of sample, and $m = 5, 6, 7, 8$ for samples of 2 have also been considered in detail.

XXIV. H. G. Sanders. "*A Note on the Value of Uniformity Trials for Subsequent Experiments.*" Journal of Agricultural Science, 1930. Vol. XX, pp. 63-73.

The question attacked is whether soil variations are sufficiently constant from year to year to give useful corrections to the yields of experimental plots from their yields under previous uniformity trials, and the data investigated were the published results of uniformity trials carried out on two fields at Aarslev (Denmark) between 1906 and 1911. In one case the plots did tend to keep constant in their relative yields, and the precision of an experiment would be increased by nearly 150 per cent, if the regression on the mean yield in the three previous years were used ; with the other field, however, the plots showed no constancy in yield (when the variation due to strips was taken out as in modern experimental methods), and consequently previous uniformity trials could give no assistance.

XXV. J. Wishart. "*The Derivation of Certain High Order Sampling Product Moments from a Normal Population.*" Biometrika, 1930. Vol. XXII, pp. 224-238.

In a recent paper on the derivation of moments and product moments of sampling distributions, R. A. Fisher dealt among other things with measures of departure from normality, and gave approximate expressions for the semi-invariants of these statistics. If a higher degree of approximation is desired, further high order product moments are required, and these are deduced in this paper, while certain simple relations existing between the formulae, which will be demonstrated elsewhere, are stated, for sampling from a normal population, thus enabling the high order results to be derived from simple expressions already known.

(*b*) Genetics

XXVI. R. A. Fisher. "*The Evolution of Dominance ; Reply to Professor Sewall Wright.*" The American Naturalist, 1929. Vol. LXIII, pp. 553-556.

The calculations which led Professor Sewall Wright to consider that the selective intensities available for the modification of dominance, are insufficient to have brought about great results are, in a different notation, identical with those that originally led the author to attach importance to them. A slight mathematical error has, however, led Professor Wright in the special case chosen for examination, to the conclusion that the selective intensity starting from a low value decreases continuously, whereas in reality, it increases in that case without limit. The conclusion that mutations have had time to become in many cases completely recessive can only be rejected by assuming that small selective intensities do not bring about effects proportional to their magnitude. Although it is inevitably impossible to demonstrate extremely slow processes experimentally, yet there are general reasons for concluding that there is no such restriction upon such small selective intensities as Professor Wright is obliged to postulate.

XXVII. R. A. FISHER. "*The Evolution of Dominance in Certain Polymorphic Species.*" The American Naturalist, 1930. Vol. LXIV, pp. 385-406.

Polymorphism in wild populations must usually imply a balance of selective agencies, of which the simplest type is a selective advantage of the heterozygote over both homozygotes. Such a condition should not be confused with the maintenance of a rare mutant type against counter-selection by means of repeated mutations. While such mutations should, on the theory of the selective modification of dominance, tend to become recessive, heterozygotes in polymorphic species will tend to resemble in external appearance whichever homozygote it is most advantageous to resemble. The selective balance must then be maintained by some constitutional disadvantage of the homozygous dominant.

Nabours' experiments with the grouse locust *Apotettix* do, in fact, show such a deficiency of homozygous dominants as is required by this thoery. The average amount of the deficiency is about 7 per cent. In six individual cases the deficiency is statistically significant, and six more show a non-significant deficiency, against two showing a non-significant excess.

The incidence of dominance and linkage in the fish *Lebistes reticulatus* strongly suggests that the colour genes found by Winge are advantageous in the male, but disadvantageous in the female.

The association of the three peculiarities of polymorphism, close linkage and the universal recessive type of dominance is found in molluscs, arthropods and vertebrates. It is tentatively suggested that, at least in the grouse locusts and the snails, the primary cause of the two other phenomena may be found in the closeness of linkage within or between chromosomes. This condition presents an obstacle to normal evolutionary development by gene substitution, and so makes it possible for abnormalities such as duplications to possess occasional advantages, so setting up the stability if the gene-ratio necessary for polymorphism ; if the advantage lies in the external appearance, the polymorphism will be manifest, and the variant form will tend to become dominant.

XXVIII. R. A. FISHER. "*Note on a Tri-Colour (Mosaic) Mouse.*" Journal of Genetics, 1930. Vol. XXIII, pp. 77-81.

The occurrence is reported of a female mouse showing both black and chocolate markings. Only one such case has occurred out of about 1,500 blacks heterozygous for chocolate, bred in the same colony. Mating with a chocolate son gave 30 chocolates, 16 blacks and no tri-colours. The case resembles that of a male guinea-pig reported by Wright and Eaton, which also shows a deficiency of heterozygous offspring. The most probable explanation of both cases is that we have a mosaic, both somatically and in the germinal tissue, originating in non-disjunction. Some apparently analogous cases in mice and rabbits point, however, to a different interpretation for these cases.

XXIX. R. A. FISHER. "*The Distribution of Gene Ratios for Rare Mutations.*" Proceedings of the Royal Society of Edinburgh, 1930. Vol. L, pp. 204-220.

The discussion of the distribution of the gene ratio of the author's paper of 1922 is amended by the use of a more exact form of the differential equation to be satisfied. A method of functional equations is developed for dealing with the termini, and is shown to lead to the same solutions as the amended differential equations, in the central portion of the range, for which the latter are valid, and further to give the terminal distribution of rare allelomorphs. The method requires the investigation of a continuous function u_v, of argument v, satisfying the recurrence formula

$$u_{v+l} = e^{u_v - l}$$

From the asymptotic form of this function its expansion in the neighbourhood of $u=o$ is derived, giving the frequencies of the required distributions.

Exceedingly minute values for the selective advantage or disadvantage make a great difference to (i) the chance of success of a mutation, and (ii) the contribution of such mutations to the specific variance. The order of magnitude to be considered is the inverse of the population of the species. The neutral zone of selective advantage in the neighbourhood of zero is thus so narrow that changes in the environment, and in the genetic constitution of species, must cause this zone to be crossed and perhaps recrossed relatively rapidly in the course of evolutionary change, so that many possible gene substitutions may have a fluctuating history of advance and regression before the final balance of selective advantage is determined.

XXX. J. B. HUTCHINSON. "*The Application of the 'Method of Maximum Likelihood' to the Estimation of Linkage.*" Genetics, 1929. Vol. XIV, pp. 519-537.

The "Method of Maximum Likelihood," developed by Dr. R. A. Fisher, is applied to the problem of estimating linkage in cases involving complementary and duplicate factors.

Variances are calculated for existing formulae, and their efficiencies are determined to show that the "Method of Maximum Likelihood" is in all cases superior to any other method of estimation.

The amount of information supplied per plant by Maximum Likelihood formulae for F_2's and backcrosses, and by other formulae for F_2's is calculated and compared with the amount of information supplied per plant by a simple—that is, completely classified—backcross. From figures 2, 3 and 4 of this paper it is possible to estimate the size of family necessary to give any required degree of accuracy.

THE SOIL

(Chemical and Physical Departments)

(a) General

XXXI. E. M. Crowther. *"The Relationship of Climatic and Geological Factors to the Composition of Soil Clay, and the Distribution of Soil Types."* Proceedings of the Royal Society (B), 1930. Vol. CVII, pp. 1-30.

An attempt has been made to separate the effects on soil formation of quantitative climatic factors (mean annual rainfall and temperature) and a qualitative geological grouping by the examination of American data for the composition of colloidal clay, using a statistical method which is capable of application to other geographical and ecological problems. Earlier contradictory statements on the relation of temperature to the composition of the clay fraction are shown to depend on a failure to recognise the positive correlation of rainfall and temperature over the greater part of U.S.A. The ratio of silica to alumina in the clay fraction is now shown to be correlated negatively with rainfall and positively with temperature, and the relative effects are such that for similar parent materials constant SiO_2/Al_2O_3 ratios are found when an increase of mean annual temperature of 1°C is accompanied by an increase of 4 cms in annual rainfall. It is suggested that this factor provides a rough measure of the joint action of rainfall and temperature on drainage and leaching in soils. The relative effects on clay of rainfall and temperature on clay composition are closely parallel to their effects on the amount of drainage in Rothamsted lysimeter experiments, if the mean monthly values of the latter be regarded as samples of different climates.

If the average rainfall and temperature factors are used to calculate the contribution of soil clay in the representative and essentially immature American soils studied by Robinson and Holmes, increasingly siliceous clays are obtained as the parent material changes through the series: hard rocks, alluvium from hard rocks, limestone, marine deposits, glacial and loessial deposits, alluvium from loess. This is roughly according to the amount of reworking in water. Highly siliceous clays may be produced either in arid climates or from repeatedly reworked material in humid ones.

A statistical attempt has been made to deduce the relative importance of rainfall and temperature in soil formation from the distribution of established soil types in U.S.A. Among Marbut's Pedocals rainfall is the more important factor but among his Pedalfers temperature is more closely correlated with the distribution of soils.

The iron-aluminium ratio of the colloidal clay changes in characteristic manner through the soil profile and it appears that its fuller examination may provide a more definite criterion for distinguishing between types of leached soils.

(*b*) Mechanical Analysis

XXXII. B. A. KEEN AND R. K. SCHOFIELD. "*Formation of Streamers in Sedimentation.*" Nature, 1930. Vol. CXXVI, pp. 93-94.

A discussion is given of the system proposed by C. E. Marshall for mechanical analysis of clays with the aid of a high-speed centrifuge. The method consists essentially in pouring a thin layer of aqueous clay suspension on the top of a sugar solution. The streamers which form when this system is left under the influence of gravity, are attributed to the formation of a clay laden layer of sugar solution immediately below the aqueous layer. This layer, having a greater density than the solution below, breaks up and streams downwards. The authors inquire whether this phenomenon may not render invalid Marshall's calculation, in which it is supposed that the particles sediment individually through the sugar solution.

(*c*) Physical Properties

XXXIII. B. A. KEEN "'*Single Value' Soil Properties. A Study of the Significance of Certain Soil Constants. IV. A Further Note on the Technique of the 'Box' Experiment.*" Journal of Agricultural Science, 1930. Vol. XX, 414-416.

Experiments on the effect of impacts on the amount of precipitated silica that can be packed into a Keen-Raczkowski box, suggest that, like the weight per unit volume, the "swelling" is a function of the degree of packing to which the material is subjected during the filling of the box. Further, the fact that such inert material as precipitated silica can show a "swelling" when saturated with moisture, raises the question as to how far imbibitional moisture is concerned in the volume expansion of soil.

XXXIV. W. B. HAINES. "*Studies in the Physical Properties of Soil, V. The Hysteresis Effect in Capillary Properties, and the Modes of Moisture Distribution associated therewith.*" Journal of Agricultural Science, 1930. Vol. XX, pp. 97-116.

A further study is made of water distribution in an ideal soil by means of carefully piled bronze balls and paraffin oil. A distinction is drawn between the conditions of rising and falling "moisture." For falling moisture the pressure deficiency, for which the meniscus can retreat into the internal cellular structure, is in the neighbourhood of 12 T/r, while for rising moisture the liquid can return whilst still under a pressure deficiency of 6.9 T/r. An examination of water equilibrium in "glistening dew," forms a link with the behaviour of soil, and the investigation illustrates the importance of hysteresis in capillary properties of soil.

XXXV. 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.*" Journal of Physical Chemistry, 1930. Vol. XXXIV, pp. 248-262.

If, in considering the flow of a plastic material through a narrow tube, it be assumed that the velocity gradient at any point depends only on the stress at that point, it necessarily follows that the mean velocity for a given stress at the wall of the tube should be directly proportional to the radius of the tube. Although thick soil pastes conform closely to this requirement, thinner pastes, whether they show rigidity or not, give marked discrepancies. These discrepancies can be accounted for by assuming that in the immediate proximity of the wall a modification of the plastic properties occurs, which imparts an additional velocity to the bulk of the material. By first subtracting this velocity a viscosity constant is obtained, independent of the dimensions of the tube.

XXXVI. G. W. SCOTT BLAIR. "*A Further Study of the Influence of the Proximity of a Solid Wall on the Consistency of Viscous and Plastic Materials.*" Journal of Physical Chemistry, 1930. Vol. XXXIV, pp. 1505-1508.

In a previous paper (R. K. Schofield and G. W. Scott Blair) it had been shown that in order to account for the flow properties of clay pastes, an anomalous region must be postulated in the neighbourhood of the wall of the tube through which the paste is caused to stream. It was assumed that this layer was relatively thin, and a single correction is made for its effect in the modified Poiseuille formula used. In this paper the modified layer is accorded a separate term in the integration, assuming for it consistency constants differing from those of the bulk of the material. The earlier "correction" term is then expressible in terms only of these consistency constants (modified and normal); of the thickness of the modified layer; and of the radius of the tube.

(*d*) Soil Cultivation

XXXVII. B. A. KEEN AND THE STAFF OF THE SOIL PHYSICS DEPARTMENT. "*Studies in Soil Cultivation. V. Rotary Cultivation.*" Journal of Agricultural Science, 1930. Vol. XX, pp. 364-389.

Experiments in rotary cultivation extending over four years (1926-1929) yielded the results that with spring-sown crops—swedes and barley—rotary cultivation gives earlier and better germination and better early growth. In every experiment, however, the final yield has either been no better or else significantly below that obtained for the plots cultivated in the usual way. Meteorological factors exercise a predominating influence—the implement used being only secondary. Rotary cultivation appears to be most effective on an unkindly soil. Sieving measurements show that it does not produce an appreciably finer tilth than the usual imple ments, but leaves the soil initially in a much looser condition.

(*e*) Physical Chemistry

XXXVIII. E. M. CROWTHER AND S. G. HEINTZE. "*Report of the Soil Reaction Committee of the Interna tional Society of Soil Science.* I. *Results of Comparative Investigations on the Quinhydrone Method. II. Conclusions and Recommendations.*" Soil Research, 1930. Vol. II, pp. 28-139, 141-152.

This is the report of a Committee set up at Budapest in 1929 as a result of criticism of the standard quinhydrone method for soil reaction measurements made by S. G. Heintze and E. M. Crowther (Paper

XVIII, Report, 1929, p. 58) and others. Comparative determinations in seven laboratories confirmed the conclusions that in many common soils the quinhydrone method may give quite erroneous results. It was recommended that a rapid preliminary test of the suitability of the soil for the quinhydrone technique should precede all precise measurements. In a special section of Part I, E. M. Crowther and S. G. Heintze bring forward additional evidence that the errors are due to the reduction of manganese dioxide to an alkaline product.

(*f*) Soil Organic Matter

XXXIX. H. J. PAGE. "*Studies on the Carbon and Nitrogen Cycles in the Soil. I. Introductory.*" Journal of Agricultural Science, 1930. Vol. XX, pp. 455-459.

The term "humic matter" is defined as the dark coloured, high molecular, colloidal organic matter which is a characteristic constituent of the soil, and "non-humic matter" includes colourless chiefly soluble organic substances and undecomposed plant residues.

XL. C. W. D. ARNOLD AND H. J. PAGE. "*Studies on the Carbon and Nitrogen Cycles in the Soil. II. The Extraction of the Organic Matter of the Soil with Alkali.*" Journal of Agricultural Science, 1930. Vol. XX, pp. 460-477.

Although the total organic carbon in the soils of various plots of the classical permanent experiments at Rothamsted receiving, respectively, organic, artificial and no manures, varied between 0.81 and 2.91 per cent, and in the subsoils between 0.54 and 1.04 per cent of the oven dry samples, there was a marked similarity between the properties of their organic matter, especially in its behaviour on extraction with cold and hot dilute caustic code. Colorimetric examinations of the extracts indicate that the organic carbon of the surface soils is more deeply coloured than that of the corresponding subsoils, that the organic carbon is most deeply coloured in extracts from surface soils receiving annual dressings of dung, and that that from subsoils of plots receiving no manure is least coloured.

XLI. H. M. S. DU TOIT AND H. J. PAGE. "*Studies on the Carbon and Nitrogen Cycles in the Soil. III. The Formation of Natural Humic Matter.*" Journal of Agricultural Science, 1930. Vol. XX, pp. 478-488.

Decomposition experiments in which soil extracts and nutrient salts were added to plant materials such as wheat straw, clover hay, maize cobs and pine sawdust, and to purified preparations of plant constituents, including lignin, cellulose, xylan, xylose, potato starch, dextrose and protein in the form of commercial blood fibrin, indicate that the formation of humic matter is more closely related to the change in lignin content of the original material than to the change in content of any other groups of plant constituents estimated.

(*g*) Analytical

XLII. R. G. Warren and A. J. Pugh. "*The Colorimetric Determination of Phosphoric Acid in Hydrochloric Acid and Citric Acid Extracts of Soils.*" Journal of Agricultural Science, 1930. Vol. XX, pp. 532-540.

The existing macromethods for the determination of phosphoric acid in soils are unsuitable for large numbers of analyses as the time and labour involved are excessive, especially for such empirical determinations as "Available Phosphoric Acid," by means of citric acid. Further in certain cases these methods are not free from serious errors. These disadvantages have prevented extensive work on soil phosphorus and attention has therefore been given to the application of colorimentric methods so that analyses may be made rapidly.

Accurate colorimetric determination of phosphoric acid in soil extracts demands not only the absence of large amounts of silica and organic matter, and a controlled acidity for development of colour, but also the absence of ferric iron. To satisfy these conditions a method was devised in which the organic matter, including citric acid, was oxidised by sodium permanganate in hydrochloric acid solution. Silica was only removed from solution for soils that contained less than .02 per cent P_2O_5 soluble in hydrochloric acid. Ferric iron was precipitated with potassium ferrocyanide, and the excess which would redissolve the iron and cause interference during colour development, was removed by ensuring the presence of sufficient manganese. Finally, the acidity was adjusted by utilising the blue to purple colour change of the precipitated ferrocyanide instead of an added indicator. Two colorimetric methods, Deniges and Fiske-Subbarow, were applied to solutions prepared in this way, and good agreement was obtained with the gravimetric method. In this method lengthy operations such as quantitative filtration, evaporation and ignition of organic matter were eliminated or reduced to a minimum.

Correction to above paper. On p. 539, l. 5, should read: "Rinse into a 1 litre graduated flask containing 500 cc. of 10 N sulphuric acid."

THE SOIL POPULATION AND ITS BEHAVIOUR

(Bacteriological and General Microbiological Departments)

XLIII. H. G. Thornton. "*The Influence of the Host Plant in Inducing Parasitism in Lucerne and Clover Nodules.*" Proceedings of the Royal Society (B), 1930. Vol. CVI, pp. 110-122.

The formation of fresh nodules upon inoculated lucerne seedlings placed in the dark soon ceases, and there is a cessation of cell division throughout the root. The bacteria become parasitic upon the host tissues. In old nodules on lucerne and clover plants growing in the light, the bacteria behave similarly. Bacteria from the original infection thread invade the nodule tissue, causing it to disintegrate. It is suggested that lack of carbohydrate is the basal factor in both conditions. When the air supply to lucerne seedlings growing in agar is limited, the nodules do not function normally but, carbohydrate supply not being the limiting factor, the host tissue is not then injured.

XLIV. H. G. THORNTON. "*The Early Development of the Root Nodule of Lucerne* (*Medicago sativa, L.*)." Annals of Botany, 1930. Vol. XLIV, pp. 385-392.

Bacteria infect the root hairs, the infection threads passing into the cortex without invading the central cylinder of the root. Cell division is thereby induced. The infection threads, naked at their growing points, tend to swell into zoogleal masses. In the older portions of the thread, a sheath is formed round them continuous with the wall of the host cell. The zoogleal masses remain unsheathed and release bacteria into the host cytoplasm. Division of the host cells ceases by the time the infection thread sheath is formed. The host cells are apparently uninjured by the bacteria save in old nodule tissue.

XLV. H. G. THORNTON AND P. H. H. GRAY. "*The Fluctuations of Bacterial Numbers and Nitrate Content of Field Soils.*" Proceedings of the Royal Society (B), 1930. Vol. CVI, pp. 399-417.

Samples of field soil were taken at two hourly intervals. Fluctuations in bacterial numbers greatly exceeding the variation in bacterial content of simultaneous samples, were found to occur by day and by night. To reduce sampling errors, a plot of soil was specially prepared, and in soil from this plot significant fluctuations in bacterial numbers were found, greatly exceeding the variation between simultaneous samples. The maximum count usually occurred about 10 a.m. No correlation between the changes in bacterial numbers of soil moisture content was found ; correlations of bacterial numbers with rainfall soil temperature, and nitrate content of soil, were doubtful. Results were examined statistically, and the methods of statistical analysis are given in full in the paper.

XLVI. H. L. JENSEN. "*Decomposition of Keratin by Soil Micro-organisms.*" Journal of Agricultural Science, 1930. Vol. XX, pp. 390-398.

Keratin, prepared from horn meal, added to moist soil and allowed to decompose in the laboratory, was found to undergo a decomposition resulting in a slow accumulation of ammonia and nitrate. The addition of keratin produced no significant increase in the number of bacteria able to grow on agar, but markedly increased the number of actinomycetes, especially in garden soil. Two strains of actinomycetes were isolated and found capable of thriving in pure culture on keratin and forming ammonia therefrom.

XLVII. A. KALNIŅŠ. "*Aerobic Soil Bacteria that Decompose Cellulose.*" (With summary in Latvian.) Latvijas Universitātes Raksti, Lauksaimniecibas Fakultātes, Serija I, 1930. Vol. XI, pp. 221-312.

A number of aerobic bacteria that decompose pure cellulose, have been isolated from 28 samples of English soils. Forty-eight strains are described. All except one are widely distributed in English soils and appear to belong to new species. The conditions of growth have been studied in considerable detail It was found that the organisms can derive energy from other carbohydrates besides cellulose. One species, *Bacterium protozoides*, was able to produce a substance resembling glucose from cellulose in quantities up to 30 per cent of the original cellulose.

XLVIII. Jane Meiklejohn. "*The Relation between the Numbers of a Soil Bacterium and the Ammonia produced by it in Peptone Solutions; with Some Reference to the Effect on this Process of the presence of Amoebae.*" Annals of Applied Biology, 1930. Vol. XVII, pp. 614-637.

Using a soil bacteria "YB" alone in liquid cultures, an inverse linear relation was found between bacterial numbers and efficiency, and the greatest rate of production of ammonia was found to correspond to a bacterial content of about 500 million per cc.; the rate was lowered by any increase in numbers above this figure.

A greatly increased lag period was observed as a result of diluting the inoculum ten times.

Comparing a soil protozoo an *Hartmanella* and "YB" against "YB" alone in sand cultures, it was found that the presence of the amoebae, while lowering the bacterial numbers, seemed to increase the rate of ammonia production.

THE PLANT IN DISEASE; CONTROL OF DISEASE

(Entomological, Insecticides and Fungicides, and Mycological Departments)

(*a*) Insect Pests and Their Control

XLIX. H. F. Barnes. "*On the Biology of Gall-Midges affecting Meadow Foxtail Grass.*" Annals Applied Biology, 1929. Vol. XVII, pp. 339-366.

Three midges do serious damage to the seeding of meadow foxtail grass; they are *Dasyneura alopecuri* (Reuter). *Stenodiplosis geniculati* (Reuter) and *Contarinia merceri* n. sp. All three occur almost wherever the grass is grown. "Blindness" or empty husks in meadow foxtail grass is due very largely to attacks of *C. merceri*, which midge does the most extended damage. Keys are given for the separation of larvae, pupae and adults. Control measures are discussed and a method of keeping sheep on the grass until a certain safety date, *i.e.*, a date when the crest of emergence of the female midges is over, is strongly advocated in districts where the bionomics is known.

L. H. F. Barnes. "*Unisexual Families in Rhabdophaga heterobia.*" The Entomologist's Monthly Magazine, 1929. Vol. LXV, pp. 256-257.

Describes experimental observations showing that unisexual families occur in this midge. This feature is extremely rare among animals with bisexual reproduction and the facts recorded are comparable with Metz's work dealing with various species of *Sciara*.

LI. H. F. Barnes. "*A New Thrips-Eating Gall Midge, Thripsobremia liothripis, Gen. et. sp. n. (Cecidomyidae).*" Bulletins of Entomological Research, 1930. Vol. XXI, pp. 331-332.

This new species of gall midge is described from material received from Trinidad by the Imperial Institute of Entomology. Its larvae are predaceous upon *Liothrips urichi* Karny, a species of thrips living upon the Melastomaceous plant, *Clidemia hirta*.

LII. H. F. BARNES. "*On Some Factors Governing Emergence of Gall-Midges.*" Proceedings of the Zoological Society, 1930. Part II, pp. 381-393.

The times of emergence of about 100,000 individual midges has been investigated under several environmental conditions, including those in which both light and temperature have been varied. The effect of extra heat, while causing earlier than normal emergence, decreases the percentage emergence, while that of extra cold is less marked. Hymenopterous parasites appear to be less affected by cold than their host midges. It is suggested that variation in the relative times of emergence of hosts and parasites, due to differential weather effects, causes sudden marked fluctuations in degree of parasitism.

LIII. H. F. BARNES. "*On the Resistance of Basket Willows to Button Gall Formation.*" Annals Applied Biology, 1930. Vol. XVII, pp. 638-640.

A preliminary account of experiments showing that different varieties of basket willow show different degrees of susceptibility to attack by the midge *Rhabdophaga heterobia*. Whereas the variety " Harrison " showed complete immunity from attack through three generations of the insect in question, five other varieties tested all proved to be heavily attacked.

LIV. H. F. BARNES. "*Gall Midges (Cecidomyidae Dipt.,) as Enemies of Aphids.*" Bulletin of Entomological Research, 1929. Vol. XX, pp. 433-442.

Vague statements have been made that in certain outbreaks Aphids have been controlled by the larvae of gall midges, but no exact proofs based on counts of the number of Aphids killed, the fecundity of the midge compared with that of the Aphid, the appetite of the midge larvae, etc., have been given. With a view to stimulating research along these lines, the species of Cecidomyidae, of which the larvae have been reported, as prey on or parasitising Aphids are enumerated, and an alphabetical list is given of the Aphids attacked by midge larvae (where the Aphid has not been identified, its food-plant is substituted).

LV. H. F. BARNES. "*Gall Midges (Cecidomyidae) as Enemies of the Tingidae, Psyllidae, Aleyrodidae and Coccidae.*" Bulletin of Entomological Research, 1930. Vol. XXI, pp. 319-329.

This paper is the second of a series on the zoophagous Cecidomyids of the world. An annotated list is given of the Cecidomyid larvae that have been reported to prey on Tingids, Psyllids, Aleurodids and Coccids, as well as alphabetical lists of the latter insects showing the Cecidomyids attacking them and the country in which the observations were made.

LVI. E. E. Edwards. "*On the Morphology of the Larva of 'Dorcus Parallelopipedus.'*" Journal of the Linnean Society of Zoology, 1930. Vol. XXXVII, pp. 93-108.

Describes the detailed external morphology of this type and the salient features connected with the digestive and nervous system. Apart from other characters the larva of *Dorcus* can be separated from those of other genera of European Lucanidae by the form and arrangement of the tubercles composing the coxal and trochanteric stridulatory areas. In its digestive system it exhibits affinities with the Scarabaeidae, while the nervous system is of a primitive type approaching that of *Lucanus*. The Malpighian Tubes are exceptional in that their distal extremities are confluent in pairs and assume, in consequence, a looped condition.

LVII. A. D. Imms. "*Observations on some Parasites of Oscinella frit. Part I.*" Parasitology, 1930. Vol. XXII, pp. 11-36.

Describes two years' observations and experiments with reference to the natural infestation of the stem generation of the frit fly by parasites. Four species of parasites were found to attack this host, one of which, *Callitula bicolor*, was previously unknown in this relation. Owing to these several species being little known, and in order to establish their identity as clearly as possible, detailed descriptions are provided and their morphological characteristics fully illustrated. During the two years in which the investigations were carried out, the total destruction of frit fly in Harpenden plots by parasites amounted to 27 per cent in 1926, and 37 per cent in 1927. Evidence afforded by field plot experiments showed that the parasites, collectively, become more abundant as the season advances with the result that frit fly, affecting late sown oats, suffers markedly heavier mortality from parasites than when it attacks oats drilled earlier in the season.

LVIII. D. M. T. Morland. "*On the Causes of Swarming in the Honey Bee (Apis mellifica); an Examination of the Brood Food Theory.*" Annals Applied Biology, 1930. Vol. XVII, pp. 137-149.

The influence of nitrogenous food is discussed in its bearing on the question of swarming and theories of the origin of the brood-food are examined. The division of labour among bees of various ages is considered in its relation to the brood-rearing cycle. A critical surplus of nurse bees is found to be associated with the formation of queen cells in preparation for swarming, and in this connection swarm control measures are reviewed and also in relation to the brood-food theory.

(*b*) Fungus Pests and Their Control

LIX. Mary D. Glynne. "*A Note on Some Experiments dealing with Sulphur Treatment of a Soil and its Effect on Wheat Yield.*" Proceedings of the Royal Society (Victoria), 1929. Vol. XLII, pp. 30-35.

Sulphur and sulphur derivatives were applied to Australian soil reported to be too badly infested with disease-causing fungi to support more than a very poor crop of wheat. Remarkable increases in crop up to 821 per cent increase over controls were obtained.

Disease appeared no more common in controls than in untreated plots suggesting a soil deficiency supplied by the treatment. This might be a deficiency of sulphur, of some element or compound set free in the soil or of something supplied by micro-organisms influenced by the treatment. A stimulation of nitrogen fixing organisms is suggested. Soil acidity also received consideration.

LX. W. A. ROACH. "*Sulphur as a Soil Fungicide against the Potato Wart Disease Organism.*" Journal of Agricultural Science, 1930. Vol. XX, pp. 74-96.

Thiosulphuric acid has been shown to exist in a free state. It is relatively stable in dilute solution ; an M/200 solution is only half decomposed at the end of one day, and an M/400 solution at the end of ten days only.

This degree of stability is sufficient to account for the fungicidal action of acidified thiosulphate solutions in terms of the liberated thiosulphuric acid.

It can be calculated that it is only necessary to assume 6 per cent of the minimum quantity of sulphur found effective against wart disease in the field to be in the form of thiosulphuric acid over a period of ten days in order to account for its toxicity.

Experiments of a preliminary nature carried out on sulphur-treated soil, proved the formation of pentathionate in Rothamsted soil kept at 30°C., but not in Ormskirk soil kept at the same temperature, nor in either soil at the lower temperatures of 0° and 15°C.

No definite evidence of the accumulation of appreciable quantities of thiosulphuric acid in the soil was obtained, but reasons are given why this negative evidence is by no means final.

Chemical considerations and the work of others suggest that the pentathionate actually identified in the soil solution arose from the thiosulphuric formed in an early stage of the oxidation of the sulphur.

The explanation of the fungicidal action of sulphur towards wart disease in soil in terms of the formation of thiosulphuric acid is alone in harmony with the ascertained facts.

(*c*) Bacterial Diseases

LXI. R. H. STOUGHTON. "*The Morphology and Cytology of 'Bacterium Malvacearum' E.F.S.*" Proceedings of the Royal Society, 1929. Vol. CV, pp. 469-484.

Bacterium malvacearum, the causal organism of the "Black Arm" disease of cotton, has been found to possess certain internal structures and a variety of different morphological forms. An internal structure is described, which passes through a division-cycle and is suggestive of a nucleus. Small granules are described, which are found in the wall of the cell and freed by a process of extrusion. These bodies resemble the "gonidia" of other writers. The occurrence and mode of formation of spherical coccus-like bodies is described. Various a-typical forms are found to occur in old cultures.

LXII. R. H. Stoughton. "*The Relation of Environmental conditions to Angular Leaf-Spot Disease of Cotton, 'Bacterium Malvacearum' E.F.S.*" Annals of Applied Biology, 1929. Vol. XVI, pp. 188-189.

An account of experiments carried out in a small experimental chamber, showing that temperature and humidity are interrelated factors in their effect on disease. An abstract of a paper read to the Association of Economic Biologists.

LXIII. R. H. Stoughton. "*Apparatus for the Growing of Plants in a Controlled Environment.*" Annals of Applied Biology, 1930. Vol. XVII, pp. 90-106.

An account of the construction of tanks and chambers for the growing of plants under independently controlled conditions of soil temperature, air temperature and air humidity. Artificial illumination is provided by two floodlights, one over each chamber.

LXIX. R. H. Stoughton. "*Thionin and Orange G for the Differential Staining of Bacteria and Fungi in Plant Tissues.*" Annals of Applied Biology, 1930. Vol. XVII, pp. 162-164.

An account of a new and simple method of differentially staining fungal and bacterial parasites in plants.

LXV. R. H. Stoughton. "*The Influence of Environmental Conditions on the Development of the Angular Leaf-Spot Disease of Cotton. II. The Influence of Soil Temperature on Primary and Secondary Infection of Seedlings.*" Annals of Applied Biology, 1930. Vol. XVII, pp. 493-503.

Using the apparatus described in the previous paper it is found that the amount of primary infection of seedlings raised from infected seed decreases at soil temperatures above 30°C., but infection is not inhibited at 40°C. Soil temperature has little or no effect on secondary infection resulting from spray inoculation of the leaves.

(*d*) Virus Diseases

LXVI. J. Caldwell. "*The Physiology of Virus Diseases in Plants. I. The Movement of Mosaic in the Tomato Plant.*" Annals of Applied Biology, 1930. Vol. XVII, pp. 429-443.

A method is described whereby it is shown that the virus agent in an infeated area of a plant does not travel across dead tissue even in the water stream; but can pass over if a bridge is left of living cells. Evidence is adduced to show that the agent apparently travels normally in the plant along the protoplasmic connections from cell to cell of the ground tissue, and that it does not travel exclusively in the vascular tissue.

LXVII. M. A. Hamilton. "*Notes on the Culturing of Insects for Virus Work.*" Annals of Applied Biology, 1930. Vol. XVII, pp. 487-492.

(1) Use of Cellophane for Breeding Cages.

Cellophane is recommended as a material to replace muslin or glass for the caging and isolation of small insects. Metal frameworks are described as a basis for the material, and some of its properties, *i.e.*, permeability to moisture and gases, and ultra violet light, general transparency and shrinkage are discussed.

(2) Artificial feeding of *Myzus persicae*.

A method is described by which *M. persicae* may be fed on artificial media. It consists of a pair of glass capsules, the upper one having a floor of fine gut skin, through which the insects, caged in a lower capsule, will absorb dyes and culture fluids.

LXVIII. P. H. JARRETT. "*Streak—a Virus Disease of Tomatoes*." Annals of Applied Biology, 1930. Vol. XVII, pp. 248-259.

Streak disease of tomatoes, derived from commercial glass-houses, and experimental streak, produced by combined inoculation of the viruses of potato mosaic and tobacco mosaic are compared.

Glasshouse streak and tobacco mosaic show an equal resistance to alcohol, heat and ageing in vitro and have, in addition, an identical host range. Treatment for one hour with 90 per cent alcohol, and for ten minutes at 85°C., did not destroy the infectivity of either of these viruses.

Glasshouse streak is shown not to contain the virus of potato mosaic, but is of itself able to produce necrosis in tomatoes without the participation of potato mosaic.

It is concluded that tobacco mosaic and the mosaic of glass-house streak are probably identical, and that much of the streak occurring in glasshouses is due to a single virus, and not a mixed infection of this with potato mosaic.

LXIX. P. H. JARRETT. "*The Role of 'Thrips tabaci' Lindeman in the Transmission of Virus Diseases of Tomato*." Annals of Applied Biology, 1930. Vol. XVII, pp. 444-451.

A description is given of experiments designed to show the role of *Thrips tabaci* Lindeman in the transmission of virus diseases of tomatoes.

The diseases tested were tobacco mosaic and glasshouse streak singly, and the viruses of each of these two combined with a potato mosaic virus to give a disease termed experimental streak.

The source of the materials used and the methods employed are described in detail.

In no case was transmission of any of the viruses recorded, although the insects had fed freely on all the plants. It is concluded that *Thrips tabaci* does not transmit virus diseases of tomatoes under all conditions. The importance of this insect as a vector of these diseases in commercial glasshouses in England is therefore doubtful.

LXX. F. M. L. SHEFFIELD AND J. HENDERSON SMITH. "*Intracellular Bodies in Plant Virus Diseases*." Nature, 1930. Vol. CXXV, p. 200.

When *Solanum nodiflorum* is infected with yellow or aucuba mosaic of tomato, it is possible to follow the development within the living cell of the protein X-bodies. A few days after inoculation, innumerable small particles appear and move passively in the cytoplasmic stream. They enlarge, aggregate and fuse until ultimately a single large mass, the X-body, is formed accompanied by a crystalline spike but by no other abnormal inclusions. In old leaves the X-body tends to crystallise out.

LXXI. J. Henderson Smith. "*Intracellular Inclusions in Mosaic of 'Solanum Nodiflorum.'*" Annals of Applied Biology, 1930. Vol. XVII, pp. 213-222.

The inclusions formed after inoculation with aucuba mosaic are described in detail and illustrated. They correspond to the vacuolate amoeboid bodies produced in other hosts by other viruses, are protein in nature, and tend to crystallise. Their mode of formation by aggregation of small particles has been followed throughout in individual living cells, and accounts satisfactorily for the appearances which have led other observers to believe that they are parasitic organisms, a view for which no support has been obtained in this work.

TECHNICAL AND OTHER PAPERS

GENERAL

LXXII. E. J. Russell. "*Agricultural Science and Arable Farming.*" National Farmers' Union Year Book, 1930, pp.

LXXIII. E. J. Russell. "*Agricultural Research Institutes and Agricultural Colleges. The Rothamsted Experimental Station.*" Superphosphate, 1930, pp. 149-157.

LXXIV. E. J. Russell. "*Winter Keep for Dairy Stock.*" Year Book of the Central Council of Milk Recording Societies, 1930.

LXXV. E. J. Russell. "*Agricultural Developments in South Africa.*" Geography, 1930. Vol. XV, pp. 445-451.

LXXVI. E. J. Russell. "*Palestinian Agriculture and its Possibilities.*" The Monthly Pioneer, May, 1930, pp. 5-6.

LXXVII. B. A. Keen. "*New Steps in School Broadcasting.*" The Listener, 1930. Vol. IV, p. 452.

CROPS, SOILS AND FERTILISERS

LXXVIII. E. J. Russell. "*Manuring and Cultivation of Sugar Beet.*" Report of Third Conference held at Harper Adams Agricultural College, March 13th, 1930, pp. 4-9.

LXXIX. E. J. Russell. "*Soils and Fertilisers.*" Agricultural Research in 1929, pp. 120-152. (Royal Agricultural Society of England, 1930.)

LXXX. E. J. Russell "*The Influence of Fertilisers on the field and Composition of Plants.*" British Association, Report of Bristol Meeting, 1930, pp. 418-419.

LXXXI. W. E. Brenchley. "*Mineral Elements in Plant Nutrition.*" British Association, Report of Bristol Meeting, 1930, pp. 401-402.

LXXXII. W. E. BRENCHLEY. "*Influence of Fertilisers on the Yield and Composition of Meadow Hay.*" British Association, Report of Bristol Meeting, 1930, pp. 420-421.

LXXXIII. W. E. BRENCHLEY. "*The Varying Effect of Lime on Grassland with Different Schemes of Manuring.*" Journal of the Ministry of Agriculture, 1930. Vol. XXXVII, pp. 663-673.

LXXXIV. E. M. CROWTHER. "*Influence of Fertilisers on the Yield and Composition of Potatoes.*" British Association, Report of Bristol Meeting, 1930, p. 420.

LXXXV. E. M. CROWTHER. "*Soils and Fertilisers.*" Annual Report of the Society of Chemical Industry, 1929. Vol. XIV, pp. 511-559.

LXXXVI. H. V. GARNER AND J. WISHART. "*Fertiliser Trials in 1929.*" Journal of the Ministry of Agriculture, 1930. Vol. XXXVII, pp. 793-802.

LXXXVII. H. LLOYD HIND AND F. E. DAY. "*The Fermentation Industries.*" Annual Report of the Society of Chemical Industry, 1929. Vol. XIV, pp. 582-618.

LXXXVIII. B. A. KEEN. "*The March of Power. Lower Cultivation Costs.*" The Field, 1930, p. 138.

LXXXIX. B. A. KEEN. "*Our Cultivation Implements and their Uses.*" The Young Farmer, 1930. Vol. II, April.

XC. L. L. LEE. "*Soil Surveys and their Utilization.*" Journal of the Ministry of Agriculture, 1930. Vol. XXXVII, pp. 653-663.

XCI. G. W. SCOTT BLAIR. "*The Rheology of Soil Pastes.*" Journal of Rheology, 1930. Vol. I, pp. 127-138.

BIOLOGICAL

XCII. H. F. BARNES. "*Control of the Meadow Foxtail Midges.*" Journal of the Ministry of Agricultural, 1930. Vol. XXXVII, pp. 694-697.

XCIII. W. B. BRIERLEY. "*Science of the Year—1929. The Biological Sciences.*" The Annual Register. Vol. CLXXI, pp. 56-61.

XCIV. W. B. BRIERLEY. "*'Botrytis Cinerea' and the Species Problem.*" Fifth International Botanical Congress, Cambridge, 1930, Abstracts of Communications, p. 234.

XCV. A. D. IMMS. "*Remarks on the Biological Control of Noxious Weeds.*" Proceedings of the Fourth International Entomological Conference, Ithaca 1929. Vol. II, pp. 107-1.

XCVI. A. D. IMMS. "*Fighting Insects by Aeroplane.*" The Listener, October, 1930, pp. 518-519.

XCVII. J. Henderson Smith. "*Virus Diseases in Plants. I. Translocation within the Plant. II. The Amoeboid Intracellular Inclusions.*" Biological Reviews, 1930. Vol. V, pp. 159-169.

XCVIII. J. Henderson Smith. "*Virus Diseases of Plants.*" A System of Bacteriology, 1930. Vol. VII, pp. 42-53.

XCIX. J. Henderson Smith. "*The Differentiation and Classification of Plant Viruses.*" Fifth International Botanical Congress, Cambridge, 1930, Abstracts of Communications, pp. 224-225.

C. R. H. Stoughton. "*Angular Leaf-Spot Disease of Cotton.*" Nature, 1930. Vol. CXXV, pp. 350-351.

CI. R. H. Stoughton. "*The Morphology and Cytology of 'Bacterium Malvacearum' E.F.S.*" Fifth International Botanical Congress, Cambridge, 1930, Abstracts of Communications, pp. 16-17.

CII. R. H. Stoughton. "*The Infection of Cotton Plants by 'Bacterium Malvacearum' in Control Chambers.*" Fifth International Botanical Congress, Cambridge, 1930, Abstracts of Communications, pp. 210-211.

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A. D. Imms. "*A General Textbook of Entomology.*" First Edition, 1925. Second Edition, 1930, with 703 pages and 607 illustrations. Methuen & Co., Essex Street, Strand, London, W.C.2. 36s.

A. D. Imms. "*Recent Advances in Entomology.*" 1930, with 374 pages and 84 illustrations. J. & A. Churchill, 40 Gloucester Place, London, W.1. 12s. 6d.

B. A. Keen. "*The Physical Properties of the Soil.*" 1930, 380 pages (with illustrations and diagrams.) Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 21s.

WOBURN EXPERIMENTAL FARM

Report for 1929-30

By Dr. J. A. Voelcker, C.I.E., M.A.

The summer drought of 1929 ended early in October and, from then, on to the end of January, 1930, there was much rain rendering cultivation difficult in spite of mild weather.

Spring was cold and dull, and not until May could the corn begin to grow or the land be prepared for roots. Meantime, much grass had grown. A prolonged drought in June and July enabled a good hay crop to be harvested, but killed the young swedes and they had to be resown. The dry " spell " broke on July 15th, the corn crops were ready about the second week in August, and were gathered in fair condition; those from the smaller experimental plots, were threshed in the field.

The rainfall for the harvest year was 30.92 inches, compared with 16.5 inches in 1928-29 and 23.5 inches in 1927-28, the average being 24.0 inches. The period October, 1929—January, 1930, was very wet.

Woburn Meteorological Records, October, 1929-December, 1930.

	Rain.			*Temperature (Mean).*			
	Total Fall	No. of Rainy Days (0.01 in. or more).	Bright Sun-shine.	Max.	Min.	1 ft. in Ground.	Grass Min.
1929—	Inches.	No.	Hours.	°F	°F	°F	°F
Oct. ..	3.19	15	113.1	56.3	42.6	50.9	37.3
Nov. ..	5.78	22	70.5	50.3	37.3	43.2	31.2
Dec. ..	4.56	23	50.4	47.4	36.8	41.5	30.6
1930—							
Jan. ..	2.69	19	54.3	47.2	36.2	41.5	34.7
Feb. ..	0.62	12	48.6	40.5	31.6	37.9	27.6
Mar. ..	1.65	10	115.1	48.1	34.1	41.4	30.2
April ..	1.60	19	100.4	52.9	39.6	47.2	36.9
May ..	2.91	19	145.0	58.8	43.3	54.1	40.3
June ..	0.45	7	209.9	68.9	50.2	64.1	46.5
July ..	2.43	17	176.5	66.7	51.4	64.3	47.8
Aug. ..	2.45	16	206.0	69.3	52.5	61.7	48.3
Sept. ..	2.59	21	118.4	63.0	49.7	59.3	46.6
Oct. ..	1.00	14	126.5	57.2	44.3	50.8	39.2
Nov. ..	3.75	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
Total or Mean 1930 ..	24.42	192	1384.4	55.5	41.9	50.5	38.5

1.—CONTINUOUS GROWING OF WHEAT AND BARLEY (STACKYARD FIELD), 54TH YEAR

Wheat.

"Million" wheat at the rate of 3 bushels per acre of seed, dressed with formalin, was drilled on November 1st, 1929. It came up well, but was so severely damaged by pheasants that resowing was necessary in December. The new crop failed and was ploughed up again; "Little Joss" was sown on March 3rd, 1930. This being better watched, came fairly, but accompanied by much weed. In spite of some hand-hoeing the plant was thin and the crop cut on September 1st. was miserable. It was spring-sown wheat and the land had received no manure since 1926, though it was fallowed in both 1927 and 1928.

The crops were threshed in the field and the results are given in Table I.

Table I.—CONTINUOUS GROWING OF WHEAT, 1930

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.	Dressed Corn per acre. bushel.	Total Corn per acre. cwt.	Weight per bushel. lb.	Straw, Chaff etc., per acre. cwt.
1	Unmanured	1.0*	0.56	55.5*	4.11
2a	Sulphate of Ammonia	—	—	—	0.22
2aa	As 2a, with Lime, Jan., 1905, repeated 1909, 1910, 1911	—	0.01	—	0.23
2b	As 2a, with Lime, December, 1897	—	0.05	—	1.47
2bb	As 2b, with Lime, repeated Jan., 1905 ..	—	0.11	—	3.57
3a	Nitrate of Soda	3.1	1.59	54.0	4.95
3b	Nitrate of Soda	3.2	1.75	58.0	4.66
4	Mineral Manures (Superphosphate and Sulphate of Potash)	3.0	1.44	52.0	9.46
5a	Mineral Manures and Sulphate of Ammonia ..	—	0.22	—	1.57
5b	As 5a, with Lime, Jan., 1905	—	0.76	—	4.20
6	Mineral Manures and Nitrate of Soda	5.3	2.68	55.5	5.19
7	Unmanured	0.5*	0.25	55.5*	1.68
8a	Mineral Manures and, in alternate years, Sulphate of Ammonia	—	0.07	—	3.11
8aa	As 8a, with Lime, Jan., 1905, repeated Jan., 1918	—	0.06	—	1.36
8b	Mineral Manures and Sulphate of Ammonia (omitted in alternate years)	—	0.07	—	1.82
8bb	As 8b, with Lime, Jan., 1905, repeated Jan., 1918	—	0.04	—	1.20
9a	Mineral Manures and, in alternate years, Nitrate of Soda	4.0	2.09	56.0	4.68
9b	Mineral Manures and Nitrate of Soda (omitted in alternate years)	3.2	1.63	54.0	4.45
10a	Superphosphate and Nitrate of Soda	3.6	1.93	58.0	5.57
10b	Rape Dust	2.9	1.52	56.0	4.57
11a	Sulphate of Potash and Nitrate of Soda ..	5.3	2.79	57.0	7.00
11b	Farmyard Manure	8.0	3.93	54.0	10.86

* Estimated

Barley.

"Plumage Archer" at the rate of 3 bushels per acre was drilled on March 3rd, 1930; it came up well, and by April was far ahead of the wheat and free from weeds. It was harvested on August 25th and threshed in the field. The results are given in Table II.

Table II.—CONTINUOUS GROWING OF BARLEY, 1930
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.	Dressed Corn per acre. bushel.	Total Corn per acre. cwt.	Weight per bushel. lb.	Straw, Chaff, etc., per acre. cwt.
1	Unmanured	13.8	6.09	48.3	6.89
2a	Sulphate of Ammonia	—	0.56	—	0.98
2aa	As 2a, with Lime, Mar., 1905, repeated 1909, 1910, 1912 and 1923	14.2	6.39	47.7	6.47
2b	As 2a, with Lime, Dec., 1897, repeated 1912 ..	15.0	6.32	46.0	6.43
2bb	As 2a, with Lime, Dec., 1897, repeated Mar., 1905	9.9	4.68	50.5	4.97
3a	Nitrate of Soda	14.6	5.93	43.3	6.32
3aa	As 3a, with Lime, Jan., 1921	11.2	4.57	43.5	4.47
3b	Nitrate of Soda	12.9	5.29	44.0	6.00
3bb	As 3b, with Lime, Jan., 1921	9.5	3.86	40.5	3.89
4a	Mineral Manures (Superphosphate and Sulphate of Potash)	14.0	6.32	50.0	7.00
4b	As 4a, with Lime, 1915	14.8	6.72	48.0	6.68
5a	Mineral Manures and Sulphate of Ammonia ..	—	1.14	—	2.05
5aa	As 5a, with Lime, Mar., 1905, repeated 1916 ..	18.9	8.29	47.5	8.29
5b	As 5a, with Lime, Dec., 1897, repeated 1912 ..	18.1	7.77	46.5	7.18
6	Mineral Manures and Nitrate of Soda	18.3	7.84	47.0	9.05
7	Unmanured	11.8	5.13	47.5	5.55
8a	Mineral Manures and, in alternate years, Sulphate of Ammonia	—	0.29	—	0.97
8aa	As 8a, with Lime, Dec., 1897, repeated 1912 ..	15.3	6.64	48.0	6.43
8b	Mineral Manures and Sulphate of Ammonia (omitted in alternate years)	—	0.36	—	0.82
8bb	As 8b, with Lime, Dec., 1897, repeated 1912 ..	17.0	7.43	47.0	7.00
9a	Mineral Manures and, in alternate years, Nitrate of Soda	17.8	7.98	48.2	7.59
9b	Mineral Manures and Nitrate of Soda (omitted in alternate years)	18.5	8.00	47.7	7.93
10a	Superphosphate and Nitrate of Soda	9.1	3.89	46.0	6.63
10b	Rape Dust	3.1	1.38	47.0	1.66
11a	Sulphate of Potash and Nitrate of Soda ..	16.2	7.07	47.0	9.20
11b	Farmyard Manure	21.7	9.50	47.5	8.77

The always-unmanured plots gave 12.8 bushels of corn per acre as against the 20.3 bushels of 1929; mineral manures gave more, sulphate of potash being superior to superphosphate; the residues from farmyard manure gave the highest yield. The residues from rape dust and from sulphate of ammonia without lime gave practically no crop.

2.—ROTATION EXPERIMENTS

The Unexhausted Manurial Value of Cake and Corn

(Stackyard Field)

Series C.

Swede seed ("Garton's Magnificent") was sown on May 30th, but the first sowing was taken by "fly." The second sowing suffered from drought, but gave a very even plant of small roots. The weights were as follows:

Table III.—SWEDES (AFTER WHEAT) Stackyard Field, Series C, 1930.
Produce per acre.

Plot.		Roots.	Tops.
		Tons	Tons
1.	Corn-fed	11.55	1.30
2.	Cake-fed	12.80	0.95

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The swedes will be fed off by sheep, receiving, on one half, corn, and, on the other half, cake, after which barley will follow as the crop of 1931.

Series D.

Barley followed the swedes of 1929, which had yielded from 4.1 tons (cake plot) to 7.25 tons (corn plot) per acre, and which had been fed off by sheep receiving, respectively, cake and corn.

" Plumage Archer " barley—3 bushels per acre—was drilled on March 28th ; it came up well and was undersown in May with red clover. From June onwards the " cake " plot looked decidedly the better, and gave the larger yield. The crop was harvested on August 14th.

Table IV.—BARLEY (AFTER SWEDES, 1929). Stackyard Field, Series D, 1930.

Produce per acre.

Plot.	*Head Corn.*		Tail Corn. Weight.	Straw, Chaff, etc.
	Bushels.	Wt. per Bushel.		
		lb.	lb.	Cwt.
No. 1—Corn-fed . .	24.7	52.6	12	15.5
No. 2—Cake-fed . .	33.6	52.1	20	20.0

The history of the plots is as follows :

Prior to 1923 the respective amounts of nitrogen fed on the two plots had been : corn-fed plot, 7.25 lb. ; and cake-fed plot, 18 lb. nitrogen per acre, but from 1923 onwards the nitrogen fed was to be 24.6 lb. per acre on the corn plot, and 56.5 lb. per acre on the cake plot. For Series D this should have begun with the root crop of 1925 ; but, as the roots failed, no cake or corn was fed. The root crop of 1929 was therefore the first to come under the new treatment, and the barley of 1930 shows that the higher nitrogen has increased the yield by 9 bushels of corn per acre.

3.—GREEN CROP AND GREEN-MANURING EXPERIMENTS

(a) *Stackyard Field—Series A.*

Upper Half : 1930 Green Crops fed off by sheep.

Tares—3 bushels per acre—were drilled April 15th, 1930, and mustard, 28 lb. per acre on April 30th. Both received 3 cwt. of superphosphate and 1 cwt. of sulphate of potash per acre. Both came up very fairly, especially the tares. On June 25th sheep were put on the plots and given also ¾ cwt. per acre of mixed linseed and cotton cake ; they remained for 13 days (to July 8th). Second green crops were then sown, August 1st and 2nd, and the produce fed off with cake towards the close of September. The land was then ploughed and prepared for wheat. This was the first time that two green crops could be grown and fed off in one season.

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The analysis of the crops was as follows :

Plot.	Dry Matter lb. per acre. 1st. crop	Dry matter lb. per acre. 2nd crop.	Total dry matter. lb. per acre.	Nitrogen 1st crop per cent.	lb. per acre.	Nitrogen 2nd crop per cent.	lb. per acre.	Total Nitrogen lb. per acre.
3. Mustard (unlimed) ..	368	534	902	2.07	7.62	3.00	16.0	23.62
4. Mustard (limed)	309	555	864	2.09	6.45	2.74	15.2	21.65
1. Tares (unlimed)	1543	1472	3015	3.57	55.09	4.30	63.4	118.13
2. Tares (limed) ..	1365	1180	2546	3.69	50.35	4.30	50.8	101.15

About five times as much nitrogen is supplied in the tares as in the mustard, and yet it has not benefited the succeeding crop.

Lower Half, 1930 : Wheat after Green Crops fed off by sheep.

The half on which green crops (tares and mustard) had been grown in 1929, was ploughed up after the sheep-feeding, and wheat ("Million"—3 bushels per acre) was drilled, November 2nd, 1929. This came up fairly, but was somewhat damaged by pheasants ; it was, however, a fair plant and throve more or less until June, when, as in most former years, it began to fail. Meantime, early in April, a number of small plots had been marked out, alike on the mustard and the tares area, and dressed with nitrate of soda at different periods ; these made much better growth.

The crop was cut on August 25th, and threshed out in the field. The yields were :

Wheat after Green Crops fed off by Sheep. Produce per acre, 1930

Plot.	*Head Corn.*		Tail Corn.	Straw, Chaff, etc.
	No. of Bushels.	Weight per Bushel.		
		lb.	lb.	Cwt.
1. After Tares fed off	1.8	56.3	3	3.2
3. After Mustard fed off	5.4	56.6	3	5.8

The limed plots (2 and 4) were damaged by sheep breaking in when the green crops were being fed on the upper half, and the produce was not weighed.

(b) *Lansome Piece.*

Here the green crops are not fed off by sheep, but ploughed in, and wheat follows in the next season. In 1930 two successive green crops were grown. Tares were drilled on April 15th—3 bushels per acre—and mustard on April 30th—28 lb. per acre—each with 3 cwt. of superphosphate, and 1 cwt. of sulphate of potash per acre. The crops grew well and were ploughed in on July 14th and 15th. Second crops were sown in early August, and these in turn were ploughed in : "Red Standard" wheat—3 bushels per acre—was then drilled on October 17th.

The results for dry matter and nitrogen in the green crops of 1930 were as follows :

Plot.	Weight of Green Matter per acre. crops. 1st	2nd	Weight of Dry matter per acre. crops. 1st	2nd	Total	Nitrogen per cent. crops. 1st	2nd	Weight of Nitrogen per acre. crops. 1st	2nd	Total.
	lb.	lb.	lb.	lb.	lb.			lb.	lb.	lb.
1. Mustard plot : old series ..	3050	2362	868	368	1236	1.17	2.50	10.2	9.2	19.4
2. Tares plot : old series ..	9500	7950	2482	961	3443	2.44	4.05	60.6	39.0	99.6
3. Mustard plot : new series	4775	3163	1094	437	1531	1.35	2.76	14.8	12.1	26.9
4. Tares plot : new series ..	12450	8338	3064	1082	4146	2.16	4.03	66.2	43.6	109.8
5. Control : new series (Weeds only) ..	4350	2400	993	324	1317	1.73	3.28	17.2	10.6	27.8

5.—MANURING OF GRASS LAND—BROAD MEAD, 1930

No manures had been applied to these plots since 1924. They were redressed in December, 1929, farmyard manure—12 tons per acre—being put on plot 5, and lime—2 tons per acre—on plot 4 ; the mineral manures were given to plots 1, 2 and 4 early in 1930. The plots, along with the rest of the field, were grazed with cattle and sheep. Plot 4 had the freshest and greenest appearance. On May 14th they were then laid in for hay which was cut on June 30th ; the results were as follows :

Plot.	Manures per acre.	Weight of Hay per acre, reckoned on a 15 per cent. Moisture Basis. lb.
1.	Superphosphate 5 cwt., S/Potash 1 cwt. ..	2703
2.	Basic Slag 10 cwt., S/Potash 1 cwt.	1615
3.	Nothing	2361
4.	Lime 2 tons, with Superphosphate 5 cwt. and Sulphate of Potash 1 cwt.	2314
5.	Farmyard Manure 12 tons	3622

Analyses.

	Plot 1.	Plot. 2.	Plot. 3.	Plot 4.	Plot 5.
Moisture	15.00	15.00	15.00	15.00	15.00
Extractive matter (by petroleum ether)	1.34	1.31	1.32	1.75	1.30
Albuminoids	10.10	9.82	9.61	9.33	8.58
Digestible Carbohydrates, etc.	44.42	43.47	43.99	43.55	42.79
Fibre	22.46	24.22	24.03	23.39	25.80
Ash	6.68	6.18	6.05	7.18	6.53
	100.00	100.00	100.00	100.00	100.00
Nitrogen	1.62	1.57	1.54	1.49	1.37
Sand	1.53	1.55	1.35	1.58	1.00

While there was little difference in composition between the hays of the first four plots, the inferiority of the fifth plot (farmyard manure) is seen in the higher fibre and the lower albuminoid content.

6.—FORAGE CROPS. WARREN FIELD, 1930

Partly as hay, partly as grain and straw.

Six plots, $\frac{1}{4}$ acre each, were sown on September 25th, 1929, in duplicate, with three different mixtures, *viz.* (*a*) Oats (2 parts), beans (1 part); (*b*) oats (2 parts), tares (1 part); (*c*) oats (2 parts), beans (2 parts) and tares (1 part). The mixed seed was sown at the rate of 2 bushels per acre. The crops all grew well, and a part of each plot was cut green on June 30th, 1930, and weighed as hay on July 10th. The yields of hay per acre reckoned on 15 per cent moisture were :*

	Tons
Oats and Beans	3.55
Oats and Tares	3.13
Oats, Beans and Tares	3.16

The mixture of oats and tares was very difficult to reap, being much "lodged."

* Actual range 16—18½ per cent.

Analyses of the hay gave the following results :

	Oats and Beans.	Oats and Tares.	Oats, Beans and Tares.
Moisture	15.00	15.00	15.00
Extractive matter (by petroleum ether) ..	.81	.81	.86
Albuminoids	8.15	6.86	10.32
Digestible Carbohydrates	40.17	42.42	40.20
Fibre	29.17	29.19	27.37
Ash	6.70	5.72	6.25
	100.00	100.00	100.00
Nitrogen	1.30	1.09	1.65
Sand	.79	1.11	.59

The remainder of the crops were allowed to ripen and were harvested. Difficulty was experienced owing to the crops not ripening together; the beans and oats were over-ripe and suffered loss by shedding and from birds, while the tares were not fully ripe. Wet weather delayed cutting, but ultimately this was done August 7th-8th, the crops being threshed on September 11th. The results were :

	Corn lb. per acre.	Straw per acre. Tons
Oats and Beans ..	1,232	2.57
Oats and Tares ..	1,305	2.17
Oats, Beans and Tares	1,697	2.51

The beans held up the crop and reduced the loss by lodging.

The Woburn Farm

REPORT BY H. G. MILLER ON THE WOBURN FARM

(For dates, yields and other information, see Table on pp. 105-8.)

So far Woburn has been mainly an arable farm, but this is a highly unprofitable policy at present. Some of it is, therefore, being laid down to grass.

In March, 1930, 8 acres of Warren Field—consisting of a heavier soil and unlike the light soil of the rest of the farm—were sown down under barley with the following seeds mixtures, in duplicate, all except II being of indigenous strains.

	lb. per acre.				
	I.	II.	III.	IV.	V.
Italian rye grass ..	—	As I but	—	—	4
Perennial rye grass ..	10	commer-	24	—	14
Cocksfoot	8	cial	10	6	—
Timothy	3	strains.	9	4	—
Meadow fescue	—		—	10	—
Rough stalked meadow grass	2		—	2	4
Late flowering red clover..	3		—	3	—
Alsike clover	1		—	1	—
Wild white clover ..	2		1	1	2

(Order from N. end of field—I, II, III, IV, V, II, I, V, IV, III.)

All mixtures looked very well by September, although the clover had failed in some places. The whole field was limed in the autumn at the rate of 2 tons burnt agricultural lime per acre.

Road Piece produced a surprisingly good crop of kale, and Great Hill a good crop of sugar beet. These are the poorest fields on the farm, and will be sown to grass, lucerne and lucerne grass mixtures in the spring of 1931.

The division of the farm will then be :

	Acres
Classical experiments	28
Arable and modern experiments	25
Permanent grassland and lucerne	76
Buildings, etc.	2
	131

The arable land consists of Lansome Field, Warren Field (6 acres nearest farm), Butt Close and Butt Furlong. These last two are no longer separated by a hedge, and 3 acres of the latter round the sand pit, have been laid down to permanent grass for pig runs.

The light soil of Woburn must be continuously covered with crops ; any available land is sown with rye in the autumn, as at Rothamsted. The crops grown are given on pp. 105-108 ; there is no fixed rotation.

The principal stock are sheep (half-bred ewes) and large black pigs. Lambing in 1930 commenced on March 22nd, and the lambs, the last of which are now (June 1931) being fattened, have done very well.

The seven intensive grazing plots : Broad Mead (4), Honey Pot (1) and Great Hill Bottom (2), produced abundant keep throughout the year, with only two applications of nitrate of soda (see p. 108). This treatment is producing marked improvement in the herbage, and so far the clovers have not visibly suffered.

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, 1930

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	Barley undersown	Plumage Archer	Feb. 25-26 tractor plough. Mar. 13-22 drag harrow 3 times, harrow and roll. Mar. 25-26 sow manures and grass seeds. 1 horse harrow	1 S/Amm. 3 Super 2 M/Pot.	Mar. 24	Aug. 12	Aug. 27	14 cwt.
	Forage	—	Sept. 25, 1929 sow forage mixtures and harrow. Mar. 14 graze with sheep. Mar. 26 sow manures and cross harrow. Part as hay and part left for harvest	1½ S/Amm. 3 Super 1 M/Pot.	Sept. 25, 1929	June 30 Aug. 7	July 10 Aug. 19	see p. 103
	Mangolds	Garton's Lemon Globe	Mar. 29-31 three horse drag harrow. Bout up 27in. ridges. Apply dung	20 tons F.Y.M.	April 29	Oct. 23	Oct. 30 Nov. 4	25-30 tons
	Potatoes	Ally	April 10-11 apply artificial manures and set potatoes. April 28, split back ridges for mangolds. April 29 sow mangolds. June 11-12, single and top dress.	1 S/Amm. 3 Super 1½ M/Pot.	April 11	Oct. 1-15	Oct 13-16	10 tons
Butt Close	Winter Oats	Grey	Oct. 2, 1929 cross cultivate and harrow. Oct. 3-5 cross drill. Mar. 25-26 cross harrow	1 S/Amm. 2 Super 1 M/Pot. ½ S/Amm top dressing	Oct. 3-5 April 22	July 31	Aug. 20	12 cwt.
Butt Furlong	Barley undersown	Plumage Archer	Plough Feb. 27–28. Mar. 6-7 harrow and drill. Mar. 19 sow grass seeds and harrow. Mar. 25-26, Cambridge roll	1½ S/Amm. 3 Super 1 M/Pot.	Mar. 6-7	Aug. 17	Aug. 26	14 cwt.
Road Piece	Hay	—	Mar. 16 harrow and roll	2 S/Amm. 3 Super 1 M/Pot.	—	June 23	June 27	50 cwt.
	Kale	Marrow Stem	April 24-29 plough. May 5 harrow and roll. 1st sowing failed owing to fly. June 6 cultivate and roll. July 3 horse hoe. Aug. 15-16 horse hoe	1 S/Amm. 3 Super 1 M/Pot. 1 N/Soda (top dressing)	May 9- June 10	— —	— —	Estimated over 20 tons.

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, 1930 (Contd.)

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
Great Hill	Kale	Thousand Head	May 16 plough in rye after sheep. May 20 3 times harrow and roll. June 25 cultivate and roll. 1st sowing taken by fly. July 28 horse hoe. Aug. 16 horse hoe	1 S/Amm. 5 Super. 1 M/Pot. 1 N/Soda (top dressing)	May 22 July 3	—	—	—
	Rye	—	—	1 S/Amm. 3 Super. 1 M/Pot.	End Sept., 1929	Aug. 2	Aug. 20	—
	Sugar Beet	Johnson's P.	Feb. 21-Mar. 10 plough. April 1-10 plough back. April 22 drag harrow and roll. June 2 singling. Continual hand hoeing	20 tons FYM 1 S/Amm. 4 Super. $1\frac{1}{2}$ Potash Salts. 1 N/Soda (TD).	April 23 April 30 May 9	Oct. 17 Nov. 10	—	$9\frac{1}{2}$ tons.
Lansome Piece	Potatoes	Ally	April 11-14 plough after rye grazed off, and harrow. April 13-30 3 times harrowed and cultivated, May 2-5 ridged. June 16-17 horse hoe. July 9-10, Aug. 14 hand hoe	—	May 5	Sept. 30-31	—	see pp. 152-3
	Barley after Sugar Beet	Plumage Archer	Sept. 8-26, plough. Feb. 5 plough back and harrow. Mar. 13 drill and harrow	2 tons lime 1 S/Amm. 3 Super. 1 M/Pot.	Mar. 13	Aug. 12	Aug. 28	12 cwt.
	Wheat	—	Nov. 5-7 plough and harrow. Drill and harrow	—	Nov. 6	Aug. 9	—	—
	Sugar Beet	Johnson's P.	April 11-14 plough after rye grazed off, and harrow. April 13-30 3 times harrow and cultivate. May 1 harrow and roll. May 27-28 flat hoe. June 10, 11, 12 single and horse hoe	—	May 3	Oct. 8	—	see p. 154

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, 1930 (*Contd.*)

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
II. Classical and Rotation Experiments— Stackyard Field	Permanent Wheat	Little Joss	Feb. 26 plough in winter wheat ruined by birds, harrow and drill. April 10 roll. May 16 hand hoe	—	Mar. 3	Sept. 1	Sept. 12	see p. 98
	Permanent Barley	Plumage Archer	Oct. 12, 1929 tractor plough. Feb. 18-20, plough and harrow. Mar. 3 harrow and drill. April 10 roll. May 20 hand hoe	—	Mar. 3	Aug. 25	Sept. 11	see p. 99
Series A (*a*)	Wheat	Million III	Oct. 12-13, 1929, plough and harrow. Nov. 2 harrow and drill. April 10, Cambridge roll. May 29 flat hoe	—	Nov. 2	Aug. 25	Sept. 11	see p. 101
A (*b*)	Vetches	—	Oct. 12, 1929 plough. Mar. 21 plough. April 15 harrow and drill. July 12 plough and harrow. Aug. 1 drill and harrow	3 Super. 1 S/Pot.	April 15 Aug. 1	Eaten off with sheep July 8 and Sept. 25		
	Mustard	—	Oct. 12, 1929 plough. Mar. 21 plough. April 30 harrow, drill and harrow. July 12 plough and harrow. Aug. 1 drill and harrow	3 Super. 1 S/Pot.	April 30 Aug. 1			
Stackyard Field— Series B (*a*)	Barley undersown	Plumage Archer	Jan. 20-25 plough. Mar. 27 harrow. Mar. 28 drill and harrow. Undersown with clover	—	Mar. 28 April 22	Aug. 13	Aug. 29	see p. 150
(*b*)	Barley	Plumage Archer	Cultivation same as (*a*)	—	Mar. 28	Aug. 13	—	see p. 150
(*c*)	Sugar Beet	Johnson's P.	Jan. 20-25 plough. April 22 cultivate and harrow. May 1 drill, harrow and roll	—	May 1	Oct. 29	—	see p. 150
(*d*)	Barley	Plumage Archer	Cultivation same as (*a*)	—	Mar. 28	Aug. 13	Aug. 29	see p. 150
(*e*)	Potatoes	Ally	Jan. 20-25 plough. April 10 cultivate and ridge. Sow potatoes and split back. May 21 chain harrow, ridge and hand hoe	—	April 10	Oct. 1	—	see p. 150

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, 1930 (*Contd.*)

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring, cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
Series B (*cont.*) (*f*)	Barley	Plumage Archer	Cultivation same as (*a*)	—	Mar. 28	Aug. 13	Aug. 29	see p. 150
Series C	Swedes	Purple Top	May 12-14 plough. May 28 harrow and drill manures. June 17 redrill and harrow. July 4 horse hoe	3 Super. 1 S/Pot.	May 29 June 17	Fed off with sheep, Jan - Mar., 1931		
Series D	Barley undersown with Clover	Plumage Archer	Feb. 4 plough after sheep. Mar 4 harrow and drill. May 1 roll	—	Mar. 4 Mar. 27 (clover)	Aug. 13	Aug. 28	see p. 100
Lansome Piece	Mustard	—	Nov. 5, 7, 8, 1929 plough. Mar. 20-21 plough back. April 14 3 times drag harrow. April 15 manure and sow vetches. April 30 sow mustard. May 1 roll. July 10 plough in both crops. Aug. 2 resow both crops. Oct. 7-11 plough in both crops.	3 Super. 1 S/Pot.	April 15 Aug. 2			
	Vetches	—			April 30 Aug. 2			
III Grazing— Broad Mead (1) (2) (3) (4)	Grazing		Chain harrow before each dressing of manure. Dressings commenced Feb. 22. Dressings at 7 day intervals. 2nd dressing commenced May 8. Plot 4 mown for hay after grazing till May 16	1 S/Amm. 1st dressing 1 N/Soda 2nd dressing				
Honey Pot (1)								
Great Hill (1) Bottom (2)	Do.							
Long Mead (1)	Do.							

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YIELDS OF EXPERIMENTAL PLOTS 1930

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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 multiplies 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 cannot reasonably be disregarded, but must be ascribed to genuine manurial or cultural effects, such as the experiment was designed to examine.

The rejection of the insignificant differences is thus a necessary preliminary, but only a preliminary, to the interpretation of the experimental results. So far as has been practicable all significant results are noted, and exhibited in the summaries of significant results. In the more successful and extensive experiments the standard error has been reduced to so low a figure, sometimes considerably less than 2 per cent, that quite small differences in yields can be detected, whereas with a standard error of 5 per cent, 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, or less, 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

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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.

THE NUMBERING OF THE FIELD PLOTS IN THE ROTATION AND REPLICATED EXPERIMENTS

Each plot designation consists of two letters and a number, with the addition that these may, for laboratory purposes, be prefixed by 31, 32, etc., to denote year.

The first letter signifies the place, and, in the case of the Rotation experiments, the nature of the experiment. Thus:

Rothamsted Four Course Rotation	=	A
Rothamsted Six Course Rotation	=	B
Woburn Six Course Rotation	=	C
Otherwise Rothamsted Experiments	=	R
And Woburn Experiments ..	=	W
Outside Centre Experiments	=	D, E, F, etc.
(Leaving out I)		

The second letter designates the crop, and is usually the first letter of the word for the crop. Thus:

Wheat ..	=	W	Turnips ..	=	T
Barley ..	=	B	Mangolds ..	=	M
Oats	=	O	Hay	=	H
Potatoes ..	=	P	Clover ..	=	C
Sugar Beet ..	=	S	Forage.. ..	=	F
Swedes ..	=	G	Rye	=	R
Lucerne ..	=	L, etc.			

The plots of each experiment are serially numbered from 1 to n. If more than one experiment is laid down on the same crop at the same centre, apart from the Rotation experiments, the plots are numbered 1 to p, p + 1 to q, q + 1 to r, etc.

The letters denoting outside centres remain the same for the same centre in different years, provided that if a centre drops out of the experimental programme, and is not likely to re-enter, its letter may be in time allotted to another centre. Both letters will be required to identify centre and crop, *i.e.*, the same letter may be used for two centres where the crops are very different and likely to remain different. It is recommended that the code letters for place and crop be used in all correspondence concerning these experiments.

Samples stored by the Chemistry Department bear a label giving the full plot symbol, as herein defined, together with the year, and such other notes, *e.g.*, grain, straw, etc., as may assist in identifying the sample where more than one has been taken from the same plot.

Illustrations :

AW 49	Rothamsted Four Course Rotation	wheat–plot 49
CS 36	Woburn Six Course Rotation	sugar beet–plot 36
RW 1–96	Rothamsted Wheat Experiment	variety trial
RW 97–144	Rothamsted Wheat Experiment	Great Knott
KP 7	(*e.g.*) Welshpool	potatoes–plot 7

https://doi.org/10.23637/ERADOC-1-63

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, 1930

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring, cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
I. Arable and Modern Experiments—								
Pastures (1)	Forage	Beans, Tares and Rye	Sept. 9–19 plough, 23 harrow, 24 and 25 drill and harrow in.	(1) Six course rotation expt. see p. 133	Sept. 24-25	—	—	see p. 133
(2)	Forage		Ploughed part of field after forage May 14-15. Harrow and drill Kale May 17 and roll. Redrilled and rerolled June 4.	(2) Commercial forage 14 tons FYM 1 N/Soda	Forage Sept. 24-25	Folded off by sheep	—	—
(3)	Kale	Marrow Stem Thousand-Head	June 4 and 5 plough, and harrow rest of field, sow Kale harrow, drill, roll. June 21 drill and roll again where failed	(3) Kale 1 N/Soda, 3 S/Amm. 4 M/Pot. and $1\frac{1}{4}$ Super.	Kale May 17-June 21	Kale consumed Dec.-Feb.	—	18 tons
Gt. Harpenden	Forage	see p. 142	see p. 142	—	—	—	—	see p. 142
	Seeds	Ital. Rye Grass Broad Red Clover	—	$1\frac{1}{3}$ S/Amm. 1 M/Pot. 3 Super. $1\frac{1}{3}$ S/Amm. later	—	June 16-23	June 27-30	2 tons
Little Hoos	Winter Oats	Grey Winter	Aug. 29-Sept. 7, 1929 tractor plough and cultivate, do. Sept. 14-16, drill and harrow Sept. 19, roll Mar. 25	1 S/Amm., 3 Super. and 1 M/Pot. (early spring) 1 S/Amm later	Sept. 14-16	July 19-25	Aug. 9-12	22 cwt.
Broad Baulk	Mangolds	see p. 149	see p. 149	—	—	—	—	see p. 149
Fosters	Wheat One year Seeds	Million 16lb. Ital. Rye Grass 12lb. Broad Red Clover	July 4-15, 1929, tractor plough clover stubble. Sept. 18-19 use thistle bar (tractor). Sept. 24 cultivate, 26 harrow for seed bed. Sept. 27 drill, 28 harrow in. Undersown with seeds April 10 and 11	1 S/Amm. 1 M/Pot. and 3 Super.	Sept. 27 Seeds April 10 and 11	Aug. 6-7	Aug. 18-19	18 cwt.

https://doi.org/10.23637/ERADOC-1-63

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, 1930 (*Contd.*)

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring, cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
Great Knott	Wheat	Million	Ploughed in mustard June 22-29, 1929. Aug. 28 disc harrow and harrow behind. Reploughed Sept. 13-19. Horse harrow and drill, tractor harrow in. See also p. 138	Basal 1 S/Amm. 1 Pot. Salts 2¼ Super. 1 S/Amm. 2nd dressing	Sept. 20-21	Aug. 7-14	Aug. 19-21	see p. 138
Long Hoos (1)	Winter Oats	Grey Winter	Sept. 28 and 30, 1929, tractor plough. Sept. 30 tractor harrow. Drill Oct. 1, harrow after. Rye Sown Sept. 26-30	1¼ cwt. S/Amm. in two dressings	Oct 1	July 26	—	22 cwt.
(2)	Forage and Mustard	Tares, Beans and Oats	Sept. 27, 1929 cultivate. Mar. 7-10, 1930 plough in dung. Mar. 13 harrow and drill forage. May 28 plough in forage, 29 harrow across. May 30 drill Kale, roll before and after. June 11, re-drill Kale, disc harrow in front, flat roll behind failed. July 11, sow mustard. Sept. 2-10 sheep penned on mustard. Rye sown Sept. 26–30	Dung 10-12 tons approx.	—	—	—	—
Long Hoos (3)	Wheat		see p. 135 Rye Sown Sept. 26-30.					see p. 135
(4)	Seeds		Six course rotation expt., see p. 132					see p. 132
(5)	Barley							see p. 132
(6)	Potatoes and Sugar Beet		Potatoes, see p. 133 Sugar Beet, see p. 132					see p. 133 see p. 132
II. Grassland—								
Gt. Harpenden	Grazing, then Hay	see 1927–8 Report	Mar. 26 tractor harrow and roll	8 basic slag & 1 S/Amm.	—	June 12-13	June 19-July 9	1 ton
	New perm. grass	see 1927–8 Report						
Fosters Corners	Grazing	see 1927–8 Report	—	—	—	—	—	—
Great Knott	Grazing	see 1927-8 Report	—	—	—	—	—	—

H

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, 1930 (*Contd.*)

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring, cwt. per Acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
Great Field	Grazing	—	Mar. 28-29, tractor harrow and roll. July 6-7 topped	2 acre hockey pitch 10-12 tons Dung, 1 S/Amm., small paddock 1 S/Amm.	—	—	—	—
Little Knott	$\frac{1}{2}$ Grazing $\frac{1}{2}$ Hay (after early Grazing)	—	—	Liquid Manure	—	July 8-9	July 17	25 cwt.
New Zealand	Grazing	—	Mar. 25 tractor harrow and roll	$1\frac{1}{4}$ S/Amm. Autumn and 1 S/Amm. Spring	—	—	—	—
Stackyard	Grazing	—	Mar. 25 tractor harrow and roll July 8 topped	$1\frac{1}{4}$ S/Amm. and 1 S/Amm. Spring	—	—	—	—
West Barnfield	Hay after early Grazing	—	April 25-28 chain harrow, April 29-30 horse roll	5 Basic Slag and 1 S/Amm.	—	June 10-11	June 17-20	28 cwt.
Sawyers E	Hay after early Grazing	—	—	2 N/Soda	—	June 6	June 14-18	30 cwt.
„ W	4 acres Hay rest Grazing	—	—	1 S/Amm. on 14 acres, 1 M/Amm.	—	June 18	June 25-July 1	—
„ NW	Grazing	—	Topped July 4-10	Autumn on 8 acres, 1 S/Amm. Spring on 16 acres	—	—	—	—

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, 1930 (*Contd.*)

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring, cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
III. Classical Experiments— Broadbalk	Wheat	Red Standard	Sept. 5 and 6, 1929 tractor cultivate across. Sept. 20 ditto, thistle bar attached. Oct. 1-8 plough. Oct. 14 and 15 harrow (tractor). 16 harrow in seed. Feb. 21 chain harrow I and II. April 23 harrow I and II across. 29 harrow whole field across. May 2 chain harrow I and II across and tooth harrow III, IV and V lengthwise	see pp. 122-3	Oct. 15	Aug. 18	Aug. 27-30	see pp. 122-3
Hoos	Barley	Plumage Archer Spratt Archer	Feb. 19 cultivate. 20-21 cultivate across. 25 and 27-Mar. 3 plough. 3-4 spring tined harrows followed by tooth harrows across. 6 roll, drag harrows, and spike harrows. 7 harrow in seed. May 1 harrow. Horse and hand hoe May 22-July 9	see p. 124	Mar. 6	Aug. 21 and Sept. 1	Sept. 8 and 9	see p. 124
	Four Course Rotation	see pp. 130-1						see pp. 130-1
Barnfield	Mangolds	Prize Winner Yellow Globe	Nov. 15, 1929 and Jan. 16-17 plough. Mar. 31-April 3 steam tackle. April 15-17 drag harrow. 23-28 horse roll. 29-May 1 applied manures and cultivate across 1 and 2 cultivate down. 9 and 10 tractor disc harrow, followed by roll down. 10 drill. 19-20 ring roll	see p. 120	May 10	—	Oct. 29-Nov. 10	see p. 120
Agdell	Clover and Fallow	—	Oct. 14 and 15 tractor plough. 31 disc harrow tractor. Nov. 1 harrow in wheat seed	see p. 119	—	July 5 1st crop. Oct 8 2nd crop	July 10 1st crop. Oct. 13 2nd crop	see p. 119
Park	Hay	—	Mar. 14 drag harrow. April 1 roll horses	see p. 121	—	June 26-28 1st crop Oct. 17-21 2nd crop	July 2-4 1st crop Oct. 22-24 2nd crop	see p. 121

CROP YIELDS ON THE EXPERIMENTAL PLOTS

Notes.—In each case the year refers to the harvest, *e.g.*, Wheat 1930 means wheat harvested in 1930. 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, 1919–27. cwt.	Country.	Mean yield per acre, 1919–27. cwt.
Great Britain..	17.4	Denmark	22.5
England	17.3	Argentine	6.6
Hertfordshire	16.3	Australia	6.6
France	10.8	Canada	8.6
Germany	14.1	United States..	7.5
Belgium	20.0	U.R.S.S. (Europe and Asia)*	5.7

Note.—Figures for Great Britain, England and Hertfordshire are taken from the Ministry of Agriculture's "Agricultural Statistics," Vol. 62. Other figures from "International Year Book of Agricultural Statistics," 1922–28.
*1924–27.

METEOROLOGICAL RECORDS, 1930

	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.
1930.	Inches.	No.	Inches.	Inches.	Inches.	Hours.	°F.	°F.	°F.	°F.	°F.
Jan. ..	3.247	18	3.016	3.084	2.911	48.8	46.3	36.4	40.2	68.4	32.8
Feb. ..	0.855	9	0.612	0.735	0.699	59.1	40.0	32.8	37.0	75.7	30.1
Mar. ..	1.451	10	0.712	0.753	0.706	123.5	48.1	34.3	39.9	99.5	30.2
April ..	2.308	15	0.858	0.964	0.886	114.8	52.2	39.7	45.2	104.5	36.3
May ..	2.904	18	0.531	0.587	0.561	166.3	58.2	44.5	51.7	119.9	40.8
June ..	0.939	4	0.116	0.148	0.145	242.6	68.0	50.3	59.7	129.1	45.9
July ..	2.321	14	0.233	0.183	0.212	194.6	66.1	52.0	61.4	129.3	47.6
Aug. ..	2.719	14	0.624	0.671	0.653	226.0	68.3	52.7	60.0	129.8	48.2
Sept. ..	3.498	17	1.694	1.710	1.669	125.0	62.3	50.8	58.2	114.9	47.4
Oct. ..	1.244	17	0.187	0.220	0.206	134.9	56.7	44.4	50.5	105.6	39.4
Nov. ..	5.114	19	4.354	4.476	4.339	76.6	48.6	36.3	43.5	78.1	32.8
Dec. ..	2.855	19	2.535	2.680	2.619	31.2	42.9	33.7	39.7	58.5	31.3
Total or Mean	29.455	174	15.472	16.211	15.606	1543.4	54.8	42.3	48.9	101.1	38.6

RAIN AND DRAINAGE.

MONTHLY MEAN FOR 60 HARVEST YEARS, 1870-1—1929-30.

	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. ..	2.363	0.804	0.779	0.717	34.0	33.0	30.3	1.559	1.584	1.646
Oct. ..	3.171	1.818	1.786	1.653	57.3	56.3	52.1	1.353	1.385	1.518
Nov. ..	2.844	2.168	2.223	2.094	76.2	78.2	73.6	0.676	0.621	0.750
Dec. ..	2.871	2.450	2.551	2.434	85.3	88.9	84.8	0.421	0.320	0.437
Jan. ..	2.422	1.987	2.183	2.082	82.0	90.1	86.0	0.435	0.239	0.340
Feb. ..	2.031	1.517	1.630	1.556	74.7	80.3	76.6	0.514	0.401	0.475
March ..	1.997	1.064	1.193	1.128	53.3	59.7	56.5	0.933	0.804	0.869
April ..	2.028	0.659	0.739	0.703	32.5	36.4	34.7	1.369	1.289	1.325
May ..	2.061	0.476	0.544	0.510	23.1	26.4	24.7	1.585	1.517	1.551
June ..	2.224	0.540	0.569	0.548	24.3	25.6	24.6	1.684	1.655	1.676
July ..	2.719	0.716	0.743	0.692	26.3	27.3	25.5	2.003	1.976	2.027
Aug. ..	2.649	0.702	0.715	0.671	26.5	27.0	25.3	1.947	1.934	1.978
Year ..	29.380	14.901	15.655	14.788	50.7	53.3	50.3	14.479	13.725	14.592

Area of each gauge 1/1000th acre.

CHEMICAL ANALYSES OF FERTILISERS USED IN REPLICATED EXPERIMENTS

Fertilisers.	%N.	% Water Sol. P_2O_5	Citric Acid Sol. P_2O_5	% Total P_2O_5	% K_2O	%Cl.
Sulphate of Ammonia	20.9	—	—	—	—	—
Muriate of Ammonia	26.0	—	—	—	—	—
Nitrate of Soda	16.0	—	—	—	—	—
Urea	45.8	—	—	—	—	—
Cyanamide	19.6	—	—	—	—	—
Dried Blood	10.4	—	—	0.52	—	—
Superphosphate	—	16.4	—	17.4	—	—
Basic Slag—High Sol	—	—	96.5	14.9	—	—
Basic Slag —Low Sol.. ..	—	—	23.0	15.1	—	—
Ground Mineral Phosphate	—	—	—	25.9	—	—
Steamed Bone Flour	—	—	—	29.2	—	—
Sulphate of Potash	—	—	—	—	48.9	—
Muriate of Potash	—	—	—	—	51.3	49.3
Potash Manure Salts (30%) ..	—	—	—	—	30.9	50.9
Potash Mineral	—	—	—	—	16.2	—
Agricultural Salt	—	—	—	—	—	56.5
Magnesium Sulphate	—	—	—	—	14.1 (MgO)	—

SOIL DATA FOR ROTHAMSTED.

ROTHAMSTED SOIL—MECHANICAL ANALYSES.

Diameter mm.	Great Harpenden. 0-10 cm.	Barnfield profile. 0-19 cm.	19-47 cm.	47-97 cm.	97-127 cm.	Broadbalk. Plot 14 :8 0-15 cm. *
Coarse sand 2-0.2 ..	9.6	6.7	1.9	2.2	6.4	9.2
Fine sand 0.2-0.02	39.6	33.0	19.1	13.1	25.0	36.0
Silt 0.02-0.002 ..	22.5	18.5	14.3	12.3	15.7	24.0
Clay below 0.002 ..	23.3	31.7	59.3	65.3	49.3	27.0
Moisture in air dry soil	2.9	4.1	6.9	8.4	6.1	2.1
Loss by solution ..	0.8	1.0	0.3	0.2	0.1	0.6
Difference	+1.3	+5.0	-1.8	-1.5	-2.6	+1.1
Total ..	100.0	100.0	100.0	100.0	100.0	100.0

* These results were obtained from the 1926 A.E.A. fractions

WOBURN DATA.

Soil Mechanical Analyses.

Diameter mm.	Woburn profile. 0-19 cm.	19-40 cm.	40-63 cm.
Coarse sand 2-0.2	39.4	41.2	32.2
Fine sand 0.2-0.02	29.8	31.9	37.3
Silt 0.02-0.002	11.5	12.3	16.5
Clay below 0.002	10.5	10.0	11.7
Air dry moisture	2.9	1.8	1.7
Loss by solution	1.0	0.7	0.3
Difference	+4.9	+2.1	+0.3
Total	100.0	100.0	100.0

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 Courses, 1848-1927.						
	Roots (Swedes) .. cwt.*	32.7	11.2	175.7	195.9	355.3	302.1
	Barley—						
	Dressed Grain bush.	22.2	20.2	23.1	27.4	31.1	35.4
	Total Straw† cwt.	13.6	13.4	13.7	15.7	18.8	21.8
	Beans—						
	Dressed Grain bush.	—	13.1	—	18.2	—	22.3
	Total Straw cwt.	—	9.2	—	13.2	—	15.3
	Clover Hay cwt.	—	27.1	—	52.3	—	52.6
	Wheat—						
	Dressed Grain bush.	24.0	22.3	28.1	30.6	28.9	30.4
	Total Straw† .. cwt.	23.4	21.6	28.6	29.8	30.8	29.8
	Present Course (21st), 1928, 1929 and 1930.						
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

* Plots 1, 3 and 5 based upon 18 courses. Plots 2, 4 and 6 based upon 17 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.

Wheat after Fallow (without Manure, 1851 and since). Hoos Field, 1927-1930.

	1927	1928	1929	1930	Average 75 years 1856—1930
Dressed Grain: Yield per acre—bushels	0.48	10.47	12.23	9.52	14.22
Dressed Grain: Weight per bushel—lb.	57.0	55.6	60.3	62.0	59. 5
Offal Grain per Acre—lb.	20.0	—	4.8	118.5	51.2
Straw per Acre—lb.	229.0	1078.3	1038.6	898.0	—
Total straw per Acre—cwt.	2.7	9.6	9.3	10.7	12.4
Proportion of Total Grain to 100 of total Straw	15.8	54.0	71.4	59.2	—

MANGOLDS—BARNFIELD, 1930

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

PRODUCE PER ACRE.

	Strip.	Strip Manures. (Amounts stated are per acre). Wide—normal spacing 26in. (as hitherto). Narrow—spacing of 20in.		1930. Cross Dressings. O None.	N Nitrate of Soda (550 lb.)	A Sulphate of Ammonia (412 lb.)	AC Sulphate of Ammonia (412 lb.) & Rape Cake	C Rape Cake (2,000 lb.)	50-Year Average, 1876-1928† Cross Dressings. O None.	N Nitrate of Soda (550 lb.)	A Sulphate of Ammonia (412 lb.)	AC Sulphate of Ammonia (412 lb.) & Rape Cake	C Rape Cake (2,000 lb.)
				Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
ROOTS	1	Dung only (14 tons)	Wide	7.65	15.39	11.55	16.68	16.69	17.47	26.16	21.70	23.58	23.53
			Narrow	11.77	17.96	12.72	19.82	18.84					
	2	Dung, Superphosphate (3½ cwt.), Sulphate of Potash (500 lb.)	Wide	11.77	16.00	10.18	20.48	18.06	18.94	26.68	24.71	27.57	26.50
			Narrow	10.43	12.75	14.10	19.47	16.39					
	4	Complete Minerals: Super. and Potash as 2, Salt (200 lb.), Sulphate of Magnesia (200 lb.)	Wide	3.21	(a)12.79*	15.75	26.78	19.02	4.60	(a)17.35	14.37	26.06	20.96
			Narrow	3.77	(b) 7.05	14.34	30.01	19.04		(b)17.81‡§			
	5	Superphosphate only (3½ cwt.)	Wide	3.62	4.39††	6.70	9.84	11.24	4.47	14.63	6.70	9.49	10.16
			Narrow	4.06		8.15	12.45	10.69					
	6	Super. (3½ cwt.) Sulphate of Potash (500 lb.) ..	Wide	4.37	5.85††	15.37	22.36	14.63	4.03	15.12	13.50	22.55	18.14
			Narrow	4.31		16.97	22.87	20.81					
	7	Super (3½ cwt.) Sulphate of Magnesia (200 lb.) & Sodium Chlodide (200 lb.)	Wide	4.23	6.04	16.39	21.48	14.99	4.86	16.04	14.70	22.31	19.10
			Narrow	4.09	7.56	19.74	22.43	19.18					
	8	No Mineral	Wide	3.55	3.37††	7.41	8.95	8.95	3.34	9.61	5.32	8.52	8.89
			Narrow	1.70		9.25	10.94	12.41					
	9	Sodium Chloride (200 lb.)., Nit. Soda (550 lb.), Sulph. Potash (500 lb.) and Sulph. Mag. (200 lb.)	Wide	21.28	—	—	—	—	—	—	—	—	—
			Narrow	20.08	—	—	—	—					
LEAVES	1	Dung only (14 tons)	Wide	2.48	4.20	3.86	6.24	5.73	3.04	4.65	4.93	5.25	4.54
			Narrow	3.31	4.34	3.82	6.38	6.72					
	2	Dung, Superphosphate (3½ cwt.), Sulphate of Potash (500 lb.)	Wide	2.90	3.98	2.56	5.18	4.80	3.16	5.15	5.49	6.29	4.80
			Narrow	2.93	3.19	3.83	5.23	4.40					
	4	Complete Minerals: Super. and Potash as 2, Salt (200 lb.) Sulphate of Magnesia (200 lb.)	Wide	0.79	(a) 3.21*	3.59	6.23	3.60	1.04	(a) 3.87	2.88	5.33	3.37
			Narrow	1.00	(b) 2.20	3.64	6.65	3.77		(b) 4.09‡§			
	5	Superphosphate only (3½ cwt.)	Wide	0.96	1.23††	2.91	4.18	4.29	1.05	3.19	2.61	3.29	2.84
			Narrow	1.12		3.58	5.00	4.35					
	6	Super. (3½ cwt.) Sulphate of Potash (500 lb.)	Wide	0.94	1.57††	3.72	6.14	3.18	0.93	3.04	2.81	5.20	2.87
			Narrow	1.10		3.55	5.55	3.75					
	7	Super. (3½ cwt.) Sulphate of Magnesia (200 lb.) and Sodium Chloride (200 lb.) ..	Wide	0.99	1.57	3.67	5.26	3.21	1.10	3.31	3.01	5.23	3.31
			Narrow	1.14	1.93	3.77	5.27	4.19					
	8	No Minerals	Wide	1.16	1.19††	3.05	3.64	3.73	0.98	3.19	2.52	3.30	2.84
			Narrow	0.75		3.38	4.00	4.19					
	9	Sodium Chloride (200 lb.), Nit. Soda (550 lb.), Sulph. Potash (500 lb.) and Sulph. Mag. (200 lb.)	Wide	3.57	—	—	—	—	—	—	—	—	—
			Narrow	3.10	—	—	—	—					

* 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. †† Wide and narrow bulked owing to small amount of produce.

HAY—THE PARK GRASS PLOTS

Plot.	Manuring (amounts stated are per acre).		1930. 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	27.7	12.3	40.0	2658	1105	3763	1
		limed ..	20.0	8.4	28.4	2052	750	2802	
2	Unmanured (after Dung 8 years, 1856–63) ..	not limed	22.8	8.8	31.6	2188	786	2974	2
		limed ..	20.9	6.2	27.1	1985	553	2538	
3	Unmanured	not limed	20.4	6.3	26.7	1862	562	2424	3
		limed ..	18.4	4.5	22.9	1686	400	2086	
4-1	Superphosphate of Lime (3½ cwt.)	not limed	25.8	5.5	31.3	2407	494	2901	4-1
		limed ..	19.0	3.0	22.0	1854	265	2119	
4-2	Superphosphate of Lime (3½ cwt.) and double dressing (412 lb.) Sulphate of Ammonia (=86 lb. N.)	not limed	8.9	1.1	10.0	780	95	875	4-2
		limed	41.3	6.9	48.2	4187	620	4807	
5-1	(N. half) Unmanured following double dressing Amm. salts (=86 lb. N.) 1856–97	not limed	17.1	4.0	21.1	1707	358	2065	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	21.9	7.7	29.6	2196	687	2883	5-2
6	Complete Mineral Manure as Plot 7; following double dressing Amm. salts (=86 lb. N.) 1856–68	not limed	28.4	12.2	40.6	2877	1089	3966	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	31.2	13.6	44.8	3145	1215	4360	7
		limed ..	45.0	20.3	65.3	4192	1820	6012	
8	Mineral Manure without Potash	not limed	24.6	9.1	33.7	2425	811	3236	8
		limed ..	18.5	8.5	27.0	1887	762	2649	
9	Complete Mineral Manure and double dressing (412 lb.) Sulphate of Ammonia (=86 lb. N.) ..	not limed	31.3	23.0	54.3	3037	2059	5096	9
		limed ..	59.5	21.5	81.0	5999	1927	7926	
10	Mineral Manure (without Potash) and double dressing Amm. salts (=86 lb. N.)	not limed	19.5	14.8	34.3	2032	1325	3357	10
		limed ..	47.0	12.0	59.0	4709	1076	5785	
11-1	Complete Mineral Manure and treble dressing (618 lb.) Sulphate of Ammonia (129 lb. N.) ..	not limed	47.3	30.0	77.3	4806	2692	7498	11-1
		limed ..	63.4	19.0	82.4	6341	1699	8040	
11-2	As Plot 11-1 and Silicate of Soda	not limed	55.3	32.4	87.7	5594	2906	8500	11-2
		limed ..	63.2	28.2	91.4	6338	2529	8867	
12	Unmanured	not limed	17.9	9.0	26.9	1809	807	2616	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	42.6	22.9	65.5	4236	2048	6284	13
		limed ..	39.2	17.4	56.6	4015	1558	5573	
14	Complete Mineral Manure and double dressing (550 lb.) Nitrate of Soda (=86lb. N.) ..	not limed	59.1	24.8	83.9	5921	2218	8139	14
		limed (sun)	51.6	13.5	65.1	5190	1210	6400	
		lmd (shade)	40.6	7.5	48.1	4079	670	4749	
15	Complete Mineral Manure as Plot 7; following double dressing Nitrate of Soda (=86 lb. N., 1858–75)	not limed	35.8	17.7	53.5	3565	1583	5148	15
		limed ..	36.0	13.2	49.2	3544	1180	4724	
16	Complete Mineral Manure and Single Dressing (275 lb.) Nitrate of Soda (= 43 lb. N.)	not limed	40.1	14.7	54.8	4126	1320	5446	16
		limed	30.9	12.6	43.5	3115	1127	4242	
17	Single dressing (275 lb.) Nitrate of Soda (=43lb. N.)	not limed	30.6	10.4	41.0	2970	936	3906	17
		limed ..	30.4	7.3	37.7	3118	655	3773	
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	20.4	12.5	32.9	2026	1116	3142	18
		limed (6788 lb.)	53.9	21.7	75.6	5367	1945	7312	
		limed (3951 lb.)	40.8	17.0	57.8	4150	1523	5673	
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	29.1	18.8	47.9	2968	1688	4656	19
		limed (3150 lb.)	24.0	13.5	37.5	2325	1213	3538	
		limed (570 lb.)	24.4	11.5	35.9	2450	1032	3482	
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	36.9	16.1	53.0	3835	1445	5280	20
		limed (2772 lb.)	36.4	15.1	51.5	3826	1353	5179	
		limed (570 lb.)	38.1	14.1	52.2	3905	1260	5165	

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.

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WHEAT—BROADBALK FIELD, 1930

Plot.	Manurial Treatment (amounts stated are per acre).	Dressed Grain, bushels per acre (in some cases estimated from half or quarter-bushel).					Total Grain, cwt. per acre.					74-year Average 1852–1925 (Prior to fallow). Total Grain, cwt.
		I	II	III	IV	V	I	II	III	IV	V	
		3rd year after fallow.		after 4 years' fallow.	after 2 years' fallow.		3rd year after fallow.		after 4 years' fallow.	after 2 years' fallow.		
2A	Farmyard Manure (14 tons)	7.5	16.8	34.7	35.9	26.1	5.4	10.2	23.4	23.1	17.3	16.3**
2B	Farmyard Manure (14 tons)	9.0	19.3	40.9	44.0	28.8	6.2	12.1	25.4	28.0	18.3	19.4
3	Unmanured since 1839	5.0	6.9	32.5	27.1	22.4	3.3	4.5	20.4	16.4	12.9	6.7
5	Complete Mineral Manure §§	4.6	6.3	34.9	29.5	25.2	3.1	4.3	21.5	18.5	14.2	7.8
6	As 5, and 206 lb. Sulphate of Ammonia	7.1	9.1	40.6	32.6	23.0	4.5	5.8	25.3	19.9	14.6	12.5
7	As 5, and 412 lb. Sulphate of Ammonia	9.1	14.9	38.9	34.6	24.2	5.8	9.4	25.9	22.6	16.2	17.6
8	As 5, and 618 lb. Sulphate of Ammonia	10.6	21.3	42.9	45.5	31.0	6.8	12.8	26.7	26.7	20.2	20.1
9	As 5, and 275 lb. Nitrate of Soda	9.9	15.8	39.1	38.7	31.2	6.4	9.4	24.6	22.8	18.3	13.9††
10	412 lb. Sulphate of Ammonia	8.0	12.7	44.1	35.5	22.4	5.3	8.1	26.2	21.8	14.8	10.9
11	As 10, and Superphosphate (3½ cwt.)	8.5	11.2	44.0	41.0	33.5	5.3	6.9	26.0	24.4	19.0	12.3
12	As 10, and Super. (3½ cwt.) and Sulph. Soda (366 lb.)	6.4	9.7	41.0	44.2	30.8	4.4	6.1	23.9	26.9	19.2	15.7
13	As 10, and Super (3½ cwt.) and Sulph. Potash (200 lb.)	6.5	10.9	42.3	37.9	29.2	4.6	7.1	25.3	23.0	17.1	17.0
14	As 10, and Super (3½ cwt.) and Sulph. Magnesia (280 lb.)	7.6	8.3	45.1	43.1	24.1	5.0	5.6	26.7	25.9	15.7	15.5
15	As 5, and 412 lb. Sulphate of Ammonia all applied in Autumn	7.2	10.5	41.1	39.8	24.5	4.7	6.8	24.8	23.7	14.2	16.1
16	As 5, and 550 lb. Nitrate of Soda	6.0	9.9	42.6	40.6	27.5	4.0	6.8	26.1	24.8	16.5	17.8††
17	Minerals alone as 5 or 412 lb. Sulphate of Ammonia alone in alternate years	A6.1	9.4	39.2	33.3	22.5	4.0	6.0	23.7	20.3	14.3	A16.1*
18		M0.6	2.9	33.7	29.8	19.1	0.5	2.1	20.3	17.9	12.2	M 8.1
19	Rape Cake (1,889 lb.)	7.2	12.7	39.8	33.9	20.9	4.7	8.0	24.3	20.6	13.2	12.6‡
20	As 7, without Super.	5.2	—	—	—	—	3.5	—	—	—	—	10.3§

For notes see p. 123. *A=Ammonia series. M=Mineral series.

WHEAT—BROADBALK FIELD, 1930

Plot.	Manurial Treatment (amounts stated are per acre).	Bushel Weight in lb. (in some cases estimated from half or quarter-bushel) I	II	III	IV	V	Total Straw†, cwt. per acre. I	II	III	IV	V	74-year Average 1852–1925 (Prior to fallow). Total Straw, cwt.
		3rd year after fallow.		after 4 years' fallow.	after 2 years' fallow.		3rd year after fallow.		after 4 years' fallow.	after 2 years' fallow.		
2A	Farmyard Manure (14 tons)	60.5	61.0	62.2	62.5	61.5	26.8	27.1	56.6	56.3	60.0	32.1**
2B	Farmyard Manure (14 tons)	59.8	61.3	61.8	61.8	61.0	29.1	27.9	60.8	62.1	62.1	34.2
3	Unmanured since 1839	61.0	60.3	63.1	63.1	59.5	6.0	5.7	37.3	24.8	24.5	9.8
5	Complete Mineral Manure§§	60.5	60.5	63.2	62.6	58.7	7.0	8.7	41.0	33.3	30.3	11.5
6	As 5, and 206 lb. Sulphate of Ammonia	60.8	60.5	62.5	62.2	62.4	10.6	11.8	54.5	43.9	40.4	20.3
7	As 5, and 412 lb. Sulphate of Ammonia	60.5	61.5	61.5	61.1	60.9	23.2	21.4	59.8	59.0	60.8	32.1
8	As 5, and 618 lb. Sulphate of Ammonia	59.4	60.6	60.7	59.6	60.5	36.2	34.9	69.3	67.1	63.8	39.8
9	As 5, and 275 lb. Nitrate of Soda	60.5	60.3	61.0	60.9	60.3	21.2	22.4	61.4	57.4	59.8	24.6††
10	412 lb. Sulphate of Ammonia	60.8	62.4	62.1	62.5	62.6	19.6	17.1	52.1	45.0	39.4	17.8
11	As 10, and Superphosphate (3½ cwt.)	60.0	60.8	60.6	60.8	58.3	16.2	14.7	54.4	51.9	51.3	21.4
12	As 10, and Super (3½ cwt.) and Sulph. Soda (366 lb.)	60.5	60.3	60.2	60.2	59.4	13.6	13.3	59.4	64.9	58.3	26.8
13	As 10, and Super (3½ cwt.) and Sulph. Potash (200 lb.)	60.5	61.5	61.0	59.3	58.4	14.3	15.3	61.3	63.2	58.1	30.6
14	As 10, and Super (3½ cwt.) and Sulph. Magnesia (280 lb.)	60.3	60.8	61.1	60.2	60.6	13.5	12.4	60.0	64.9	50.8	26.8
15	As 5, and 412 Sulphate of Ammonia all applied in Autumn	60.3	61.6	61.5	62.1	59.4	10.0	11.6	51.9	51.6	35.1	28.2
16	As 5, and 550 lb. Nitrate of Soda	59.5	61.0	60.5	61.1	59.6	24.3	25.1	69.7	61.4	60.5	35.2††
17	Minerals alone as 5 or 412 lb. Sulphate of Ammonia	A59.8	61.0	61.2	61.0	61.2	11.6	14.2	53.3	56.3	50.6	A28.1*
18	alone in alternate years	M —	60.0	62.9	62.4	62.3	2.0	3.3	36.3	37.1	28.4	M12.3
19	Rape Cake (1,889 lb.)	60.0	61.0	62.0	62.3	61.8	13.7	14.9	49.5	50.1	40.7	22.0‡
20	As 7, without Super	58.5	—	—	—	—	12.6	—	—	—	—	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.

PERMANENT BARLEY PLOTS

Hoos Field, 1930

Plot	Manuring (Amounts stated are per acre)	Total Grain per acre Plumage Archer cwt.	Total Grain per acre Spratt Archer cwt.	76 Years' Average 1852-1928 Dressed Grain per acre. bush.‖	Total Straw per acre. Plumage Archer cwt.	Total Straw per acre. Spratt Archer cwt.	76 Years' Average 1852-1928 Total Straw per acre. cwt.†
1O	Unmanured	0.3	0.4	13.4	1.0	0.8	7.8
2O	Superphosphate only (3½ cwt.) ..	4.9	4.6	19.0	4.1	3.8	9.8
3O	Alkali Salts only (200 lb. Sulphate of Potash; 100 lb. Sulphate of Soda; 100 lb. Sulphate of Magnesia)	1.8	1.5	14.3	2.8	2.1	8.7
4O	Complete Minerals; as 3O with Superphosphate (3½ cwt.) ..	3.6	4.8	19.0	3.3	4.1	11.2
5O	Potash (200 lb.) and Superphosphate (3½ cwt.)	4.2	4.2	15.5	4.1	4.6	9.4
1A	Ammonium Salts only (206 lb. Sulphate of Ammonia)	1.4	2.0	23.7	2.2	3.3	13.7
2A	Superphosphate and Amm. Salts ..	9.0	9.5	35.8	8.9	8.4	20.4
3A	Alkali Salts and Amm. Salts ..	3.9	2.6	25.8	5.5	4.1	16.0
4A	Complete Minerals and Amm. Salts	7.4	8.9	39.3	8.4	8.7	23.6
5A	Potash, Super. and Amm. Salts ..	6.6	6.1	33.8	9.7	8.6	21.7
1AA	Nitrate of Soda only (275 lb.) ..	2.4	2.4	24.3*	4.3	4.1	15.4*
2AA	Superphosphate and Nitrate of Soda	9.0	9.5	38.8*	9.3	9.4	23.1*
3AA	Alkali Salts and Nitrate of Soda ..	4.0	4.0	24.5*	5.5	5.5	16.6*
4AA	Complete Minerals and Nitrate of Soda	8.5	8.7	37.7*	9.3	8.5	23.6*
1AAS	As Plot 1AA and Silicate of Soda (400 lb.)	3.4	5.5	30.2*	3.8	6.7	18.2*
2AAS	As Plot 2AA and Silicate of Soda (400 lb.)	10.3	10.7	39.7*	10.5	11.2	23.9*
3AAS	As Plot 3AA and Silicate of Soda (400 lb.)	6.4	6.7	31.2*	7.2	7.1	19.9*
4AAS	As Plot 4AA and Silicate of Soda (400 lb.)	9.6	10.5	39.9*	10.3	10.4	25.4*
1C	Rape Cake only (1,000 lb.) ..	6.0	6.2	35.5	6.7	6.5	20.6
2C	Superphosphate and Rape Cake ..	9.0	9.1	38.1	10.7	9.9	22.0
3C	Alkali Salts and Rape Cake ..	7.3	8.2	33.7	9.6	9.3	20.4
4C	Complete Minerals and Rape Cake	8.3	8.9	37.5	10.0	10.1	22.6
7-1	Unmanured (after dung (14 tons) for 20 years (1852–71) ..	4.0	4.9	22.5‡	4.4	5.1	13.5‡
7-2	Farmyard Manure (14 tons) ..	7.7	8.1	44.6	9.1	10.0	28.1
6-1	Unmanured since 1852	1.6	0.9	14.7	2.7	2.3	8.6
6-2	Ashes from Laboratory furnace ..	2.3	2.9	15.7	2.7	3.3	9.3
1N	Nitrate of Soda only (275 lb.) ..	2.1	1.7	28.7§	2.6	2.4	17.8§
2N	Nitrate of Soda only (275 lb.) ..	6.8	5.1	31.7§§	8.8	7.2	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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SCHEME FOR CONTINUOUS ROTATION EXPERIMENTS COMMENCING 1930

Rotation I.—FOUR COURSE ROTATION EXPERIMENT.

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.

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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.)

First Series A H (Plots 1-25) Seeds Hay.—Layout in 1929-30.

BLOCKS					
a	1 / 5	2 / 2	3 / 1	4 / 3	5 / 4
b	6 / 5	7 / 1	8 / 3	9 / 4	10 / 2
c	11 / 3	12 / 2	13 / 5	14 / 4	15 / 1
d	16 / 1	17 / 3	18 / 4	19 / 5	20 / 2
e	21 / 4	22 / 1	23 / 5	24 / 3	25 / 2

Upper Figure—Plot Number
Lower Figure—Treatment Number

Hence plot 15 receives treatment 1 in the first year of the experiment, etc.

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

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Second Series A W (Plots 26-50) Wheat.—Layout in 1929-30.

BLOCKS					
a	26 3	27 2	28 5	29 4	30 1
b	31 4	32 2	33 1	34 5	35 3
c	36 1	37 4	38 3	39 5	40 2
d	41 4	42 5	43 3	44 2	45 1
e	46 2	47 4	48 3	49 1	50 5

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

Third Series A B (Plots 51-75) Barley.—Layout in 1929-30.

BLOCKS					
a	51 3	52 4	53 1	54 2	55 5
b	56 3	57 4	58 5	59 2	60 1
c	61 2	62 4	63 3	64 1	65 5
d	66 5	67 1	68 3	69 4	70 2
e	71 4	72 2	73 1	74 5	75 3

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

Fourth Series A T (Plots 76-100) Turnips.—Layout in 1929-30.

BLOCKS					
a	76 4	77 2	78 5	79 3	80 1
b	81 5	82 2	83 1	84 4	85 3
c	86 2	87 1	88 5	89 4	90 3
d	91 2	92 4	93 1	94 5	95 3
e	96 5	97 2	98 3	99 1	100 4

Rotation II.—SIX COURSE EXPERIMENT.

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.

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 ef 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 A, C, E the order of the sets of treatments is N, P, K, and on series B, D, F, the order is N, K, P, *i.e.*, on plots of series A, C, E treatment ON is followed by treatment 4P, OP by 4K, and OK by 4N, while on series B, D, F, 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. The lay-out of the plots in the latter season is shown in the plan.

Rotation II, Six Course –Long Hoos (Section 4) 1930-31.

First Series—B W (Plots 1-15) Wheat.

1 3P	2 OP	3 ON	4 4K	5 2K
6 4N	7 2P	8 3N	9 OK	10 1K
11 1P	12 2N	13 1N	14 3K	15 4P

Second Series.—B S (Plots 16-30) Sugar Beet.

16 3N	17 4P	18 2P	19 3P	20 3K
21 ON	22 2N	23 1P	24 OK	25 4N
26 1N	27 OP	28 4K	29 2K	30 1K

Third Series.—B B (Plots 31-45) Barley.

31 2K	32 OK	33 OP	34 2P	35 3N
36 3K	37 1K	38 4N	39 4K	40 ON
41 4P	42 3P	43 1P	44 2N	45 1N

Fourth Series.—B C (Plots 46-60) Clover.

46 3P	47 OP	48 1K	49 4N	50 2N
51 1P	52 4K	53 2K	54 3N	55 1N
56 2P	57 OK	58 3K	59 ON	60 4P

Fifth Series.—B P (Plots 61-75) Potatoes.

61 4P	62 OK	63 1P	64 OP	65 1N
66 3K	67 1K	68 2P	69 ON	70 4K
71 2K	72 3P	73 4N	74 2N	75 3N

Sixth Series.—B F (Plots 76-90) Forage-Crop (followed by Mustard and Rye).

76 4K	77 OP	78 3K	79 OK	80 ON
81 2P	82 3P	83 4N	84 2N	85 3N
86 1P	87 2K	88 1K	89 4P	90 1N

Upper Figure—Plot Number.
Lower Figure—Treatment Symbol.

Rotation I., Four-Course, Hoos Field, 1930 (First Preliminary year).

For full particulars of experiment see p. 125.

Plots $\frac{1}{40}$ acre.

TREATMENTS:

1. Farmyard manure. } 50 cwt. organic matter per acre.
2. Artificial farmyard manure prepared by Adco process. } 50 cwt. organic matter per acre.
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 1930.
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 1930 shown in bold type.

A H (Plots 1-25) Seeds Hay.

Seed sown: Oct. 3rd, 1929. Cut: July 9th.

Yield of Dry Matter in cwt. per acre.

N

BLOCKS	Plot						Plot
a	1	(5) 13.6	(2) **27.9**	(1) 11.4	(3) 10.7	(4) 11.8	5
b	6	(5) 9.6	(1) 8.9	(3) **42.5**	(4) 11.4	(2) 12.9	10
c	11	(3) 9.3	(2) 8.2	(5) 10.0	(4) 10.7	(1) **22.5**	15
d	16	(1) 9.3	(3) 8.6	(4) **21.8**	(5) 11.1	(2) 15.7	20
e	21	(4) 10.7	(1) 10.7	(5) **17.9**	(3) 13.6	(2) 10.7	25

A W (Plots 26-50) Wheat (harvested by sampling method.)

Seed sown: March 20th (autumn sowing failed). Harvested: Sept. 22nd. Variety: Little Joss.

N.

Yield of Grain in cwt. per acre.

BLOCKS	Plot						Plot
a	26	(3) 14.4	(2) **17.2**	(5) 10.2	(4) 11.6	(1) 16.0	30
b	31	(4) **19.8**	(2) 14.8	(1) 15.4	(5) 14.1	(3) 12.8	35
c	36	(1) 13.9	(4) 14.9	(3) 15.9	(5) **20.8**	(2) 20.1	40
d	41	(4) 17.6	(5) 16.9	(3) 14.9	(2) 18.3	(1) **15.9**	45
e	46	(2) 14.0	(4) 13.0	(3) **24.5**	(1) 15.0	(5) 10.9	50

Yield of straw in cwt. per acre.

BLOCKS	Plot						Plot
a	26	(3) 24.2	(2) **28.1**	(5) 15.2	(4) 17.1	(1) 26.3	30
b	31	(4) **28.3**	(2) 22.9	(1) 21.3	(5) 22.2	(3) 20.8	35
c	36	(1) 21.0	(4) 22.4	(3) 24.3	(5) **30.4**	(2) 29.5	40
d	41	(4) 28.6	(5) 25.9	(3) 22.7	(2) 29.0	(1) **28.6**	45
e	46	(2) 23.2	(4) 20.2	(3) **35.3**	(1) 24.7	(5) 24.2	50

A B (Plots 51-75) Barley.

Seed sown: March 19th. Harvested: Sept. 1st. Variety: Plumage Archer.

N.

Yield of Grain in cwt. per acre.

BLOCKS							
a	51	3 **22.5**	4 11.7	1 12.7	2 10.4	5 11.8	55
b	56	3 15.1	4 11.3	5 **17.6**	2 10.6	1 11.0	60
c	61	2 **22.8**	4 11.1	3 13.1	1 10.5	5 12.7	65
d	66	5 14.6	1 **16.2**	3 10.7	4 10.0	2 12.5	70
e	71	4 **21.3**	2 9.9	1 10.6	5 12.1	3 13.1	75

Yield of Straw in cwt. per acre.

51	3 **30.1**	4 33.1	1 30.8	2 26.1	5 28.7	55
56	3 39.0	4 38.8	5 **37.9**	2 30.8	1 32.7	60
61	2 **30.5**	4 42.5	3 42.2	1 31.3	5 37.0	65
66	5 31.6	1 **38.3**	3 34.2	4 28.6	2 31.1	70
71	4 **25.9**	2 23.7	1 27.9	5 29.3	3 27.4	75

A T (Plots 76-100) Turnips.

Seed sown: July 15th (after swedes, which failed). Lifted: Nov. 11th-13th Variety: Green Top.

N.

Yield of Roots (washed) in tons per acre.

BLOCKS							
a	76	4 7.39	2 **9.66**	5 6.54	3 3.23	1 3.71	80
b	81	5 6.93	2 6.32	1 5.27	4 2.11	3 **10.86**	85
c	86	2 6.98	1 **9.00**	5 4.37	4 1.69	3 2.27	90
d	91	2 6.46	4 3.41	1 3.61	5 **4.02**	3 2.44	95
e	96	5 6.26	2 1.06	3 2.18	1 1.55	4 **9.52**	100

Yield of Tops in tons per acre.

76	4 4.39	2 **7.17**	5 4.04	3 2.45	1 3.06	80
81	5 4.45	2 3.68	1 3.93	4 1.96	3 **8.34**	85
86	2 4.26	1 **5.51**	5 3.88	4 1.60	3 2.84	90
91	2 3.94	4 2.21	1 3.50	5 **2.85**	3 2.19	95
96	5 4.27	2 0.94	3 2.58	1 1.61	4 **6.17**	100

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Rotation II., Six-Course, 1930.

For full particulars of experiment see p. 128

Plots $\frac{1}{40}$ acre

TREATMENTS:

N—4, 3, 2, 1 and 0 units of N, each with 2 units P_2O_5 and 2 units K_2O.
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.
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.

B S—Sugar Beet—Long Hoos VI.

Manures applied: May 8th. Seed sown: May 9th. Lifted: Sept. 26th-30th. Variety: Johnson P.

N.W.

Washed Roots—tons per acre.

4N 6.96	0N 6.32	3P 7.05	4P 6.35	4K 5.44
1N 7.07	3N 8.03	2P 8.04	1K 6.97	0K 5.79
2N 5.95	1P 6.39	0P 5.54	3K 5.98	2K 5.24

Tops—tons per acre.

4N 11.65	0N 7.34	3P 9.83	4P 9.29	4K 9.38
1N 9.27	3N 10.53	2P 11.34	1K 9.69	0K 10.26
2N 7.76	1P 8.33	0P 8.50	3K 7.85	2K 9.16

B B—Barley—Long Hoos V.

Manures applied: Feb. 27th. Seed sown: Feb. 28th. Harvested: Aug. 15th. Variety: Plumage Archer.

N.E.

Yield of Grain in cwt. per acre.

4P 25.5	1P 25.9	2K 29.4	0K 30.1	3N 22.3
2P 26.6	0P 28.0	3K 30.4	4N 30.5	2N 27.4
3P 25.4	1K 28.6	4K 28.9	1N 25.2	0N 21.2

Yield of Straw in cwt. per acre.

4P 37.0	1P 24.3	2K 40.3	0K 29.7	3N 23.0
2P 31.2	0P 30.4	3K 35.5	4N 34.8	2N 29.7
3P 38.6	1K 33.4	4K 33.2	1N 26.8	0N 23.1

B C—Clover Hay—Long Hoos IV.

Manures applied: Mar. 3rd. Seed sown: April 18th, 1929. Cut: June 14th.

Yield of Dry Matter in cwt. per acre.

N.E.

4P 38.8	1P 35.0	1N 32.7	0N 22.3	3K 36.9
0P 35.7	3P 35.7	4N 46.7	1K 37.1	2K 36.2
2P 35.9	3N 42.2	2N 34.2	4K 36.1	0K 33.1

B W—Wheat—Great Knott.

Manures applied: Mar. 4th. Seed sown: Sept. 20th, 1929. Harvested: Aug. 9-11th. Variety: Million.

N.E.

Yield of grain in cwt. per acre.

0K 24.9	1K 26.7	2P 24.8	1P 20.3	2N —
4K 30.6	2K 31.1	3P 26.2	1N 21.6	0N —
3K 30.2	4P 31.2	0P 28.3	3N 25.6	4N —

Yield of straw in cwt. per acre.

0K 63.7	1K 65.1	2P 63.9	1P 58.1	2N —
4K 68.3	2K 81.2	3P 68.1	1N 52.7	0N —
3K 79.8	4P 71.1	0P 65.3	3N 68.1	4N —

The end three plots, and part of the adjoining three, were discarded owing to lodging.

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B P—Potatoes—Long Hoos VI.

Manures applied : April 1st. Planted : April 3rd. Lifted : Sept. 25th-26th. Variety : Ally.

Yield of Roots in tons per acre.

N.E.

0P 9.09	1P 6.67	4K 7.23	1K 5.13	1N 6.05
3P 7.14	4P 6.18	0K 3.70	3N 5.73	4N 6.72
2P 6.44	3K 6.91	2K 6.04	0N 4.50	2N 5.68

B F—Forage Crop—Pastures Field.

Manures applied : Mar. 25th. Seed sown : Sept. 24th-25th. Harvested : June 13th (followed by Mustard and Rye)

Yield of Dry Matter in cwt. per acre.

N.E.

3K 43.4	1K 48.4	1P 46.6	3P 48.7	4N 51.2
4K 45.4	2K 47.7	0P 50.0	0N 39.8	1N 46.5
0K 41.4	4P 45.9	2P 48.4	3N 53.2	2N 52.0

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.	N		P		K	
Sugar Beet—Roots, tons	1.49	± 1.79	1.52	± 1.79	—0.68	± 1.08
Tops, tons	**6.59**	± 2.26	2.05	± 2.26	—1.44	± 1.36
Barley—Grain, cwt.	**10.5**	± 4.2	—3.7	± 4.2	—0.2	± 2.5
Straw, cwt.	13.1	± 9.1	18.3	± 9.1	3.6	± 5.4
Clover Hay—dry matter, cwt.	**38.9**	± 3.5	4.6	± 3.5	2.3	± 2.1
Wheat—Grain, cwt.	—		7.8	± 6.7	6.0	± 4.0
Straw, cwt.	—		14.4	± 14.0	9.6	± 8.4
Potatoes—tons	2.75	± 1.38	**—3.57**	± 1.38	**3.54**	± 0.83
Forage—dry matter, cwt.	**19.6**	± 6.0	—4.2	± 6.0	1.2	± 3.6

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.
Sugar Beet—Roots	3.46	3.52	—2.61	± 4.16
Tops	**10.57**	3.30	—3.85	± 3.63
Barley—Grain	**5.81**	—2.03	—0.22	± 2.36
Straw	6.24	8.76	2.90	± 4.34
Clover Hay—dry matter	**16.24**	1.92	1.62	± 1.47
Wheat—Grain	—	4.27	5.43	± 3.65
Straw	—	3.16	3.49	± 3.08
Potatoes	6.63	**—8.61**	**14.23**	± 3.33
Forage—dry matter	**6.22**	—1.33	0.61	± 1.92

Significant results are in bold type. Negative sign means depression.

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Barley: Comparison of Nitrogenous Fertilisers, Sulphate and Muriate of Ammonia, Nitrate of Soda and Cyanamide.

R B—Long Hoos (Section 5), 1930.

N.E.

I.	C	S	N	M	O
II.	N	O	S	C	M
III.	S	N	M	O	C
IV.	M	C	O	N	S
V.	O	M	C	S	N

System of Replication: Latin Square.
Area of Each Plot: 1/40th acre.
Treatments:
O = No Nitrogen.
S = Sulphate of Ammonia.
M = Muriate of Ammonia
N = Nitrate of Soda.
C = Cyanamide.
(S, M, N, C) at the rate of 0.4 cwt. N per acre.

All manures applied Feb. 28th, except Cyanamide which was sown Mar. 3rd.
Drilled: Feb. 28th. Harvested: Aug. 15th.
Variety: Plumage Archer. Previous crop: Sugar Beet (tops eaten off by sheep).

Actual weight in lb.

	Grain.					Straw.				
Row.	O	S	M	N	C	O	S	M	N	C
I. ..	47.25	70.50	65.75	69.50	62.50	52.75	75.00	73.25	76.50	66.50
II. ..	67.00	72.25	64.75	68.00	64.25	74.00	86.25	67.50	80.00	74.25
III. ..	58.75	69.00	70.75	81.50	57.75	72.75	74.00	87.25	88.50	66.75
IV. ..	60.50	63.50	69.25	65.50	67.25	73.50	69.50	77.50	82.50	72.75
V. ..	53.25	63.00	71.50	68.50	60.50	54.25	68.00	69.75	69.50	84.50

Summary of Results.

	Average yield.	No Nitrogen	Sulphate of Ammonia.	Muriate of Ammonia.	Nitrate of Soda.	Cyanamide.	Mean.	Standard Error.
Grain ..	cwt. per acre	20.5	24.2	24.4	25.2	22.3	23.3	0.47
	per cent.	87.8	103.6	104.8	108.1	95.7	100.0	2.01
Straw ..	cwt. per acre	23.4	26.6	26.8	28.4	26.1	26.2	0.71
	per cent.	89.1	101.5	102.1	108.1	99.3	100.0	2.70

Significant response to all forms of nitrogenous fertiliser in both grain and straw. With grain the yield of the cyanamide plots is significantly below that of the others, while the highest yield of all is that from the Nitrate of Soda plots. With straw the yields are in the same order as with grain, but the differences in this case are hardly significant.

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WHEAT

(*a*) Variety Trial.
(*b*) Nitrogenous Fertilisers as Top Dressing: Sulphate and Muriate of Ammonia.

Each in single and double dressings.
R W—Long Hoos (Section 3), 1930.

A S.E. B

Sq, Sw, M, Y, Y, Sq, Sw, M, M, Y, Sw, Sq, Sq, Sw, M, Y, Sq, Y, M, Sw, M, Sw, Y, Sq, Y, M, Sw, Sq, Sw, Y, Sq, M

	S, L	M, E. & L	O(1)	S, E	S, E	O (2)	S, L	M, E & L	
C	S, L	O (1)	M, E & L	S, E	O (2)	S, E & L	M, L	M, E	D
	M, E	O (1)	S, E & L	M, L	S, E & L	M, E	M, L	O (2)	

E F

SYSTEM OF REPLICATION: 6 randomised blocks.
AREA OF EACH BLOCKLET: 1/60th acre.
S = Sulphate of Ammonia } at the rate of
M = Muriate of Ammonia. } 0.2 cwt. N per acre.
O (1) and O (2) = No Top Dressing.
E = Early Top Dressing (Mar. 31st.)
L = Late Top Dressing (May 15th.)
E and L = Early and Late Top Dressing.
Basal Dressing: 3 cwt. Super. and 1½ cwt. Muriate of Potash per acre.

Strips running across the blocks were allotted to 4 varieties as indicated in plan.
Sq. = Square-Head's Master.
Sw. = Swedish Iron.
M = Million III.
Y = Yeoman II.
Wheat sown: Oct. 11th, 1929.
Harvested: Aug. 15th-16th, 1930.
Previous crop: Seeds.

Actual weights in lb.—Total Grain.

Variety.	Blocks.	O (1)	O (2)	S.E.	S.L.	M.E.	M.L.	S. E. & L.	M. E. & L.
Square-Head's Master	A and D	22.00	21.50	19.00	16.50	21.75	20.50	27.75	16.75
	C ,, F	24.50	23.50	28.75	29.50	25.75	20.50	28.25	25.50
	B ,, E	30.25	24.50	22.50	28.75	29.00	28.50	30.75	21.25
Average in cwt. per acre		13.1		12.5	13.3	13.7	12.4	15.5	11.3
Swedish Iron	A and D	31.50	31.50	31.00	26.50	29.50	31.75	36.75	27.00
	C ,, F	37.00	33.25	38.25	39.00	35.25	34.25	35.50	31.25
	B ,, E	39.50	39.25	34.75	38.75	39.00	35.00	32.75	39.00
Average in cwt. per acre		18.9		18.6	18.6	18.5	18.0	18.7	17.4
Million III	A and D	25.50	19.50	22.75	18.75	20.75	24.75	26.25	21.50
	C ,, F	30.50	23.75	23.50	34.75	25.75	21.00	24.50	29.75
	B ,, E	31.75	25.25	21.00	30.75	32.25	26.00	40.00	16.50
Average in cwt. per acre		14.0		12.0	15.0	14.1	12.8	16.2	12.1
Yeoman II	A and D	29.25	23.25	27.75	21.25	23.50	28.25	31.25	23.00
	C ,, F	30.00	29.25	24.50	29.25	28.00	30.25	28.50	28.50
	B ,, E	25.50	31.00	27.50	35.25	27.75	27.75	35.75	29.75
Average in cwt. per acre		15.0		14.2	15.3	14.2	15.4	17.1	14.5

Wheat, Long Hoos, 1930 (*cont.*)

Actual weights in lb.—Total Straw.

Variety.	Blocks.	O (1)	O (2)	S.E.	S.L.	M.E.	M.L.	S. E. & L.	M. E. & L.
Square-Head's Master	A and D	35.50	34.50	42.50	49.50	41.75	32.50	49.25	49.25
	C ,, F	41.50	33.50	54.25	59.50	46.25	45.00	50.75	51.50
	B ,, E	46.75	48.00	48.00	46.50	50.00	39.50	52.25	44.25
Average in cwt. per acre		21.4		25.8	27.8	24.6	20.9	27.2	25.9
Swedish Iron	A and D	40.00	38.00	49.00	49.00	40.00	40.25	56.25	50.50
	C ,, F	50.00	41.75	53.75	53.00	47.75	38.75	49.00	50.25
	B ,, E	53.50	53.75	52.25	47.25	50.00	47.00	50.25	58.50
Average in cwt. per acre		24.7		27.7	26.7	24.6	22.5	27.8	28.4
Million III	A and D	41.00	30.50	45.25	51.25	43.25	33.75	42.25	44.00
	C ,, F	41.50	41.25	43.50	55.25	39.75	31.00	43.50	45.25
	B ,, E	44.25	38.75	50.00	43.25	49.75	40.50	55.50	48.50
Average in cwt. per acre		21.2		24.8	26.7	23.7	18.8	25.2	24.6
Yeoman II	A and D	39.75	29.75	44.25	47.25	37.50	40.75	55.75	58.00
	C ,, F	41.00	35.75	41.00	46.25	45.00	41.75	48.50	44.00
	B ,, E	36.00	47.00	49.50	55.75	42.25	39.25	53.25	49.75
Average in cwt. per acre		20.5		24.1	26.7	22.3	21.7	28.1	27.1

Summary of Results—(a) Effect of Top Dressing (averaging varieties).

Grain. cwt. per acre.	Sulph./Amm. Not applied early.	Sulph./Amm. Applied early.	Sulph./Amm. Mean.	Mur./Amm. Not applied early.	Mur./Amm. Applied early.	Mur./Amm. Mean.	Mean of Sulphate and Muriate Not applied early.	Mean of Sulphate and Muriate Applied early.	Mean of Sulphate and Muriate Mean.
Not applied late	15.2	14.3	14.8	15.2	15.1	15.2	15.2	14.7	15.0
Applied late	15.6	16.9	16.2	14.7	13.8	14.2	15.2	15.4	15.3
Mean	15.4	15.6	15.5	15.0	14.4	14.7	15.2	15.1	15.1
Standard Errors	0.84 cwt. ; of margins 0.59 cwt.						0.59 cwt.; of margins 0.42 cwt.		

Grain. per cent.	Sulph./Amm. Not applied early.	Sulph./Amm. Applied early.	Sulph./Amm. Mean.	Mur./Amm. Not applied early.	Mur./Amm. Applied early.	Mur./Amm. Mean.	Mean of Sulphate and Muriate Not applied early.	Mean of Sulphate and Muriate Applied early.	Mean of Sulphate and Muriate Mean.
Not applied late	100.9	94.9	97.9	100.9	99.9	100.4	100.9	97.4	99.2
Applied late	103.1	111.7	107.4	97.1	91.5	94.3	100.1	101.6	100.8
Mean	102.0	103.3	102.6	99.0	95.7	97.4	100.5	99.5	100.0
Standard Errors	5.54 ; of margins 3.92.						3.92 ; of margins 2.77.		

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Straw. cwt. per acre.	Sulph./Amm.			Mur./Amm.			Mean of Sulphate and Muriate		
	Not applied early.	Applied early.	Mean.	Not applied early.	Applied early.	Mean.	Not applied early.	Applied early.	Mean.
Not applied late	21.9	25.6	23.8	21.9	23.8	22.8	21.9	24.7	23.3
Applied late	27.0	27.1	27.0	21.0	26.5	23.8	24.0	26.8	25.4
Mean	24.4	26.4	25.4	21.4	25.2	23.3	23.0	25.8	24.4
Standard Errors	0.45 cwt. ; of margins 0.32 cwt.						0.32 cwt.; of margins 0.22 cwt.		

Straw. per cent.	Sulph./Amm.			Mur./Amm.			Mean of Sulphate and Muriate		
	Not applied early.	Applied early.	Mean.	Not applied early.	Applied early.	Mean.	Not applied early.	Applied early.	Mean.
Not applied late	90.1	105.1	97.6	90.1	97.8	94.0	90.1	101.5	95.8
Applied late	110.7	111.2	111.0	86.2	108.9	97.6	98.4	110.1	104.2
Mean	100.4	108.2	104.3	88.2	103.4	95.8	94.2	105.8	100.0
Standard Errors	1.94 ; of margins 1.37.						1.37 ; of margins 0.97.		

Summary of Results—(b) Varietal Response.

Grain.	Million III.	Yeoman II.	Square-Head's Master.	Swedish Iron.	Mean.	Standard Error.
cwt. per acre	13.8	15.1	13.1	18.5	15.1	0.34
per cent.	91.1	99.9	86.8	122.2	100.0	2.26
Straw.						
cwt. per acre	23.3	23.9	24.4	25.9	24.4	0.47
per cent.	95.6	98.0	100.1	106.3	100.0	1.94

Significant advantage of sulphate over muriate of ammonia with straw, but not with grain. With straw significant responses occur to sulphate applied late and to muriate applied early. Swedish Iron yielded significantly higher than the other varieties, while Yeoman showed an advantage in grain only over Million and Square-Head's Master.

WHEAT

Nitrogenous Fertilisers as Top Dressings : Sulphate and Muriate of Ammonia.

Each in single and double dressings.

R W—Great Knott, 1930.

N.E.

A	M. E & L.	O(a)	S.L.	S.E.
	M.E	O (b)	M.L.	S.E & L.
B	S.L.	S.E.	O (a)	S.E& L.
	M.L.	M.E & L.	M.E.	O (b)
C	S.L.	S.E.	M.L.	M.E & L.
	S.E & L.	O (a)	M.E.	O (b)

System of Replication : 6 randomised blocks of 8 plots each.
Only three blocks were harvested.
Area of Each Plot : 1/40th acre.
S = Sulphate of Ammonia. } at the rate of 0.2
M = Muriate of Ammonia . } cwt. Nitrogen per acre.
O (a), O (b) = No Top Dressing.
E = Early Top Dressing (Mar. 27th).
L = Late Top Dressing (May 16th).
E and L = Early and Late Top Dressing.
All plots received 2½ cwt. Superphosphate, and 1 cwt. Potash Salt (30 per cent) per acre.
Variety : Million.
Wheat sown : Sept. 20th, 1929. Harvested : Aug. 8th-11th, 1930.
Previous Crop : Sheep feed, followed by summer fallow.

Actual weights in lb.—Total Grain.

Blocks	O (a)	O (b)	S.E.	S.L.	M.E.	M.L.	S. E. & L.	M. E. & L.
A	74.25	78.50	64.50	78.75	63.50	96.75	63.50	85.25
B	85.00	61.00	67.00	60.00	84.75	68.25	53.00	75.00
C	81.50	74.75	79.00	85.75	81.50	86.25	77.50	65.75

Actual weights in lb.—Total Straw.

Blocks	O (a)	O (b)	S.E.	S.L.	M.E.	M.L.	S. E. & L.	M. E. & L.
A	151.50	165.50	154.75	152.50	180.00	166.50	156.75	182.75
B	163.75	131.00	187.00	179.50	190.75	176.75	159.00	180.00
C	176.50	119.25	183.00	187.75	174.50	156.75	207.50	153.75

Summary of Results.

Grain. cwt. per acre	Sulph./Amm.			Mur./Amm.			Mean of Sulphate and Muriate		
	Not applied early.	Applied early.	Mean.	Not applied early.	Applied early.	Mean.	Not applied early.	Applied early.	Mean.
Not applied late	27.1	25.1	26.1	27.1	27.4	27.2	27.1	26.2	26.7
Applied late	26.7	23.1	24.9	29.9	26.9	28.4	28.3	25.0	26.7
Mean	26.9	24.1	25.5	28.5	27.2	27.8	27.7	25.6	26.7
Standard Errors	2.13 cwt. ; of margins 1.51 cwt.						1.51 cwt.; of margins 1.06 cwt.		

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Grain. per cent	Sulph./Amm.			Mur./Amm.			Mean of Sulphate and Muriate		
	Not applied early.	Applied early.	Mean.	Not applied early.	Applied early.	Mean.	Not applied early.	Applied early.	Mean.
Not applied late	101.6	94.0	97.8	101.6	102.6	102.1	101.6	98.3	100.0
Applied late	100.3	86.7	93.5	112.2	100.9	106.6	106.2	93.8	100.0
Mean	101.0	90.4	95.7	106.9	101.8	104.3	103.9	96.1	100.0
Standard Errors	7.99 ; of margins 5.65.						5.65 ; of margins 4.00.		

Straw. cwt. per acre	Sulph./Amm.			Mur./Amm.			Mean of Sulphate and Muriate		
	Not applied early.	Applied early.	Mean.	Not applied early.	Applied early.	Mean.	Not applied early.	Applied early.	Mean.
Not applied late	54.0	62.5	58.2	54.0	64.9	59.4	54.0	63.7	58.8
Applied late	61.9	62.3	62.1	59.5	61.5	60.5	60.7	61.9	61.3
Mean	58.0	62.4	60.2	56.8	63.2	60.0	57.4	62.8	60.1
Standard Errors	4.12 cwt. ; of margins 2.91 cwt.						2.91 cwt. ; of margins 2.06 cwt.		

Straw. per cent	Sulph./Amm.			Mur./Amm.			Mean of Sulphate and Muriate		
	Not applied early.	Applied early.	Mean.	Not applied early.	Applied early.	Mean.	Not applied early.	Applied early.	Mean.
Not applied late	89.9	104.0	97.0	89.9	108.1	99.0	89.9	106.0	98.0
Applied late	103.0	103.7	103.4	99.1	102.4	100.8	101.0	103.0	102.0
Mean	96.4	103.9	100.2	94.5	105.2	99.9	95.4	104.5	100.0
Standard Errors	6.85 ; of margins 4.84.						4.84 ; of margins 3.42.		

Muriate appears to do better than sulphate in yield of grain, but the difference is not significant. No significant response to the top dressing in grain, but with straw the single dressing, applied early, appears to be effective.

Wheat: Comparison of Nitrogenous Fertilisers, Sulphate of Ammonia and Cyanamide, applied in Autumn and Spring. Effect of Dicyanodiamide. Effect of grazing with sheep in Spring.

R W—Long Hoos, (Section 3), 1930.

N.E.

A		B		C	
10	4	1	2	2	10
13	16	3	5	9	7
7	15	9	6	15	4
9	12	16	11	5	3
11	14	14	12	1	8
3	1	8	13	16	12
2	5	7	15	11	13
6	8	4	10	14	6

System of Replication: 3 randomised blocks.
Area of Each Plot: 1/60th acre.
Treatments: Sulphate of Ammonia and Cyanamide at the rate of 0.3 cwt. N. per acre, applied in Autumn and Spring.
Half of the plots grazed by sheep and half treated with Dicyanodiamide at the rate of 0.2 cwt. N. per acre, applied in Autumn, as shown in Key to Treatments.
All plots received 3 cwt. Super., 1½ cwt. Muriate of Potash per acre, applied Oct. 11th. Autumn dressings applied: Cyanamide and Dicyanodiamide, Oct. 15th, 1929; Sulphate of Ammonia, Oct. 22nd. Spring dressings applied April 15th. Sheep put on to "grazing" plots for one day, May 9th.
Variety: Million.
Wheat Sown: Oct. 22nd, 1929. Harvested Sept. 1st, 1930.
Previous Crop: Hay. The plots were harvested by the sampling method, 24 random metre lengths taken from each plot, constituting a single sample.

Key to Treatments.

Treatments.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Sulph./Amm. in Autumn	x	x	x	x												
Sulph./Amm. in Spring ..					x	x	x	x								
Cyanamide in Autumn									x	x	x	x				
Cyanamide in Spring ..													x	x	x	x
Dicyanodiamide ..			x	x			x	x			x	x			x	x
Grazing		x		x		x		x		x		x		x		x

Actual weights in grams per sample.—Grain.

Blocks.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A ..	1046.5	885.0	893.0	604.0	819.5	783.5	1211.5	689.0	1004.5	746.0	1041.5	993.0	826.5	946.5	772.0	559.0
B ..	561.5	375.5	720.5	702.0	492.0	608.5	700.0	742.0	770.5	625.0	750.5	782.0	754.0	740.5	720.5	614.0
C ..	617.0	324.0	480.0	556.5	600.0	289.5	321.0	497.5	515.0	266.5	636.0	498.5	414.5	415.0	636.5	636.0

Actual weights in grams per sample.—Straw.

Blks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	1447.5	1216.5	1199.5	1112.5	1215.5	1088.0	1602.0	1049.5	1321.0	1264.5	1397.0	1431.0	1354.0	1269.0	1410.5	1038.0
B	1209.0	815.0	1246.0	1219.5	1238.5	1199.0	1264.0	1185.0	1142.5	1126.5	1384.5	1422.0	1377.0	1096.0	1253.0	1064.0
C	1191.0	866.5	1462.0	1154.5	1317.5	601.0	1440.0	1111.0	1250.0	802.5	1350.5	1180.0	1120.5	989.5	1109.0	1053.0

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Summary of Results.

Average Yield in cwt. per acre.	Grain. Sulph./ Amm. Autumn	Grain. Cyana-mide Autumn	Grain. Sulph./ Amm. Spring	Grain. Cyana-mide Spring	Grain. Mean	Straw. Sulph./ Amm. Autumn	Straw. Cyana-mide Autumn	Straw. Sulph./ Amm. Spring	Straw. Cyana-mide Spring	Straw. Mean
No Grazing, no Dicy.	16.1	16.6	13.9	14.5	15.3	27.9	27.0	27.4	28.0	27.6
Dicyanodiamide ..	15.2	17.6	16.2	15.5	16.1	28.4	30.0	31.3	27.4	29.3
Grazing	11.5	11.9	12.2	15.3	12.7	21.0	23.2	21.0	24.3	22.4
Grazing and Dicy. ..	13.5	16.5	14.0	13.1	14.3	25.3	29.3	24.3	22.9	25.4
Mean	14.1	15.6	14.1	14.6	14.6	25.6	27.4	26.0	25.6	26.2
Per cent.—										
No Grazing, no Dicy.	110.6	113.8	95.0	99.2	104.6	106.8	103.1	104.7	106.9	105.4
Dicyanodiamide ..	104.1	120.7	111.0	105.8	110.4	108.4	114.7	119.5	104.7	111.8
Grazing	78.8	81.4	83.6	104.5	87.1	80.4	88.6	80.1	93.1	85.6
Grazing and Dicy.	92.6	113.0	95.9	89.9	97.8	96.8	111.9	92.8	87.6	97.3
Mean	96.5	107.2	96.4	99.8	100.0	98.1	104.6	99.3	98.1	100.0
Standard Error ..	1.75 cwt. or 11.99 per cent.					1.73 cwt. or 6.62 per cent.				

The yield of the grazed plots is significantly below that of the ungrazed plots. The difference in yield in favour of the plots treated with cyanamide as against those treated with sulphate of ammonia is not significant, while the difference in favour of the plots having an autumn dressing of dicyanodiamide is significant only in the case of straw, but not where a Spring dressing of cyanamide was given. There are no differences in yield between the plots having autumn and spring applications of the nitrogenous fertilisers.

Forage Crop: Comparison of Oats and Barley, Vetches and Peas.

Effect of Sulphate of Ammonia in single and double dressings.

Effect of Muriate of Potash and Superphosphate.

RF—Great Harpenden, 1930.

E.

	O	B	O	B	O	B	O	B	O	B	O	B	
I.	2	7	4	1	12	11	6	5	3	8	10	9	V
II.	1	12	6	5	11	10	8	9	4	2	3	7	P
III.	4	8	7	3	10	6	2	1	12	11	9	5	V
IV.	11	10	8	4	7	5	9	6	2	1	12	3	P
V.	12	2	9	8	5	1	4	3	10	7	11	6	V
VI.	8	9	3	11	2	4	10	7	5	6	1	12	P
VII.	5	4	1	6	3	8	11	10	9	12	7	2	V
VIII.	3	6	10	7	9	2	12	4	11	5	8	1	P
IX.	10	3	5	12	1	9	7	8	6	4	2	11	V
X.	9	5	11	10	8	12	1	2	7	3	6	4	P
XI.	6	1	12	2	4	7	3	11	8	9	5	10	V
XII.	7	11	2	9	6	3	5	12	1	10	4	8	P

SYSTEM OF REPLICATION: Latin Square.

AREA OF EACH PLOT: 1/50th acre. Half cut for hay, half harvested.

TREATMENTS: Sulphate of Ammonia at the rate of 0, 0.2 and 0.4 cwt. N. per acre. Muriate of Potash at the rate of 0.5 cwt. K_2O per acre, and Superphosphate at the rate of 0.5 cwt. P_2O_5 per acre, alone and in combination.

Basal Crop: Beans (70-80 lb. per acre.)

O. B=Pairs of strips one way allotted to oats (Progress, 2 bushels per acre) and barley (Plumage Archer, 2 bushels per acre) respectively.

P, V=Pairs of strips the other way allotted to peas (1 bushel per acre) and vetches (1 bushel per acre) respectively.

Manures sown: Mar. 8th-13th.

Beans sown: Mar. 13th-22nd.

Other crops: Mar. 18th-19th.

Half-plots cut for hay: July 14.

Remainder harvested: Aug. 19.

Previous crop: Wheat.

Key to Treatments.

Treatments.	1	2	3	4	5	6	7	8	9	10	11	12
Sul./Amm. ..	0	0	0	0	1	1	1	1	2	2	2	2
Mur./Pot. ..	0	1	0	1	0	1	0	1	0	1	0	1
Superphosphate ..	0	0	1	1	0	0	1	1	0	0	1	1

(a) Produce weighed as hay.

Actual weights in lb. of Dry Matter.

Row.	1	2	3	4	5	6	7	8	9	10	11	12
I. ..	23.0	18.5	15.5	19.5	25.5	22.0	34.0	29.0	25.5	22.0	33.5	27.5
II. ..	24.5	26.5	19.5	17.0	32.5	18.5	31.5	25.0	32.0	35.0	32.5	43.0
III. ..	27.0	25.0	21.5	24.5	32.0	31.5	26.5	33.0	35.5	32.5	41.0	36.0
IV. ..	26.0	28.0	26.5	28.0	32.0	38.0	34.0	35.5	36.5	39.0	34.5	36.5
V. ..	28.5	32.5	29.5	23.0	31.0	35.0	38.0	43.5	34.5	38.5	40.5	40.0
VI. ..	19.5	21.5	29.0	25.5	31.5	35.5	31.5	32.0	40.5	31.0	37.5	34.5
VII...	23.0	24.5	23.0	29.5	29.5	36.0	23.0	33.5	34.5	41.0	33.0	41.5
VIII.	22.0	30.0	38.5	30.5	37.0	43.5	35.5	29.5	37.0	41.0	38.0	40.0
IX. ..	34.5	18.5	44.5	33.0	44.5	37.0	44.0	44.0	44.5	54.0	43.0	51.5
X. ..	34.5	35.5	38.5	33.0	43.5	36.0	42.5	44.0	48.0	48.0	47.0	46.0
XI. ..	37.0	34.0	31.5	35.0	40.0	40.0	41.5	43.5	48.5	41.0	48.5	44.5
XII...	36.0	43.5	34.5	38.5	40.5	40.5	41.0	39.5	54.0	52.5	52.5	49.5

Summary of Results (Separate Treatments).

	Average yield of Dry Matter in cwt. per acre.	No Nitrogen.		Single Nitrogen.		Double Nitrogen.	
		Without Mur./Pot.	With Mur./Pot.	Without Mur./Pot.	With Mur./Pot.	Without Mur./Pot.	With Mur./Pot.
No Super	Oats with Vetches ..	25.7	18.5	32.4	29.5	31.1	32.8
	,, ,, Peas ..	25.6	27.7	32.1	28.3	36.2	32.1
	Barley ,, Vetches ..	25.8	27.1	25.7	30.5	35.3	36.6
	,, ,, Peas ..	21.4	27.4	32.4	34.8	37.6	39.0
Super	Oats with Vetches ..	20.8	22.8	27.8	38.8	32.8	33.0
	,, ,, Peas ..	25.9	24.8	35.0	29.6	33.9	34.2
	Barley ,, Vetches ..	28.4	27.9	33.8	32.7	37.1	41.5
	,, ,, Peas ..	29.6	26.1	29.3	35.3	40.2	38.6

Effect of Sulphate of Ammonia.

Average yield of Dry Matter in cwt. per acre.	No Nitrogen.	Single Sulph./Amm.	Double Sulph./Amm.	Mean.
Oats with Vetches ..	21.9	32.1	32.4	28.8
,, ,, Peas	26.0	31.3	34.1	30.5
Barley ,, Vetches ..	27.3	30.7	37.6	31.9
,, ,, Peas	26.1	32.9	38.9	32.6
Mean	25.3	31.8	35.8	31.0

The mixture containing barley has yielded better than the mixture containing oats. No difference between vetches and peas. Strong response to both single and double dressings of sulphate of ammonia. No effect of potash. The small response to superphosphate is not significant.

(b) Produce Threshed.

Actual weights in lb.—Grain.

Row.	1	2	3	4	5	6	7	8	9	10	11	12
I. ..	21.25	11.25	6.00	12.50	17.00	9.50	23.25	16.50	18.50	8.50	21.75	8.75
II. ..	13.25	19.75	8.75	10.25	22.25	12.75	19.00	11.50	20.50	21.25	11.75	25.25
III. ..	20.25	14.50	22.00	13.75	22.75	24.00	12.75	25.75	13.25	12.25	23.75	13.00
IV. ..	20.25	13.50	18.50	21.50	20.75	24.50	13.25	14.00	14.00	26.25	16.00	13.00
V. ..	25.50	27.50	25.25	19.25	13.75	24.75	23.50	28.00	14.00	14.50	14.00	17.50
VI. ..	14.75	19.00	18.25	27.75	15.75	28.50	29.50	19.00	26.50	14.25	31.25	24.75
VII...	14.00	22.50	18.00	27.00	16.00	28.50	12.50	28.25	14.25	29.00	13.75	26.25
VIII.	18.75	24.00	19.75	23.50	24.00	26.25	24.75	15.00	17.25	19.25	15.25	16.50
IX. ..	15.25	13.25	25.75	28.00	15.25	16.25	15.00	31.75	26.25	18.00	24.25	28.25
X. ..	17.25	28.00	25.25	28.00	29.75	15.75	16.25	23.00	17.00	30.00	20.00	28.75
XI. ..	29.75	31.75	19.00	21.75	13.00	17.50	31.25	15.00	26.75	28.25	28.75	18.25
XII...	20.00	24.00	32.00	20.00	16.75	22.25	20.00	29.00	32.25	30.25	28.50	30.75

Actual weights in lb.—Straw.

Row.	1	2	3	4	5	6	7	8	9	10	11	12
I. ..	22.25	30.00	18.00	31.00	25.00	31.50	26.75	21.50	24.00	24.00	29.00	33.00
II. ..	30.75	22.00	23.50	24.25	23.75	27.25	22.00	29.75	32.00	27.75	29.50	29.75
III. ..	26.25	33.00	25.00	34.50	26.25	29.75	27.25	28.25	34.50	37.50	30.75	34.50
IV. ..	19.00	26.75	20.00	24.50	25.00	32.25	30.50	28.50	33.75	30.75	36.25	32.00
V. ..	25.75	26.50	28.25	29.25	31.75	27.25	27.50	33.50	33.50	37.50	35.00	37.50
VI. ..	27.00	27.75	30.00	29.50	34.75	31.00	35.50	40.25	29.50	39.50	37.25	31.75
VII...	26.00	27.50	31.75	27.00	32.00	31.50	28.75	35.50	37.75	38.00	38.00	33.75
VIII.	21.25	25.25	32.75	25.25	29.75	27.25	27.25	29.50	34.25	37.75	33.25	35.50
IX. ..	27.25	27.75	26.25	31.00	37.00	35.50	36.25	39.75	34.75	39.25	33.75	35.75
X. ..	32.50	31.75	27.25	36.00	35.75	30.50	33.75	38.25	44.50	41.00	45.75	37.25
XI. ..	31.75	35.25	36.00	42.50	39.50	42.50	38.25	39.50	34.75	42.75	41.75	51.75
XII...	32.75	40.50	33.00	34.00	40.25	40.50	38.25	37.00	43.75	42.25	37.50	44.25

Forage Crop, Great Harpenden, 1930 (*cont.*)

Summary of Results (Separate Treatments).

Grain.

	Average yield in cwt. per acre.	No Nitrogen. Without Mur./Pot.	No Nitrogen. With Mur./Pot.	Single Nitrogen. Without Mur./Pot.	Single Nitrogen. With Mur./Pot.	Double Nitrogen. Without Mur./Pot.	Double Nitrogen. With Mur./Pot.
No Super	Oats with Vetches ..	13.1	11.6	12.9	12.9	12.4	11.9
	,, ,, Peas ..	14.6	16.8	14.5	15.1	14.4	15.0
	Barley ,, Vetches ..	21.6	24.3	17.8	23.0	21.3	25.6
	,, ,, Peas ..	17.4	21.4	21.6	23.6	23.6	24.1
Super	Oats with Vetches ..	12.8	15.0	12.0	13.4	12.4	12.8
	,, ,, Peas ..	13.9	13.5	14.7	14.7	14.1	13.2
	Barley ,, Vetches ..	21.7	24.6	23.2	23.3	22.0	24.3
	,, ,, Peas ..	22.5	22.5	21.8	25.9	26.7	24.4

Straw.

	Average yield in cwt. per acre.	No Nitrogen. Without Mur./Pot.	No Nitrogen. With Mur./Pot.	Single Nitrogen. Without Mur./Pot.	Single Nitrogen. With Mur./Pot.	Double Nitrogen. Without Mur./Pot.	Double Nitrogen. With Mur./Pot.
No Super	Oats with Vetches ..	23.8	27.0	31.3	32.6	31.5	30.9
	,, ,, Peas ..	27.5	28.3	33.5	29.2	33.5	34.5
	Barley ,, Vetches ..	23.7	26.6	22.9	26.3	27.8	36.1
	,, ,, Peas ..	18.0	23.5	25.5	26.9	31.3	31.6
Super	Oats with Vetches ..	25.5	30.6	27.5	35.3	32.6	35.0
	,, ,, Peas ..	25.7	26.0	30.5	29.7	32.3	30.1
	Barley ,, Vetches ..	23.7	25.9	27.5	28.1	30.2	31.0
	,, ,, Peas ..	23.9	25.7	25.2	33.0	33.4	31.9

Effect of Potash and Superphosphate.

Average Yield in cwt. per acre.	Grain. Without Potash.	Grain. With Potash.	Grain. Without Super.	Grain. With Super.	Grain. Mean.	Straw. Without Potash.	Straw. With Potash.	Straw. Without Super.	Straw. With Super.	Straw. Mean.
Oats with Vetches ..	12.6	12.9	12.5	13.1	12.8	28.7	31.9	29.5	31.1	30.3
,, ,, Peas ..	14.4	14.7	15.1	14.0	14.6	30.5	29.6	31.1	29.1	30.1
Barley ,, Vetches ..	21.3	24.2	22.2	23.2	22.7	26.0	29.0	27.2	27.7	27.5
,, ,, Peas ..	22.3	23.6	21.9	24.0	22.9	20.9	34.1	26.1	28.9	27.5
Mean	17.6	18.9	17.9	18.6	18.2	26.5	31.2	28.5	29.2	28.8

Effect of Sulphate of Ammonia.

Average Yield in cwt. per acre.	Grain. No Nitrogen.	Grain. Single Sulph/Amm.	Grain. Double Sulph/Amm.	Straw. No Nitrogen	Straw. Single Sulph/Amm.	Straw. Double Sulph/Amm.
Oats with Vetches	13.1	12.8	12.4	26.7	31.7	32.5
,, ,, Peas	14.7	14.8	14.1	26.9	30.7	32.6
Barley ,, Vetches	23.1	21.8	23.3	24.9	26.2	31.3
,, ,, Peas	20.9	23.2	24.7	22.8	27.7	32.1
Mean	18.0	18.2	18.6	25.3	29.1	32.1

Oats have done better with peas than with vetches in the grain. The barley mixtures have yielded significantly better than the oats mixtures in grain, but the reverse is the case with straw. Response to potash only on mixtures containing barley. The small response to superphosphate is insignificant. Large response to sulphate of ammonia in straw, but nothing with grain.

POTATOES

Nitrogenous Fertiliser : Sulphate of Ammonia.
Potassic Fertilisers : Sulphate and Muriate of Potash and Potash Salt (30%).
Each in single and double dressings.
Superphosphate.

R P—Long Hoos (Section 6), 1930.

S.W.

	G			D			A			
	4M / —	2 / —	9S / —	9P / —	3 / —	— / 1	— / 2	6P / —	— / 4S	
	— / 6S	3 / —	1 / —	4P / —	— / 5S	— / 2	— / 9M	— / 1	7P / —	
	— / 7M	— / 5P	8P / —	7S / —	— / 8M	— / 6M	— / 5M	— / 8S	— / 3	
	— / 4S	— / 1	9M / —	8P / —	— / 2	— / 7M	1 / —	4P / —	— / 2	
H	7P / —	6P / —	8S / —	— / 3	9S / —	5P / —	9P / —	— / 5S	7S / —	B
	2 / —	— / 3	— / 5M	— / 6S	— / 1	4M / —	3 / —	— / 8M	— / 6M	
	— / 3	— / 2	5S / —	1 / —	3 / —	— / 8S	— / 8P	— / 3	9S / —	
	8M / —	— / 6M	— / 9P	9M / —	— / 7P	— / 6P	— / 2	— / 4M	6S / —	
	1 / —	4P / —	7S / —	— / 4S	— / 5M	2 / —	7M / —	— / 1	5P / —	
		I			F			C		

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 form of Sulphate of Potash, Muriate of Potash and Potash Salt. 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 (12-13 tons per acre) applied January 14.

Manures applied : April 1st-2nd.

Potatoes planted : April 2nd-3rd. Lifted : Sept. 24th-25th.

Variety : Ally. Previous Crop : Wheat.

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	236.25	208.00	197.00	146.25	179.50	156.25	159.00	120.75	187.00
0	1	208.00	247.00	220.75	158.50	159.25	213.25	164.00	130.50	171.50
0	2	193.75	228.25	242.25	170.00	177.25	200.00	203.75	153.25	216.00
1	0	193.75	169.75	218.25	156.25	215.50	201.50	156.50	198.25	166.75
1	1	245.50	248.75	198.50	216.75	231.50	223.00	202.50	196.00	220.75
1	2	284.75	257.50	220.25	260.25	206.00	189.75	197.75	220.50	229.75
2	0	196.50	245.00	247.25	238.25	196.50	260.00	169.25	198.75	213.50
2	1	310.50	234.75	208.00	229.75	234.25	223.25	183.75	201.50	223.25
2	2	268.00	286.75	248.00	211.50	260.25	237.25	227.00	233.50	245.75

K

Potatoes, Long Hoos, 1930 (*cont.*)

Actual weights in lb.—Sub-plots without Phosphate.

S/Amm	Potash	A	B	C	D	E	F	G	H	I
Quantities										
0	0	225.00	181.25	209.50	138.00	171.25	150.00	157.75	150.50	138.00
0	1	233.00	222.25	187.00	139.25	135.25	200.50	138.75	148.75	135.00
0	2	160.50	202.25	198.50	196.00	169.25	179.50	157.25	174.75	177.00
1	0	178.75	161.50	184.50	187.50	243.00	175.00	136.25	199.25	171.00
1	1	218.00	268.00	183.50	226.00	185.00	220.00	177.25	187.50	206.75
1	2	268.00	222.75	206.25	215.00	176.50	185.75	205.75	210.75	230.75
2	0	182.25	221.50	211.75	227.50	195.50	207.75	140.00	179.25	204.25
2	1	271.00	197.00	213.25	154.00	197.50	188.25	198.75	202.25	192.75
2	2	237.00	229.25	181.75	206.00	203.00	211.00	181.75	181.50	226.75

Summary of Average Yields.—Separate Treatments.

Average yield in tons per acre.		Without Superphosphate.			With Superphosphate.		
		No S/Amm.	Single S/Amm.	Double S/Amm.	No S/Amm.	Single S/Amm.	Double S/Amm.
No Potash		7.55	8.12	8.78	7.89	8.32	9.75
Single Potash	Sulphate	8.66	10.43	9.07	8.21	10.21	9.32
	Muriate	6.86	9.31	8.09	8.10	9.89	10.23
	Potash Salts	7.39	8.12	9.84	8.59	9.41	10.94
Double Potash	Sulphate	8.56	9.89	8.43	9.14	10.34	10.94
	Muriate	7.81	9.95	9.37	9.27	11.12	10.99
	Potash Salts	7.66	8.76	9.85	8.14	9.29	11.07

Summary of Significant Results.

(*a*) 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 ..	7.55	8.12	8.78	8.15	84.1	90.5	97.9	90.8
	Single Potash..	7.64	9.29	9.00	8.64	85.1	103.5	100.3	96.3
	Double Potash	8.01	9.53	9.22	8.92	89.3	106.2	102.7	99.4
Mean		7.73	8.98	9.00	8.57	86.2	100.1	100.3	95.5
With Super	No Potash ..	7.89	8.32	9.75	8.65	87.9	92.7	108.6	96.4
	Single Potash..	8.30	9.84	10.16	9.43	92.5	109.7	113.3	105.2
	Double Potash	8.85	10.25	11.00	10.03	98.7	114.3	122.6	111.9
Mean		8.35	9.47	10.30	9.37	93.0	105.6	114.8	104.5
Mean of super and no super		8.04	9.22	9.65	8.97	89.6	102.8	107.6	100.0

Standard Error = 0.215 tons or 2.40 per cent.

(*b*) 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 Salt.	Sulphate of Potash.	Muriate of Potash.	Potash Salt.
Without Super	No Potash ..		8.15			90.8	
	Single Potash ..	9.39	8.09	8.45	104.6	90.1	94.2
	Double Potash ..	8.96	9.04	8.76	99.9	100.8	97.6
Mean of Single and Double Potash		9.18	8.56	8.60	102.3	95.4	95.9
With Super	No Potash ..		8.65			96.4	
	Single Potash ..	9.25	9.41	9.65	103.1	104.8	107.5
	Double Potash ..	10.14	10.46	9.50	113.0	116.6	105.9
Mean of Single and Double Potash		9.70	9.94	9.58	108.0	110.7	106.7

Standard Error = 0.215 tons or 2.40 per cent.

Significant response to first dressing of sulphate of ammonia both with and without superphosphate, and to second dressing only in the presence of superphosphate. The response to potash is small in the absence of superphosphate, but significant where superphosphate is also added. There is a significant response to superphosphate, especially on the higher yields.

Potatoes (Dr. Salaman's experiment).
Variety Test: Virus-free Strain and Scottish Stock Seed.
Effect of increasing dressings of complete fertiliser.
RP—Laboratory Garden, 1930.

N.

I.	P B T	T C P	P A T	P D T
II.	P C T	P D T	P B T	T A P
III.	P D T	P A T	T C P	P B T
IV.	T A P	P B T	T D P	T C P

System of Replication: Latin Square.
Area of Each Plot: 20 in. x 225 in.
Treatments:
A = No Fertiliser.
B = 1 unit of complete Fertiliser.
C = 2 units of complete Fertiliser.
D = 4 units of complete Fertiliser.
1 unit = { 1 cwt. per acre of Sulphate of Ammonia; 1 cwt. per acre of Sulphate of Potash; 2 cwt. per acre of Superphosphate. }
Plots split at random for:
P = Scottish stock seed (from Perth).
T = Dr. Salaman's virus free strain (from Thetford).
Manures applied: May 23rd.
Potatoes planted: May 23rd. Lifted: Oct. 7th.

Actual weights in lb.

Row.	Scottish Stock Seed.				Virus-free Strain.			
	A	B	C	D	A	B	C	D
I. ..	15.5	24.0	29.0	26.0	16.5	27.0	27.5	36.0
II. ..	15.5	23.5	26.5	31.5	13.5	23.0	27.5	31.0
III. ..	18.5	17.5	29.0	32.0	17.5	21.5	28.0	33.5
IV. ..	18.0	23.5	27.0	28.5	20.0	25.0	25.5	33.0

Summary of Results.

Average yield per plot.	No Fertiliser.	Single Dressing.	Double Dressing.	Quadruple Dressing.	Mean.	Standard Error.
Scottish Stock Seed in lb. ..	16.9	22.1	27.9	29.5	24.1	0.96
,, ,, ,, per cent...	68.2	89.5	112.7	119.3	97.4	3.88
Virus-free Strain in lb. ..	16.9	24.1	27.1	33.4	25.4	0.96
,, ,, per cent. ..	68.2	97.5	109.7	134.9	102.6	3.88

Significant responses to all applications of complete fertiliser. The small advantage in yield of the virus-free strain over the Scottish seed is not significant. No significant difference between varieties in their response to the fertiliser.

L

https://doi.org/10.23637/ERADOC-1-63

SUGAR BEET

Comparison of Chloride Dressings: Muriate of Potash and Agricultural Salt.

R S—Long Hoos (Section 6), 1930.

N.E.

I.	S	M & S	O	M
II.	M	O	M & S	S
III.	M & S	M	S	O
IV.	O	S	M	M & S

SYSTEM OF REPLICATION: Latin Square.
AREA OF EACH PLOT: 1/60th acre.
TREATMENTS:
O = No Chloride dressing.
M = Muriate of Potash. } at the rate of 0.8 cwt.
S = Agricultural Salt. } Chloride per acre.
All plots had dung (12-13 tons per acre) applied Jan. 14th; 2 cwt. per acre Nitrate of Soda and 3 cwt. per acre Superphosphate, applied May 23rd.
Chloride dressings applied: May 8th.
Seed sown: May 9th. Lifted: Sept. 30th-Oct. 2nd.
Previous Crop: Wheat.

Actual weights in lb.

Row.	Roots (unwashed) O	M	S	M & S	Tops. O	M	S	M & S
I. ..	399.5	398.0	391.0	386.5	357.5	397.5	353.0	372.5
II. ..	403.0	406.0	406.5	391.5	359.5	347.5	336.5	324.5
III. ..	370.0	407.5	385.5	397.0	314.5	347.0	305.0	329.5
IV. ..	379.5	390.0	425.5	390.5	319.0	325.0	344.5	335.5

Summary of Results.

Average yield.	No Muriate No Salt.	Muriate of Potash.	Salt.	Muriate of Pot. & Salt	Mean.	Standard Error.
Roots (washed)—						
tons per acre ..	7.30	7.53	7.57	7.37	7.44	0.129
per cent. ..	98.1	101.2	101.7	99.0	100.0	1.73
Tops, tons per acre ..	9.04	9.49	8.97	9.12	9.15	0.142
per cent. ..	98.8	103.6	97.9	99.6	100.0	1.55
Sugar percentage in roots	17.51	17.65	17.45	17.79	17.60	0.168

The response to Muriate of Potash and Salt is insignificant with roots. The tops appear to respond better to Muriate of Potash than to Salt, but the difference is scarcely significant.

CULTIVATION EXPERIMENT

R M—Mangolds, The Broad Baulk, 1930.

S.W.

A

P	Sf	Sr

B | C

Sf	Sr	P	Sr	Sf	P

SYSTEM OF REPLICATION : 3 randomised blocks.
AREA OF EACH PLOT : 1/20th acre.
TREATMENTS :
P = Ploughed.
Sf = Simar cultivation—Land left flat.
Sr = Simar cultivation—Land ridged.
All plots had 3 cwt. super, 3 cwt. Sulphate of Ammonia and 4 cwt. Muriate of Potash per acre.
Ploughed and first Simar cultivation—Feb. 24th.
Second Simar cultivation—May 1st.
Manures applied : May 2nd.
All plots rolled and harrowed : May 5th.
Drilled : May 8th. Lifted : Oct. 27th.
Variety : Yellow Globe. Previous Crop : Swedes.

Actual yields.

Blocks.	Roots in lb.			Tops in lb.			No. of Roots.		
	P	Sf	Sr	P	Sf	Sr	P	Sf	Sr
A ..	4120	4080	3300	1133.0	1056.5	869.0	914	859	1018
B ..	2674	2126	2474	776.5	677.75	634.0	699	651	670
C ..	3576	2892	3668	835.5	701.0	897.0	841	789	883

Summary of Results.

Average yield.	Plots ploughed.	Simar cultivation land left flat.	Simar cultivation land ridged.	Mean.	Standard Error.
Roots, tons per acre ..	30.86	27.08	28.10	28.68	2.082
,, per cent. ..	107.6	94.4	98.0	100.0	7.26
Tops, tons per acre ..	8.17	7.25	7.14	7.52	0.538
,, per cent. ..	108.6	96.4	95.0	100.0	7.16
Roots, number per acre	16360	15327	17140	16276	456.0
,, ,, per cent.	100.5	94.2	105.3	100.0	2.80

The differences between the yields for the three cultivation treatments are not significant.

WOBURN

Rotation II., Six-Course, Stackyard Field, 1930.

For full particulars of experiment see Rothamsted Report p. 128.

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_2O.
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.
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.

C B—Barley (Plots 1-15).

Manures applied: Mar. 22nd. Seed sown: Mar. 28th. Harvested: Aug. 13th-14th. Variety: Plumage Archer.

N.W.

Yield of grain in cwt. per acre.

1	1K 20.7	2K 19.6	0N 13.6	1N 18.9	2P 22.1	5
6	3K 21.1	0K 19.3	4N 23.0	1P 22.1	0P 22.0	10
11	4K 20.4	2N 18.2	3N 20.7	3P 19.4	4P 20.5	15

Yield of straw in cwt. per acre.

1K 33.5	2K 32.9	0N 29.4	1N 35.6	2P 36.7
3K 34.1	0K 33.3	4N 44.6	1P 37.6	0P 36.3
4K 36.3	2N 36.8	3N 46.4	3P 37.6	4P 39.3

C S—Sugar Beet (Plots 31-45).

Manures applied: April 29th. Seed sown: April 30th. Lifted: Oct. 9th. Variety: Johnson P.

N.W.

Washed Roots—tons per acre.

31	2N 3.20	1N 3.39	4P 3.45	1P 4.16	1K 4.12	35
36	3N 3.87	4N 4.50	2P 3.91	4K 4.43	0K 4.18	40
41	0N 3.41	3P 3.80	0P 4.11	2K 4.39	3K 4.14	45

Tops—tons per acre.

2N 6.02	1N 4.61	4P 5.04	1P 6.29	1K 7.07
3N 5.54	4N 6.27	2P 4.80	4K 6.80	0K 7.05
0N 4.70	3P 5.64	0P 6.43	2K 7.34	3K 7.14

C P—Potatoes (Plots 61-75).

Manures applied: April 8th. Planted: April 10th. Lifted: Oct. 1st. Variety: Ally.

Yield of Roots in tons per acre.

N.W.

61	3K 11.83	1K 9.46	0N 8.23	4N 12.82	3P 9.90	65
66	2K 12.07	0K 11.16	2N 11.73	1P 11.83	0P 9.22	70
71	4K 12.€6	3N 13.06	1N 11.17	4P 12.84	2P 10.74	75

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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.	N		P		K	
Barley—Grain, cwt.	**13.7**	± 2.3	−3.8	± 2.3	1.0	± 1.4
Straw, cwt.	**27.5**	± 3.8	4.0	± 3.8	2.6	± 2.3
Sugar Beet—Roots, tons	**1.77**	± 0.49	**−1.12**	± 0.49	0.21	± 0.29
Tops, tons	**2.71**	± 0.91	**−2.29**	± 0.91	−0.17	± 0.55
Potatoes— tons	**7.38**	± 2.39	3.54	± 2.39	2.15	± 1.43

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.
Barley—Grain	**10.24**	−2.83	1.29	± 1.70
Straw	**11.23**	1.64	1.80	± 1.54
Sugar Beet—Roots ..	**6.76**	**−4.27**	1.32	± 1.87
Tops	**6.73**	**−5.67**	−0.71	± 2.26
Potatoes	**9.84**	4.72	4.77	± 3.18

Significant results are in bold type. Negative sign means depression.

REPLICATED EXPERIMENTS AT WOBURN

Potatoes: Comparison of Sulphates of Potash and Magnesium and Mineral Potash. Effect of Superphosphate.

W P—Lansome, 1930.

S.W.

— O	— S	— K	M —
— S	K —	— M	— O
— K	— M	O —	S —
— M	— O	— S	— K
IV.	III.	II.	I.

SYSTEM OF REPLICATION : Latin Square. Each plot divided into two sub-plots.
AREA OF EACH WHOLE PLOT : 1/40th acre.
TREATMENTS :
O=No Potash or Magnesium.
M=Sulphate of Magnesium.
S=Sulphate of Potash.
K=Potash Mineral.
Sulphate of Potash and Potash Mineral at the rate of 0.6 cwt. K_2O per acre, Sulphate of Magnesium at the rate of 0.257 cwt. MgO per acre, equivalent to 0.6 cwt. K_2O, Superphosphate at the rate of 0.5 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.
Land limed and dunged in 1929.
Manures applied : May 5th. Potatoes planted : May 6th.
Potatoes lifted : Sept. 30th-Oct. 1st. Variety : Ally.
Previous Crop : Potatoes followed by Fodder Crop (Rye, Vetches and Beans).

Actual weights in lb.

Column.	Superphosphate.				No Superphosphate.			
	O	M	S	K	O	M	S	K
I. ..	352.50	350.25	377.25	386.75	377.00	339.25	388.75	384.50
II. ..	358.00	315.75	305.00	291.00	319.75	336.25	338.25	306.75
III. ..	248.75	286.75	263.00	283.75	257.50	326.00	274.50	256.75
IV. ..	273.25	255.75	255.00	276.25	256.50	274.75	262.00	279.75

Summary of Results.

Average yield.	Tons per acre.				Per cent.			
	No Potash or Magn's'm	Sulphate of Magn's'm	Sulphate of Potash	Potash Mineral	No Potash	Sulphate of Magn's'm	Sulphate of Potash	Potash Mineral
Without Superphosphate ..	10.81	11.40	11.28	10.96	98.3	103.6	102.5	99.6
With Superphosphate ..	11.00	10.79	10.72	11.05	100.0	98.1	97.4	100.5

Mean 11.00 tons. Standard Error = 0.257 tons or 2.34 per cent.
No response to superphosphate, or to the potash or magnesium treatments.

https://doi.org/10.23637/ERADOC-1-63

WOBURN

Potatoes: Nitrogenous Fertilisers, Sulphate of Ammonia and Cyanamide.

Phosphatic Fertilisers, Superphosphate and Slag.

W P—Lansome, 1930.

N.W.

I.	C Sl	C P	S P	S Sl
II.	C P	C Sl	S Sl	S P
III.	S Sl	S P	C Sl	C P
IV.	S P	S Sl	C P	C Sl

System of Replication: Latin Square.
Area of Each Plot: 1/45th acre.
Treatments: Sulphate of Ammonia and Cyanamide at the rate of 0.2 cwt. N per acre, and Superphosphate and Slag (High Soluble) at the rate of 0.5 cwt. P_2O_5 per acre, in combination as follows:
C, Sl.=Cyanamide and Slag.
C, P=Cyanamide and Superphosphate.
S, Sl.=Sulphate of Ammonia and Slag.
S, P=Sulphate of Ammonia and Superphosphate.
Land limed and dunged, 1929. Manures applied: May 5th.
Potatoes planted: May 7th. Lifted: Sept. 30th. Variety: Ally.
Previous Crop: Potatoes followed by Fodder Crop (Rye, Vetches and Beans).

Actual weights in lb.

Row.	C, Sl	C, P	S, Sl	S, P
I. ..	653.25	619.50	604.75	577.50
II. ..	638.25	642.75	530.25	601.25
III. ..	522.25	591.50	572.75	618.75
IV. ..	565.75	559.00	512.00	470.25

Summary of Results.

Average yield.	Cyanamide Slag.	Cyanamide Super.	Sulph./Amm. Slag.	Sulph./Amm. Super.	Mean.	Standard Error.
Tons per acre	11.95	12.12	11.15	11.39	11.65	0.406
Per cent.	102.6	104.0	95.7	97.8	100.0	3.48

There is a small non-significant advantage of the plots treated with cyanamide over those treated with sulphate of ammonia. No difference between plots treated with slag and superphosphate.

WOBURN

Sugar Beet: Potassic and Chloride Dressings, Muriate of Potash, Mineral Potash, Agricultural Salt.

Effect of Superphosphate.

W S—Lansome, 1930.

S.W.

K / —	— / S	M / —	O / —
M / —	K / —	— / O	— / S
S / —	O / —	— / K	— / M
— / O	— / M	S / —	K / —
IV.	III.	II.	I.

System of Replication: Latin Square. Each plot divided into two sub-plots.
Area of Each Whole Plot: 1/40th acre.
Treatments:
O = No Salt, no Potash.
M = Muriate of Potash. } at the rate of 0.6 cwt.
K = Potash Mineral. } K_2O per acre.
S = Salt to give same amount of Chloride as in Muriate of Potash.
Superphosphate at the rate of 0.5 cwt. per acre water soluble P_2O_5 applied to one out of each pair of sub-plots, indicated by the treatment symbol occurring on that half.
Land dunged and limed, 1929. Manures applied: May 2nd.
Beet sown: May 3rd. Lifted: Oct. 7th-8th. Variety: Johnson's P.
Previous Crop: Potatoes followed by Fodder Crop (Rye, Vetches and Beans).

Actual yields in lb.

		Roots (dirty).				Tops.			
Column.		O	M	K	S	O	M	K	S
I.	Super	381	373	362	358	193	205	243	195
II.	Super	401	447	412	418	188	205	194	229
III.	Super	371	363	410	367	196	223	204	186
IV.	Super	391	399	422	433	199	174	214	188
I.	No Super	383	425	402	410	188	203	206	206
II.	No Super	393	413	446	426	183	195	219	225
III.	No Super	392	406	401	448	188	214	215	206
IV.	No Super	397	343	314	430	209	200	132	193

Summary of Results.

Average yield in tons per acre.		No Salt, No Potash.	Muriate of Potash.	Salt.	Potash Mineral.	Mean.	Standard Error.
Roots (washed)	No Super.	9.12	9.24	9.98	9.10	9.27	0.397
	Super.	8.99	9.21	9.18	9.35		
Tops	No Super.	6.86	7.25	7.41	6.89	7.16	0.336
	Super.	6.93	7.21	7.12	7.63		
Sugar percentage in roots	No Super.	19.24	19.36	19.29	19.32	19.35	0.196
	Super.	19.38	19.46	19.33	19.45		

Average yield per cent.		No Salt, No Potash.	Muriate of Potash.	Salt.	Potash Mineral.	Mean.	Standard Error.
Roots (washed)	No Super.	98.3	99.7	107.7	98.2	100.0	4.28
	Super.	97.0	99.4	99.0	100.9		
Tops	No Super.	95.7	101.2	103.5	96.2	100.0	4.68
	Super.	96.7	100.6	99.5	106.6		

The small response in roots to the application of salt in the absence of superphosphate is not significant. No response to muriate of potash, potash mineral or superphosphate. With tops there is a significant response to the potash and salt dressings but no differences between these, and no response to superphosphate.

REPLICATED EXPERIMENTS AT OUTSIDE CENTRES

Grassland. Meadow Hay.

(Basic Slag Committee).

Mr. W. Eydes, Walton Lodge Farm, Walton, Chesterfield, Derby, 1930.

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 : Latin Square
Area of Each Plot : 1/15 acre.
Soil : Clay 6 in. deep.
Treatments :
O = Control.
S = Super.
M = Mineral Phosphate.
L = Low Soluble Slag (23.0%).
H = High soluble Slag (96.5%).
Dressings providing 1 cwt. P_2O_5 per acre, applied Feb. 4th.
Hay cut : July 15th. Weighed : Aug. 7th-8th.

Actual weights in lb.

Row.	O	M	L	H	S
I. ..	175	183	165	152	203
II. ..	217	179	225	226	225
III. ..	197	224	236	235	186
IV. ..	231	210	216	254	292
V. ..	207	186	204	177	234

Summary of Results

Average Yield.	Control.	Mineral Phosphate.	Low Sol. Slag.	High Sol. Slag.	Super-Phosphate.	Mean.	Standard Error.
Cwt. per acre	27.5	26.3	28.0	28.0	30.5	28.1	1.28
Per cent. ..	98.0	93.7	99.8	99.6	108.8	100.0	4.54

The response to the dressings of mineral phosphate and high and low soluble slags are not significant. The plots treated with superphosphate give a significantly higher yield than any of the others.

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Grassland. Meadow Hay.
(Basic Slag Committee).
Mr. W. H. Limbrick, Badminton Farm, Badminton, Glos., 1930.

Permanent grass.

I.	S	O	L	M	H
II.	M	L	H	O	S
III.	O	H	M	S	L
IV.	H	S	O	L	M
V.	L	M	S	H	O

SYSTEM OF REPLICATION: Latin Square.
AREA OF EACH PLOT: 1/10th acre.
Soil: Light red loam 8 in. deep.
TREATMENTS:
O=Control.
S=Super.
M=Ground Mineral Phosphate.
L=Low soluble Slag (23.0%).
H=High soluble Slag (96.5%).
Dressings providing 1 cwt. P_2O_5 per acre, applied Jan. 31st-Feb. 1st.
Hay cut: June 16th. Weighed: June 20th-24th.

Actual weights in lb.

Row.	Hay as weighed.					Air dry weights.				
	O	M	L	H	S	O	M	L	H	S
I. ..	442	420	422	403	512	345	335	333	299	380
II. ..	472	402	446	478	490	362	332	355	368	380
III. ..	479	520	489	504	553	379	388	374	395	420
IV. ..	551	434	494	514	559	451	383	412	413	449
V. ..	458	547	489	516	497	337	439	410	421	382

Summary of Results.

Average yield.	Control.	Mineral Ph'phate.	Low Sol. Slag.	High Sol. Slag.	Super-ph'phate.	Mean.	Standard Error.
Hay as weighed—							
Cwt. per acre ..	42.9	41.5	41.8	43.1	46.6	43.2	1.33
Per cent. ..	99.3	96.1	96.8	99.9	108.0	100.0	3.07
Air dry weights—							
Cwt. per acre ..	33.5	33.5	33.6	33.9	35.9	34.1	1.01
Per cent. ..	98.2	98.4	98.7	99.4	105.4	100.0	2.96

There has been no response to the slags, or to mineral phosphate. The yield of hay as weighed in the field was significantly increased by the dressing of superphosphate. This increase, when expressed as air-dried hay was, however, much smaller, and hardly significant.

Barley: Effect of Nitrogenous Fertilisers, and of Sulphate of Potash and Superphosphate.

H. G. Nevile, Esq., Wellingore, 1930.

Plan and Actual Weights in grams per sample.

Grain								Straw							
K 172	KP 265	K 177	KP 214	KP 262½	O 213½	P 124	K 115	K 211	KP 280½	K 179½	KP 234	KP 320½	O 246½	P 144½	K 159½
P 159	O 159	O 159	P 129	K 196½	P 219½	O 184½	KP 124	P 177	O 161	O 192	P 160½	K 261	P 291	O 226	KP 161½
P 128	K 182	K 236½	P 182½	K 116	P 146	KP 196½	P 199½	P 148½	K 229	K 250	P 201½	K 133½	P 159½	KP 234	P 253
KP 188	O 179½	KP 183	O 156	KP 98½	O 134	K 209½	O 170½	KP 216½	O 193	KP 208½	O 173½	KP 122	O 181½	K 237½	O 216
O 107½	KP 134	KP 167½	P 196½	P 189½	O 144½	KP 195½	O 159½	O 64	KP 134½	KP 194½	P 222½	P 214½	O 180½	KP 271½	O 204½
P 119½	K 118	K 134	O 149	KP 191	K 207½	P 190	K 214½	P 125½	K 115½	K 147½	O 166½	KP 205	K 223½	P 210	K 250½
P 191	KP 153½	K 103½	P 90	P 180	KP 225	K 198½	O 223½	P 201½	KP 162	K 99	P 99½	P 216	KP 255½	K 201½	O 237
O 155	K 170½	KP 97	O 80	K 153	O 172½	KP 212½	P 165½	O 167	K 172½	KP 103	O 84½	K 186½	O 222	KP 226	P 210½

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: Latin Square.
AREA OF EACH WHOLE PLOT: 1/50th acre.
Soil: Light loam on Oölitic limestone.

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 (KP).

Plots harvested by sampling method.

Manures applied: March 10th.

Barley sown: March 10th. Harvested: August 22nd.

Variety: Plumage Archer.

Previous Crop: Barley.

M

https://doi.org/10.23637/ERADOC-1-63

Barley, Wellingore, 1930 (*cont.*)

Summary of Results.

Average Yield in cwt. per acre.	Grain					Straw				
	No Nitrogen	Cyana-mide	Nitrate of Soda	Sulph. Amm.	Mean	No Nitrogen	Cyana-mide	Nitrate of Soda	Sulph./Amm.	Mean
No Potash or Super.	11.0	13.7	14.1	16.7	13.9	12.1	16.5	16.6	18.4	15.9
Sulphate of Potash ..	9.9	16.7	16.9	15.5	14.8	11.1	17.7	19.6	18.3	16.7
Superphosphate ..	10.4	15.4	15.5	15.5	14.2	11.5	18.1	17.5	19.0	16.5
Potash and Super. ..	9.9	16.4	18.9	18.1	15.8	11.3	18.2	22.1	20.9	18.1
Mean	10.3	15.6	16.4	16.4	14.7	11.5	17.6	19.0	19.2	16.8
Standard Error ..			1.14					1.25		
Per cent.										
No Potash or Super.	75.2	93.5	96.1	113.7	94.6	72.1	98.0	98.7	109.3	94.6
Sulphate of Potash ..	67.2	113.6	115.3	105.6	100.4	65.8	105.4	116.5	108.8	99.1
Superphosphate ..	71.2	105.3	105.7	105.4	96.9	68.6	107.6	104.3	113.1	98.4
Potash and Super. ..	67.4	112.2	129.0	123.4	108.0	67.6	108.3	131.8	124.2	108.0
Mean	70.2	106.2	111.6	112.0	100.0	68.6	104.8	112.8	113.8	100.0
Standard Error ..			7.78					7.44		

Significant response to all forms of nitrogenous fertiliser for both grain and straw, but the differences between the yields of plots having sulphate of ammonia, nitrate of soda and cyanamide are not significant. The response to potash is significant for grain, but only in the presence of a nitrogenous dressing : while that to phosphate is not significant for either grain or straw.

Barley: Effect of Nitrogenous Fertilisers, and of Sulphate of Potash and Superphosphate.

Mr. J. M. Templeton, Farm Institute, Sparsholt, Winchester, 1930.

Plan and Actual Weights in grams per sample.

Grain								Straw							
P 219	KP 186½	O 162½	P 132½	K 146	KP 161	K 152	KP 90½	P 223½	KP 185½	O 174	P 152½	K 161½	KP 192½	K 136	KP 105
O 174½	K 188½	K 165	KP 164	O 131	P 192	P 147	O 163	O 167½	K 180½	K 138	KP 158½	O 148½	P 193½	P 152½	O 145
KP 209½	O 240½	O 171	KP 219	O 140	KP 209	KP 234½	P 159½	KP 206½	O 241	O 173	KP 206	O 157	KP 177½	KP 218½	P 153
K 203	P 259	P 207	K 151	P 205	K 206	K 183	O 201	K 204	P 245	P 186½	K 142	P 207	K 194½	K 185½	O 196½
P 236½	O 203	P 160½	KP 191	K 177	P 172½	KP 185	P 133½	P 229½	O 197	P 150½	KP 157½	K 178½	P 167	KP 168	P 135½
KP 257½	K 207½	O 160½	K 176½	KP 170½	O 163	K 173	O 156½	KP 249½	K 210	O 152½	K 171½	KP 176	O 173½	K 171½	O 161½
P 249½	KP 220½	K 215½	O 232½	P 150	KP 183	O 163½	P 126	P 229	KP 231½	K 213	O 228	P 163½	KP 179½	O 154½	P 135½
O 259	K 230	KP 245	P 262	K 175	O 207½	KP 174½	K 102	O 240½	K 215	KP 243	P 248	K 147	O 206	KP 160½	K 130

Plan showing Nitrogenous Treatments applied to whole plots.

O	C	N	S
C	S	O	N
N	O	S	C
S	N	C	O

SYSTEM OF REPLICATION: Latin Square.
AREA OF EACH WHOLE PLOT: 1/50th acre.
Soil: Thin 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.

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 (KP).

Plots harvested by sampling method.

Manures applied: March 25th-26th.

Barley sown: April 15th. Harvested: August 12th-13th.

Previous Crop: Barley.

Barley, Sparsholt, 1930 (*cont.*)

Summary of Results.

Average Yield in cwt. per acre.	Grain. No Nitrogen	Grain. Cyanamide	Grain. Nitrate of Soda	Grain. Sulph./Amm.	Grain. Mean	Straw. No Nitrogen	Straw. Cyanamide	Straw. Nitrate of Soda	Straw. Sulph./Amm.	Straw. Mean
No Potash or Super.	11.9	14.3	14.3	14.1	13.6	11.8	14.6	14.4	13.7	13.6
Sulphate of Potash ..	12.6	13.4	14.0	13.3	13.3	12.6	12.3	14.4	12.5	13.0
Superphosphate ..	13.3	12.6	15.9	14.5	14.1	13.4	13.0	15.4	13.7	13.9
Potash and Super. ..	14.2	13.8	16.8	13.1	14.5	12.7	13.3	16.9	13.4	14.1
Mean	13.0	13.5	15.2	13.8	13.9	12.6	13.3	15.3	13.3	13.6
Standard Error ..			0.92					0.69		
Per cent.										
No Potash or Super.	85.9	103.2	103.3	101.7	98.5	86.5	107.2	105.5	100.3	99.9
Sulphate of Potash ..	90.5	96.3	101.2	95.5	95.9	92.7	90.5	105.5	92.0	95.2
Superphosphate ..	95.6	90.8	114.4	104.4	101.3	98.1	95.4	112.9	100.7	101.8
Potash and Super. ..	102.4	99.8	120.8	94.2	104.3	93.3	97.6	123.7	98.4	103.2
Mean	93.6	97.5	109.9	99.0	100.0	92.6	97.7	111.9	97.8	100.0
Standard Error ..			6.65					5.07		

Plots treated with nitrate of soda have given a significantly higher yield than all others. The response to sulphate of ammonia and cyanamide was not significant. No effect of potash. There was some evidence of a response to superphosphate, but the increase only approached significance in the presence of potash and nitrate of soda.

https://doi.org/10.23637/ERADOC-1-63

Potatoes: Effect of Superphosphate on Two Varieties.

G. Major, Esq., Newton Farm, Lincs., 1930.

	B	A	A	B	B	A	B	A
I.	0	0	2½	2½	10	10	5	5
II.	5	5	10	10	2½	2½	0	0
III.	10	10	0	0	5	5	2½	2½
IV.	2½	2½	5	5	0	0	10	10

VARIETIES: British Queen (A) and King Edward (B) in random strips.
SYSTEM OF REPLICATION: Latin Square.
AREA OF EACH SUB-PLOT: 1/60th acre.
TREATMENTS: Superphosphate at the rate of 0, 2½, (0.4 cwt. P_2O_5), 5 and 10 cwt. per acre. All plots received Sulphate of Ammonia at the rate of 0.8 cwt. N per acre and Sulphate of Potash at the rate of 2 cwt. K_2O per acre. Dunged in previous autumn.
Manures applied: April 2nd.
Potatoes planted: April 3rd. Lifted: Oct. 21st-22nd.
Previous Crop: Wheat.

Actual weights in lb.

Row.	British Queen.				King Edward.			
	0	2½	5	10	0	2½	5	10
I. ..	518	528	495	554	676	546	586	578
II. ..	476	558	532	512	559	562	611	598
III. ..	502	468	545	538	570	575	599	601
IV. ..	472	557	582	579	625	646	651	602

Summary of Results.

Average yield.	British Queen.				King Edward.			
	No Super.	2½ cwt. Super.	5 cwt. Super.	10 cwt. Super.	No Super.	2½ cwt. Super.	5 cwt. Super.	10 cwt. Super.
Tons per acre ..	13.18	14.14	14.42	14.62	16.27	15.60	16.39	15.93
Per cent. ..	87.5	93.8	95.7	97.0	108.0	103.5	108.7	105.7
Mean	14.09				16.05			
Standard Error ..	0.375 tons or 2.49 per cent.							

King Edwards yielded significantly better than British Queen. Significant response to British Queen variety with first dressing of superphosphate: further response to higher dressing is not significant. No response to superphosphate on King Edward variety.

https://doi.org/10.23637/ERADOC-1-63

Potatoes: Effect of Sulphate of Potash and Mineral Potash.
A. W. Oldershaw, Esq., Tunstall, Nr. Ipswich, 1930.

C			A		
K	O	S	K	S	O
O	K	S	S	O	K
D			B		

SYSTEM OF REPLICATION: 4 randomised blocks.
AREA OF EACH WHOLE PLOT: 1/60th acre. Each plot divided into two sub-plots.
Soil: Very light sand (almost out of cultivation).
Variety: Great Scott.
TREATMENTS:
O = Control.
S = Sulphate of Potash at the rate of 1.5 cwt. K_2O per acre.
K = Potash Mineral equivalent to Sulphate of Potash.
Sulphate of Magnesia, providing Magnesium equivalent to the Potash applied to one out of each pair of sub-plots, indicated by the treatment symbol occurring on that half.
All plots received Nitrate of Soda at the rate of 0.6 cwt. N per acre, and basic Superphosphate at the rate of 0.6 cwt. P_2O_5 per acre.
Manures applied: April 1st, except Nitrate of Soda which was applied as an early top dressing.
Potatoes planted: April 6th. Lifted: Oct. 8th-10th.

Actual weights in lb.

Block.	With Sulphate of Magnesia.			Without Sulphate of Magnesia.		
	O	S	K	O	S	K
A ..	557	486	514	461	581	423
B ..	468	547	491	418	525	490
C ..	516	520	433	547	507	438
D ..	455	447	508	459	493	503
Average in tons per acre	13.37	13.39	13.03	12.62	14.10	12.42

Summary of Results.

Average Yield.	Control.	Sulphate of Potash	Potash Mineral.	Mean.	Standard Error.	Without S/Mag.	With S/Mag.	Mean.	Standard Error.
Tons per acre ..	12.99	13.75	12.72	13.16	0.541	13.05	13.26	13.16	0.287
Per cent.	98.8	104.5	96.7	100.0	4.12	99.2	100.8	100.0	2.18

Slight non-significant advantage due to sulphate of potash. No response to potash mineral or sulphate of magnesia.

Potatoes: Effect of Superphosphate and Sulphate of Potash.
E. V. Cooke, Esq., The Limes, North Fen, Bourne, Lincs., 1930.

	A			B	
0P 2K	1P 2K	1P 1K	0P 1K	0P 2K	1P 1K
2P 1K	0P 1K	2P 0K	2P 0K	1P 0K	2P 1K
1P 0K	2P 2K	0P 0K	1P 2K	2P 2K	0P 0K
1P 1K	0P 2K	2P 2K	1P 0K	2P 0K	0P 2K
0P 0K	1P 0K	1P 2K	1P 1K	2P 2K	1P 2K
2P 1K	2P 0K	0P 1K	0P 0K	0P 1K	2P 1K
	C			D	

SYSTEM OF REPLICATION: 4 randomised blocks.
AREA OF EACH PLOT: 1/70th acre.
Soil: Black Fen land.
Variety: King Edward.
TREATMENTS: Superphosphate (P) at the rate of 0, 0.8 and 1.6 cwt. P_2O_5 per acre, and Sulphate of Potash (K) at the rate of 0, 1 and 2 cwt. K_2O per acre, in all combinations.
Manures applied: April 23rd.
Potatoes planted: April 25th.
Lifted: Sept. 25th.

Actual weights in lb.

Blocks.	1	2	3	4	5	6	7	8	9
A ..	372	293	392	360	459	388	344	439	406
B ..	334	444	437	393	385	434	366	438	439
C ..	234	291	279	295	339	297	332	413	479
D ..	262	385	338	335	382	367	297	365	421

Summary of Results.

	Tons per acre.				Per cent.			
Average yield.	No Super.	5 cwt. Super.	10 cwt. Super.	Mean.	No Super.	5 cwt. Super.	10 cwt. Super.	Mean.
No Potash ..	9.39	11.04	11.30	10.58	81.7	96.1	98.3	92.0
2 cwt. Sul./Pot. ..	10.80	12.23	11.61	11.55	94.1	106.4	101.1	100.5
4 cwt. Sul./Pot. ..	10.46	12.93	13.63	12.34	91.1	112.6	118.7	107.5
Mean	10.22	12.07	12.18	11.49	89.0	105.0	106.0	100.0
Standard Error ..	0.647				5.63			

Significant response to the single dressing of superphosphate—no further response to the double dressing. Significant response, on the average, to the single and double dressings of sulphate of potash.

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Potatoes: Effect of Inorganic and Organic Fertilisers. Mr. Inskip, Stanford, Biggleswade, 1930.

1.—HEAVY LAND.

I.	4	3	2	1
II.	1	2	3	4
III.	3	4	1	2
IV.	2	1	4	3

VARIETY: King Edward.
SYSTEM OF REPLICATION: Latin Square.
AREA OF EACH PLOT: 1/50th acre.
TREATMENTS:
1 = Blood, Superphosphate.
2 = Sulphate of Ammonia, Superphosphate.
3 = Sulphate of Ammonia, Steamed Bone Flour.
4 = Blood, Steamed Bone Flour.
Rates: 0.5 cwt. N and 0.6 cwt. P_2O_5 per acre. All plots received Sulphate of Potash at the rate of 1.25 cwt. K_2O per acre.
Manures applied: April 2nd-3rd.
Potatoes set: April 2nd.
Lifted: Oct. 1st.

Actual weights in lb.

Row.	1	2	3	4
I. ..	645	667	670	787
II. ..	752	637	655	576
III. ..	642	627	686	575
IV. ..	621	762	596	660

Summary of Results.

Average Yield.	Blood Super.	Sulph/Amm. Super.	Sulph/Amm. Steamed Bone Flour.	Blood Steamed Bone Flour.	Mean.	Standard Error.
Tons per acre ..	14.84	15.03	14.55	14.50	14.73	0.311
Per cent. ..	100.8	102.0	98.8	98.4	100.0	2.11

No significant differences in yield.

2.—LIGHT LAND.

— 1	— 2	— 3	4 —
— 4	— 3	1 —	2 —
— 2	1 —	4 —	— 3
3 —	4 —	— 2	— 1
IV	III.	II.	I.

VARIETY: Great Scott.
SYSTEM OF REPLICATION: Latin Square.
AREA OF EACH WHOLE PLOT: 1/50th acre. Each plot divided into two sub-plots.
TREATMENTS:
1 = Blood, Superphosphate.
2 = Sulphate of Ammonia, Superphosphate.
3 = Sulphate of Ammonia, Steamed Bone Flour.
4 = Blood, Steamed Bone Flour.
Rates: 0.3 cwt. N and 0.4 cwt. P_2O_5 per acre. Sulphate of Potash at the rate of 0.88 cwt. K_2O 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-3rd.
Potatoes planted: April 2nd.
Lifted: Sept. 5th.

https://doi.org/10.23637/ERADOC-1-63

Actual weights in lb.

Row.	Potash. 1	2	3	4	No Potash. 1	2	3	4
I. ..	118.0	118.0	104.5	125.0	105.5	116.0	96.5	96.0
II. ..	128.0	125.0	113.5	106.5	116.5	125.0	130.5	104.0
III. ..	99.5	124.5	126.5	123.0	128.5	124.5	97.5	108.0
IV. ..	125.0	140.5	144.0	129.0	125.0	115.5	138.0	115.0
Average in tons per acre	5.25	5.67	5.45	5.40	5.31	5.37	5.16	4.72

Summary of Results.

Average Yield.	Blood, Super.	Sulph/Amm. Super.	Sulph/Amm. Bone Flour.	Blood, Bone Flour.	Mean.	Standard Error.
Tons per acre ..	5.28	5.52	5.31	5.06	5.29	0.127
Per cent. ..	99.8	104.3	100.3	95.6	100.0	2.40

Average yield.	Without Potash.	With Potash.	Mean.	Standard Error.
Tons per acre ..	5.14	5.44	5.29	0.124
Per cent.	97.1	102.9	100.0	2.35

The differences between the nitrogenous and phosphatic treatments are not significant. There is a small, non-significant advantage due to the potassic dressing.

3.—EXPERIMENT ON FISH MEAL.

I.	II.	III.	IV.
A	A	B	B
B	B	A	A

Soil: Heavy loam.
VARIETY: King Edward.
SYSTEM OF REPLICATION: 4 randomised blocks.
AREA OF EACH PLOT: 1/50th acre.
TREATMENT:
A=Sulphate of Ammonia and Superphosphate.
B=Sulphate of Ammonia and Fish Meal.
Rates: 0.5 cwt. N and 0.6 cwt. P_2O_5 per acre. All plots received Sulphate of Potash at the rate of 1.25 cwt. K_2O per acre.
Manures applied: April 3rd.
Potatoes planted: April 1st. Lifted: Oct. 1st.

Actual weights in lb.

Treatment.	I.	II.	III.	IV.
A	756	658	757	712
B	790	701	714	682

Summary of Results.

Average yield.	S./Ammonia Super.	S./Ammonia Fish Meal.	Mean.	Standard Error.
Tons per acre	16.09	16.11	16.10	0.346
Per cent.	99.9	100.1	100.0	2.15

No difference in yield.

Sugar Beet: Effect of Nitrogenous Fertilisers, and of Muriate of Potash and Agricultural Salt.

Farm of Messrs. C. S. and G. M. Wilson, Colchester.

A			B		
7	9	8	2	7	5
4	1	5	4	9	6
6	2	3	1	3	8
5	2	8	4	9	7
4	6	9	8	5	1
7	1	3	3	2	6
C			D		

System of Replication: 4 randomised blocks of 9 plots each.
Area of Each Plot: 1/60th acre.
Treatments: Sulphate of Ammonia and Nitrate of Soda at the rate of 0.4 cwt. N per acre, Muriate of Potash at the rate of 0.8 cwt. K_2O per acre, and Salt equivalent in Chloride to Muriate of Potash, as shown in the Key to Treatments.
All plots received dung, and Superphosphate at the rate of 0.4 cwt. P_2O_5 per acre.
Soil: Light sandy gravel.
Manures applied: April 25th.
Seed sown: April 28th. Lifted: Nov. 6th-7th.
Variety: Kuhn P.

Key to Treatments.

Treatment.	1	2	3	4	5	6	7	8	9
Nitrogen ..				S/A	S/A	S/A	N/S	N/S	N/S
M/Potash		x	x		x	x		x	x
Salt ..			x			x			x

Actual weights in lb.

Treatments.		Roots (dirty).				Tops.			
N	K	A	B	C	D	A	B	C	D
O	O	239	263	412	501	177	145	323	285
O	M/P	349	352	456	436	301	256	360	317
O	M/P & S	286	369	352	327	234	257	286	256
S/A	O	213	359	463	380	195	256	305	267
S/A	M/P	221	267	466	468	202	291	364	368
S/A	M/P & S	389	304	478	529	331	351	430	453
N/S	O	256	383	482	507	236	366	347	411
N/S	M/P	357	399	495	523	352	456	417	384
N/S	M/P & S	329	370	514	502	340	363	427	379

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Summary of Results.

Average yield in tons per acre.	Roots (washed). No Potash	Mur./Pot.	M/Pot. & Salt.	Mean	Tops. No Potash	Mur./Pot.	M/Pot. & Salt.	Mean	Average Sugar Percentage. No Potash	Mur./Pot.	M/Pot. & Salt.	Mean.
No Nitrogen ..	8.59	9.68	8.10	8.79	6.23	8.26	6.92	7.14	18.94	18.79	19.36	19.03
Sulph./Amm.	8.59	8.64	10.33	9.19	6.85	8.20	10.48	8.51	18.85	18.14	18.66	18.55
Nitrate of Soda	9.89	10.77	10.42	10.36	9.11	10.77	10.10	9.99	18.55	18.74	18.72	18.67
Mean	9.02	9.70	9.62	9.45	7.40	9.08	9.17	8.55	18.78	18.56	18.91	18.75
Standard Error	0.607				0.523				0.241			

Average yield per cent.	Roots (washed). No Potash	Muriate of Potash	M/Potash and Salt	Mean	Tops. No Potash	Muriate of Potash	M/Potash and Salt	Mean
No Nitrogen ..	91.0	102.4	85.8	93.1	72.9	96.7	80.9	83.5
Sulph./Amm. ..	91.0	91.5	109.3	97.3	80.1	96.0	122.6	99.6
Nitrate of Soda ..	104.7	114.1	110.3	109.7	106.5	126.1	118.2	116.9
Mean	95.6	102.7	101.8	100.0	86.5	106.3	107.2	100.0
Standard Error ..	6.43				6.12			

Significant response to sulphate of ammonia when applied to those plots having muriate of potash and salt. Nitrate of soda plots significantly superior to sulphate of ammonia plots except in the presence of muriate of potash and salt. The response to muriate of potash is only significant with tops; further response is produced by adding salt only on those plots having sulphate of ammonia. The application of nitrogenous dressing has lowered the sugar percentage significantly.

Experiments at other centres, carried out by the local workers on the lines of those described on the preceding pages.

Potatoes. Mr. J. E. Arden, Owmby Cliff, Lincolnshire, 1930.

Latin Square : Plots 1/80th acre. Soil : Cliff (limestone).
Basal Manuring : 4 cwt. Sulphate of Ammonia and 3 cwt. Muriate of Potash per acre.
Variety : King Edward. Potatoes planted : April 17th. Lifted : Oct. 10th.

Average Yield.	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre ..	11.37	12.19	11.85	12.34	11.94	0.169
Per cent. ..	95.2	102.1	99.3	103.4	100.0	1.41

Significant response to the first dressing of superphosphate. No further response to the higher dressings.

Potatoes. Midland Agricultural College, Loughborough, 1930.

Randomised blocks : Plots 1/48.4 acre. Soil : Light gravel.
Basal Manuring : 3 cwt. Sulphate of Ammonia and 3 cwt. Sulphate of Potash per acre.
Variety : King Edward. Potatoes planted : April 11th. Lifted : Sept. 19th. Previous Crop : Spring Oats.

Average Yield.	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre ..	10.03	10.98	9.05	9.70	9.94	0.449
Per cent. ..	100.9	110.5	91.1	97.6	100.0	4.52

The yield has been significantly depressed by the heavier dressings (4 and 8 cwt.) of superphosphate.

Potatoes. County School, Welshpool, Montgomeryshire, 1930.

Randomised blocks : Plots 1/160th acre. Soil : School Garden.
Basal Manuring : 10 tons of F.Y.M. per acre, Sulphate of Ammonia at the rate of 0.8 cwt. N per acre, and Sulphate of Potash at the rate of 2 cwt. K_2O per acre.
Variety : Great Scott. Potatoes planted : May 7th. Lifted : Sept. 29th-Oct. 3rd.
Previous Crop : Sugar Beet.

Average Yield.	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre ..	9.18	11.64	13.29	12.36	11.62	0.339
Per cent. ..	79.0	100.2	114.4	106.4	100.0	2.92

Significant responses to dressings of 2 and 4 cwt. of superphosphate. Slight set-back with the highest dressing, which, however, is not significant.

Potatoes. Mr. J. Clarke, Eskham House, Nateby, Lancashire, 1930.

Latin Square : Plots 1/62 acre. Soil : Moss soil on deep peat.
Basal Manuring : Dung at the rate of 12 tons per acre, 2 cwt. per acre Sulphate of Potash and 2 cwt. Sulphate of Ammonia per acre.
Variety : King Edward. Potatoes planted : May 1st. Lifted : Sept. 22nd.

Average Yield.	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre ..	9.24	9.54	9.50	9.44	9.43	0.269
Per cent. ..	98.0	101.2	100.7	100.1	100.0	2.85

No response to superphosphate.

Potatoes. Mr. George, Great Nash, Llangwm, 1930.

Latin Square: Plots 1/185th acre. Soil: Sandy-hungry.
Basal Manuring: 2 cwt. per acre Sulphate of Ammonia and 2 cwt. per acre Sulphate of Potash.
Variety: Kerr's Pink. Potatoes planted: May 2nd. Lifted: Jan. 5th, 1931.

Average Yield.	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre ..	7.94	9.21	9.68	9.96	9.20	0.216
Per cent. ..	86.4	100.1	105.2	108.3	100.0	2.34

Significant response to superphosphate. The increment in yield falls off at the higher levels.

Potatoes. Grammar School, Burford, Oxon, 1930.

Latin Square: Plots 1/100th acre. Soil: Light loam on limestone.
TREATMENTS: Sulphate of Ammonia and Blood at the rate of 0.6 cwt. N per acre. Superphosphate and Bone Flour at the rate of 0.8 cwt. P_2O_5 per acre.
Basal Manuring: Sulphate of Potash at the rate of 1.4 cwt. K_2O per acre.
Variety: Kerr's Pink. Potatoes planted: April 10th. Lifted: Oct. 7th.

Average Yield.	Sulph/Amm. Bone Flour.	Dried Blood, Bone Flour.	Dried Blood, Super.	Sulph/Amm. Super.	Mean.	Standard Error.
Tons per acre ..	9.03	8.82	9.91	9.05	9.20	0.554
Per cent. ..	98.1	95.8	107.7	98.4	100.0	6.02

No significant differences between treatments.

Potatoes. Sailors' Orphan Homes School, Hull, 1930.

Latin Square: Plots 1/435 acre. Soil: Heavy Clay.
TREATMENTS: Sulphate of Ammonia at the rate of 0.4 cwt. N per acre, and Superphosphate at the rate of 0.5 cwt. P_2O_5 per acre.
Basal Manuring: Sulphate of Potash at the rate of 1 cwt. per acre K_2O.
Variety: Kerr's Pink. Potatoes planted: April 29th-30th. Lifted: Oct. 1st.

Average Yield.	Sulph/Amm. Super.	Sulph/Amm. Bone Flour.	Super Blood.	Bone Flour. Blood.	Mean.	Standard Error.
Tons per acre ..	11.69	9.86	10.88	9.01	10.36	0.425
Per cent. ..	112.9	95.2	105.0	87.0	100.0	4.10

Yield of plots receiving superphosphate significantly better than that of those receiving bone flour, irrespective of the source of nitrogen. The mean of all plots having sulphate of ammonia is significantly higher than that of those having nitrogen in the form of blood.

Sugar Beet. County School, Welshpool, Montgomeryshire, 1930.

Randomised blocks: Plots 1/160th acre. Soil: School Garden.
TREATMENTS: Sulphate of Ammonia, Cyanamide and Nitrate of Soda at the rate of 0.4 cwt. N per acre.
Basal Manuring: F.Y.M. at the rate of 10 tons per acre, Superphosphate at the rate of 0.8 cwt. P_2O_5 per acre and Muriate of Potash at the rate of 1 cwt. K_2O per acre.
Variety: Garton's Warrington. Beet sown: May 20th. Lifted: Oct. 28th-30th. Previous Crop: Mangolds and Swedes.

Average Yield.	No Nitrogen.	Nitrate of Soda.	Sulphate of Ammonia.	Cyanamide.	Mean.	Standard Error.
Roots (washed), tons per acre	11.59	12.57	13.32	11.96	12.36	0.135
Roots, per cent.	93.7	101.8	107.7	96.8	100.0	1.09
Tops, tons per acre	17.11	20.50	21.86	18.82	19.57	0.270
Tops, per cent.	87.4	104.7	111.7	96.2	100.0	1.38
Sugar percentage in roots ..	16.49	16.75	16.47	16.83	16.63	0.235

Significant responses to all forms of nitrogenous fertiliser. Sulphate of ammonia has proved significantly superior to nitrate of soda, while nitrate of soda in turn has produced a significantly higher yield than cyanamide. No significant differences in sugar percentage.

Sugar Beet. South Eastern Agricultural College, Wye, Kent, 1930.

Latin Square: Plots 1/50th acre. Soil: Light chalk loam.
TREATMENTS: Sulphate of Ammonia with seed at the rate of 3 cwt. per acre, Nitrate of Soda, top dressed, at the rate of 444 lb. per acre and Calcium Cyanamide before drilling at the rate of 3 cwt. per acre.
Basal Manuring: Superphosphate at the rate of 4 cwt. per acre, and Muriate of Potash at the rate of 2 cwt. per acre.
Variety: Klein Wanzleben. Beet sown: May 8th. Lifted: Oct. 28th-30th.
Previous Crop: Sugar Beet.

Average Yield.	No Nitrogen.	Sulphate of Ammonia.	Nitrate of Soda.	Cyanamide.	Mean.	Standard Error.
Roots (washed) tons per acre..	10.61	12.44	12.72	12.65	12.11	0.187
Roots, per cent.	87.6	102.8	105.1	104.5	100.0	1.55
Tops, tons per acre	11.90	15.36	18.19	16.15	15.40	0.401
Tops, per cent.	77.3	99.7	118.1	104.9	100.0	2.60
Sugar percentage in roots ..	17.83	17.53	17.59	17.85	17.70	0.566

Significant responses to all forms of nitrogenous fertiliser. Nitrate of soda plots significantly better than the sulphate of ammonia and cyanamide plots in tops, but not in roots. No significant differences in sugar percentage.

Sugar Beet. South Eastern Agricultural College, Wye, Kent, 1930.

Latin Square: Plots 1/50th acre. Soil: Light chalk loam.
TREATMENTS: Muriate of Potash at the rate of 2 cwt. per acre and Salt (176 lb. per acre) providing equivalent Chlorine to Muriate of Potash.
Basal Manuring: Superphosphate at the rate of 4 cwt. per acre and Sulphate of Ammonia at the rate of 3 cwt. per acre.
Variety: Klein Wanzleben. Beet sown: May 8th. Lifted: Oct. 22nd-25th.
Previous Crop: Sugar Beet.

Average Yield.	Control.	Salt.	Muriate of Potash.	Muriate of Potash & Salt	Mean.	Standard Error.
Roots (washed) tons per acre..	12.58	13.02	13.29	13.27	13.04	0.137
Roots, per cent.	96.5	99.8	102.0	101.7	100.0	1.05
Sugar percentage in roots	16.42	16.66	16.80	16.60	16.62	0.128

Significant response to the potassic and salt dressings. No further response to the double dressing.

Sugar Beet. County Farm Institute, Moulton, Northampton, 1930.

Latin Square: Plots 1/50th acre. Soil: Sandy loam.
TREATMENTS: Muriate of Potash at the rate of 2 cwt. per acre and Salt (196 lb. per acre) providing equivalent Chlorine to Muriate.
Basal Manuring: Superphosphate at the rate of 2 cwt. per acre, Steamed Bone Flour at the rate of 1 cwt. per acre, 2 cwt. Sulphate of Ammonia per acre.
Variety: Klein Wanzleben E. Beet sown: May 2nd. Lifted: Oct. 22nd.

Average Yield.	Control.	Muriate of Potash.	Salt.	Muriate of Potash & Salt	Mean.	Standard Error.
Roots (washed) tons per acre..	10.08	11.76	11.85	11.54	11.31	0.483
Roots, per cent.	89.2	104.0	104.8	102.0	100.0	4.27
Tops, tons per acre	13.70	13.48	14.43	14.48	14.02	0.854
Tops, per cent...	97.7	96.1	102.9	103.2	100.0	6.09
Sugar percentage in roots ..	17.02	17.52	17.81	18.26	17.65	0.175

Significant response in roots to muriate of potash and salt applied separately, but no further response when they were applied together. With tops the small response to salt is insignificant. Muriate of potash and salt have significantly increased the sugar percentage in roots, while on the plots receiving both muriate of potash and salt the sugar percentage is significantly greater than on the plots receiving the dressings separately.

Sugar Beet. The University of Leeds, Askham Bryan, Yorks, 1930.

Latin Square: Plots 1/20th acre. Soil: Light drift on Sandstone.
TREATMENTS: Nitrate of Soda with seed, Sulphate of Ammonia with seed and Nitrate of Soda as top dressing. Applications equivalent to 2 cwt. Sulphate of Ammonia per acre.
Variety: Johnson's Improved. Beet sown: May 3rd. Lifted: Oct. 29th-30th.
Previous Crop: Wheat.

Average Yield.	No Nitrogen.	N./Soda top dressing.	N./Soda with seed.	S/Ammonia with seed.	Mean.	Standard Error.
Roots (washed) tons per acre..	8.23	9.17	9.76	10.08	9.31	0.233
Roots, per cent.	88.4	98.5	104.8	108.3	100.0	2.50
Tops, tons per acre	9.48	10.94	11.59	11.62	10.90	0.221
Tops, per cent...	86.9	100.3	106.3	106.5	100.0	2.03
Sugar percentage in roots ..	18.01	18.26	18.02	17.89	18.05	0.215

Significant response to all forms of nitrogenous fertiliser with both roots and tops. Yield of plots having the dressing with the seed is significantly greater than that of plots having the top dressing. No difference between sulphate of ammonia and nitrate of soda when applied with seed. No significant differences in sugar percentage.

Barley. South Eastern Agricultural College, Wye, Kent, 1930.

Latin Square: Plots 1/50th acre. Soil: Light chalk loam.
TREATMENTS: Salt at the rate of 88 lb. per acre and Muriate of Potash at the rate of 1 cwt. per acre.
Basal Manuring: Superphosphate at the rate of 4 cwt. per acre and Sulphate of Ammonia at the rate of 1 cwt. per acre.
Variety: Plumage Archer. Barley sown: Mar. 4th. Harvested: Aug. 12th.
Previous Crop: Barley.

Average Yield.	No Salt or Potash.	Muriate of Potash.	Salt.	Muriate of Potash &Salt	Mean.	Standard Error.
Grain, cwt. per acre	19.4	20.0	20.2	20.3	20.0	0.77
Grain, per cent.	97.3	100.1	101.2	101.5	100.0	3.88
Straw, cwt. per acre	17.4	17.4	16.6	16.7	17.0	0.71
Straw, per cent.	102.1	102.1	97.5	98.2	100.0	4.16
Nitrogen percentage in grain..	1.33	1.31	1.30	1.30	1.31	0.009

No response to the potassic or salt fertilisers. Application of salt has depressed the nitrogen percentage significantly, while muriate of potash has been without effect.

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Lawes Agricultural Trust

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