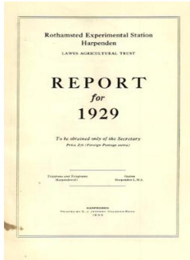
ROTHAMSTED RESEARCH

Report for 1929

Full Table of Content



Rothamsted Experimental Station
Harpenden

REPORT
for
1929

Rothamsted Experimental Station Report for 1929

Rothamsted Research

Rothamsted Research (1930) *Rothamsted Experimental Station Report for 1929 ;* Report For 1929, pp 1 - 128 **- DOI: https://doi.org/10.23637/ERADOC-1-111**

Rothamsted Experimental Station
Harpenden

LAWES AGRICULTURAL TRUST

REPORT
for
1929

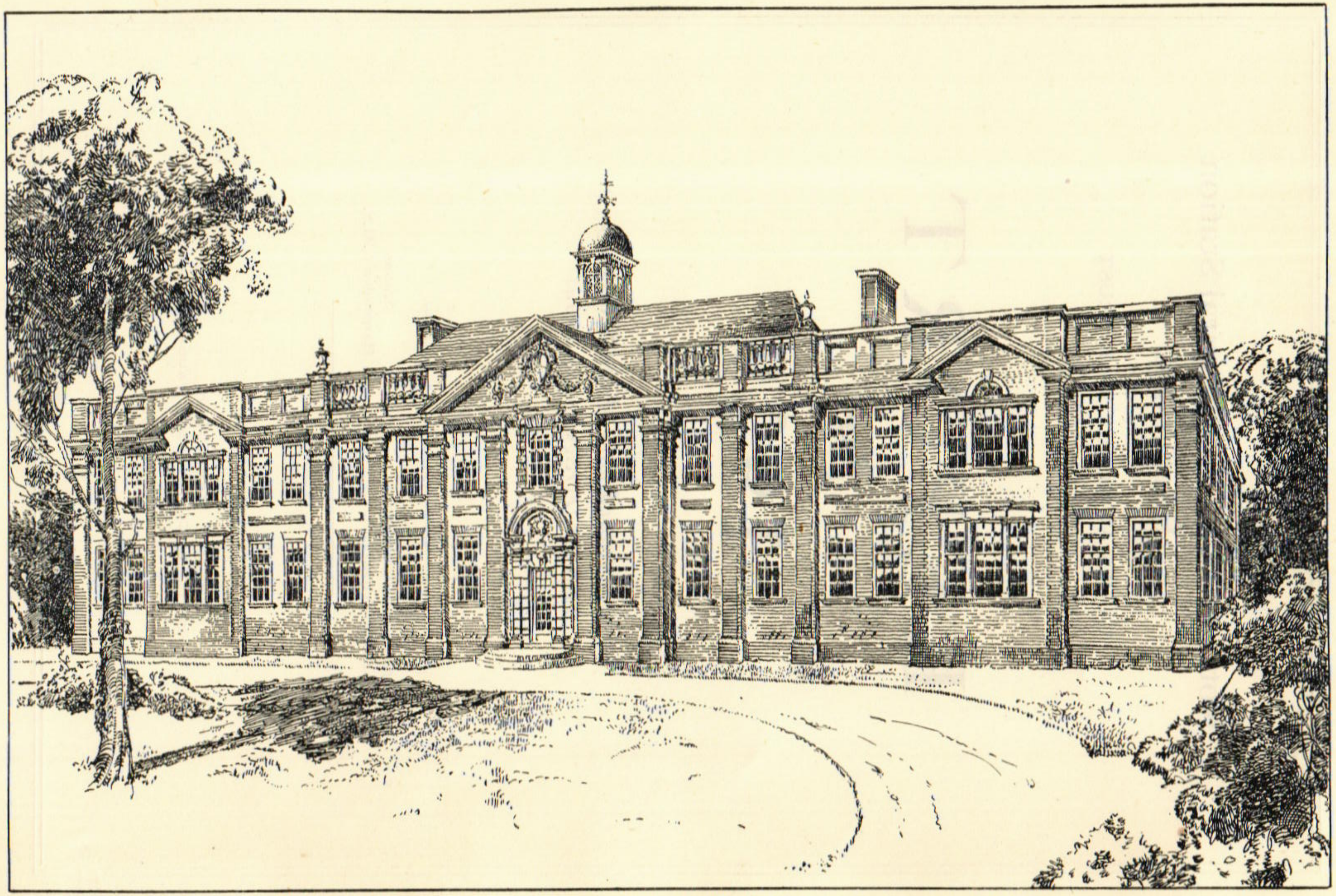
To be obtained only of the Secretary

Price 2/6 (Foreign Postage extra)

Telephone and Telegrams
Harpenden 621

Station
Harpenden L.M.S.

HARPENDEN
PRINTED BY D. J. JEFFERY, VAUGHAN ROAD
1930



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

REPORT

FOR

1929

https://doi.org/10.23637/ERADOC-1-111

Contents

https://doi.org/10.23637/ERADOC-1-111

Experimental Station Staff

Director : Sir E. John Russell, D.Sc., F.R.S.
Assistant Director : B. A. Keen, D.Sc., F.Inst.P.

INSTITUTE of PLANT NUTRITION and SOIL PROBLEMS

The James Mason Bacteriological Laboratory—

Head of Department ...	H. G. Thornton, B.A., D.Sc.
Assistant Bacteriologist...	H. Nicol, M.Sc., A.I.C.
Laboratory Attendants ...	Sheila Arnold.
	Muriel Russell.

Botanical Laboratory—

Head of Department ...	Winifred E. Brenchley, D.Sc., F.L.S.
Assistant Botanist ...	Katherine Warington, M.Sc.
Laboratory Assistant ...	Elizabeth Kingham.
Laboratory Attendants ...	Kathleen Dellar.
	May Dollimore.

Chemical Laboratory—

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.
	Signe G. Heintze, Mag.Phil.
Post - Graduate Research Workers	A. J. Pugh, B.Sc.
	J. K. Basu, M.Sc.
	T. J. Mirchandani, M.Sc.
	N. H. Parbery, B.Sc.
	K. E. Troell, M.A.
Barley Investigations (Institute of Brewing Research Scheme) ...	L. R. Bishop, M.A., Ph.D.
	F. E. Day, B.Sc., F.I.C.
Special Assistant... ...	E. Grey.
Laboratory Assistants ...	A. H. Bowden.
	F. Seabrook.
	G. Lawrence.
	H. A. Smith.
Laboratory Attendants ...	Maud Bracey.
	Rose Robinson.

https://doi.org/10.23637/ERADOC-1-111

Laboratory for Fermentation Work—

Head of Department ...	E. H. Richards, B.Sc., F.I.C. (Iveagh Research Chemist).
Assistant Chemist ...	S. H. Jenkins, M.Sc., A.I.C.
Post - Graduate Research Workers	A. G. Norman, B.Sc., Ph.D., F.I.C. 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. Hilda Parsons.

General Microbiology Laboratory—

Head of Department ...	D. W. Cutler, M.A., F.L.S., F.Z.S.
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	B. K. Mukerji, D.Sc.
Laboratory Assistant ...	Mabel Dunkley.
Laboratory Attendant ...	Molly Johnson.

Physical Laboratory—

Head of Department ...	B. A. Keen, D.Sc., F.Inst.P.
Assistant Physical Chemist	R. K. Schofield, M.A., Ph.D. (Empire Cotton Growing Corporation Soil Physicist).
Assistant Physicists ...	G. W. Scott Blair, B.A. (Goldsmiths' Company Physicist). G. H. Cashen, M.Sc.
Post - Graduate Research Worker	Prof. L. L. Lee.
Assistant	Jessie Walker.
Laboratory Assistants ...	W. C. Game. R. F. S. Hearmon.
Laboratory Attendants ...	K. D. Anderson. 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. J. O. IRWIN, M.A., M.Sc.
Computer (Honorary) ...	W. D. CHRISTMAS.
Post - Graduate Research Workers	FRANCES E. ALLAN, M.A. R. J. KALAMKAR, B.Sc.
Research Worker (Honorary)	B. P. SCATTERGOOD, M.A.
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, Ph.D.
Cytologist	FRANCES M. L. SHEFFIELD, Ph.D., F.L.S.
Entomologist ...	MARION A. HAMILTON, Ph.D.
Glasshouse Superintendent	MARGARET M. BROWNE.
Post - Graduate Research Workers	PHYLLIS H. JARRETT, M.Sc. L. M. J. KRAMER, B.A.

Laboratory Assistant ...	Doris Tuffin.
Laboratory Attendant ...	Edna Evenett.
Glasshouse Attendant ...	Hilda Hale.

FIELD EXPERIMENTS

Guide Demonstrator ...	H. V. Garner, M.A., B.Sc.
Assistant Demonstrator...	E. H. Gregory.
Plant Physiologist ...	A. R. Clapham, M.A.
Field Superintendent ...	B. Weston.
Assistants	G. F. Cole. S. A. W. French.
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. ———
Stockmen	T. J. Lewis. J. R. Vipond.
Tractor Driver	J. Underhill.
Labourers	W. Holland. T. Missenden.

LIBRARY

Librarian	Mary S. Aslin.

SECRETARIAL STAFF

Secretary	W. Barnicot.
Assistant Secretary ...	Constance K. Catton.
Director's Private Secretary	Annie E. Mackness.
Senior Clerk	Beatrice E. Allard.
Junior Clerks	Nora Leverton. 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.
Ploughman	...	G. TYLER.
Assistant Ploughman	...	J. TYLER.
Stockman ...	...	W. McCALLUM.
Labourers ...	...	J. McCALLUM. K. McCALLUM.

MEMBERS WHO HAVE LEFT SINCE LAST REPORT AND THE APPOINTMENTS TO WHICH THEY PROCEEDED

R. B. DAWSON, M.Sc.	...	Director of Research, St. Ives Research Station, British Golf Unions, Bingley, Yorks.
P. H. H. GRAY, M.A.	...	Head of Teaching in Bacteriology and General Research, and Assistant Professor in Soil Bacteriology, Macdonald College, Quebec.
R. P. HOBSON, B.Sc., Ph.D. ...	...	Assistant Entomologist, London School of Hygiene and Tropical Medicine.
MARY S. MARTIN, B.Sc.	...	Lecturer in Botany, University College, Cardiff.
H. SANDON, M.A....	...	Lecturer in Zoology, Egyptian University, Cairo.

Temporary Workers, 1929.

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 1929 :—

SENT OFFICIALLY BY GOVERNMENTS AND CORPORATIONS :

(1) *From Great Britain and the Empire—*

Colonial Office Agricultural Officers: H. W. Jack (Federated Malay States), M. Greenwood, K. T. Hartley, C. H. Wright (Nigeria), G. W. Nye (Uganda).

Indian Government: A. T. Sen, M.Sc.

Rhodesian Government: H. J. Blofield.

Imperial Chemical Industries: W. G. Eggleton.

(2) *From Foreign Countries—*

International Education Board Fellow: Dr. Elizabeth F. McCoy (Wisconsin).

Denmark: Dr. C. S. Ostergaard, J. K. Hansen, H. L. Jensen.

Norway: Karl Solberg.

Russia: Prof. J. W. Turin.

Sweden: Dr. M. Koffman.

United States of America: Prof. H. Hotelling (California).

OTHER WORKERS :

Dr. Miriam Bishop, S. W. Johnson, Dr. Margaret Madge, A. Stuart Miller, Miss Amy H. Pearce, J. Pepper, H. G. Sanders, T. W. Simpson, H. J. L. Whitehead.

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 Bureau commenced work on May 1st, 1929. Its function 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 communications is not confined to Official Correspondents, but extends to all workers in soil science whose names are known to 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 E. J. Russell. 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:

"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.

Ernest Benn, Ltd., 8 Bouverie Street, London, E.C. 4; or from the Secretary, Rothamsted Experimental Station, Harpenden, Herts.

Numbers 1 to 10 inclusive are also published in book form:—Vol. I (1-5), Vol. II (6-10), 10/- each. Postage extra. Obtainable from the Secretary, Rothamsted Experimental Station, Harpenden, Herts.

For Students and Agricultural Experts

"The Rothamsted Memoirs on Agricultural Science." Quarto Series, vols. 1-3 (1859-1883), 20/- each. Octavo, 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. 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. Fifth Edition, 1926. Longmans, Green & Co., 39 Paternoster Row, London, E.C. 4. 18/-.

"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. 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.

"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, Second Edition, revised and enlarged, 1927. The University Press, Cambridge. 10/6.

"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, B.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. 6d.

"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 :—

1908-1914 (annual).	1/- each.
1915-1917 (triennial).	2/6.
1918-1920 (triennial).	2/6.
1921-1922 (biennial).	2/6.
1923-1924 (biennial).	2/6.
1925-1926 (biennial).	2/6.
1927-1928 (biennial).	2/6.

Foreign postage extra.

"RECORDS OF THE ROTHAMSTED STAFF, HARPENDEN," containing personal notes and accounts of 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. 1921. The University Press, Cambridge. 8/-.

For use in Schools

"LESSONS ON SOIL," by E. J. Russell. 1926. The University Press, Cambridge. 3/-.

For General Readers

"THE FERTILITY OF THE SOIL," by E. J. Russell. 1913. 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. 8d. 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., F.Z.S. 1925. Christophers, 22 Berners Street, London, W.1. 4/6.

"THE GENETICAL THEORY OF NATURAL SELECTION," by R. A. Fisher, 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.

Signed Engraver's Proofs on India paper, £4 4s. each.

Ordinary Lettered Proofs on hand-made paper, £2 2s. each.

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

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 1929-30, the Ministry of Agriculture has made a grant of £27,400 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, Fertilizer Sales, Ltd., 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 part of the Records and Statistical Department, Staff Common Room and Conference Room.

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, Rockefeller 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 Engineers' 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 computer 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 and Canada 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 recently 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 Chemist to the Sudan Government, has been 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 site adjoining the laboratory on the South side in readiness for the time when further accommodation will be necessary.

REPORT FOR THE YEAR 1929.

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; they include soil management, the use of fertilisers, plant diseases and the value of the resulting crop. This last is the most difficult because of its indefiniteness: chemistry is not yet sufficiently advanced to allow of a rigid description of a crop, and in consequence the help of the expert user of the crop is obtained. Thus the work on wheat is done in consultation with the Research Association of British Flour Millers, that on barley with the Institute of Brewing, on potatoes with Messrs. Lyons; in each instance the crop is under close investigation from the time of sowing right up to its conversion into the final form of bread, beer, boiled, mashed or fried potatoes.

The programme being so wide has necessarily a considerable element of permanence. It is not sufficient to know *how* to get good results on our own farm: we have to discover *why* some methods are good and some are not, for only in this form is the information really useful to farmers working under other conditions of soil and climate. The safest and in the end the quickest method is to plan the investigation so as to give information about the underlying facts and principles.

It is for the agriculturist to extract from the information thus obtained whatever is likely to bear on the agricultural problems of the day. The agricultural situation changes somewhat rapidly, but in essentials it still remains as it was when the Report for 1927-8 was written. Prices of produce are low and costs of production high: nowhere is farming really prosperous. Science and engineering have done their work so well that the food-producing power of the world exceeds the present demand, and there is no sign in the market of any of the shortages which have from time to time been predicted. Low temperature research is leading to improvements in refrigerator transport so that produce can be transported for thousands of miles and kept for months, and then

https://doi.org/10.23637/ERADOC-1-111

offered to the British housewife in such a way that she can hardly distinguish it from the fresh produce of a British farm. From all over the Empire and from great parts of Europe, the United States and South America, growers are pouring their produce on to the British market—almost the only one open to them outside their own country—and they aim at pouring out still more. Neither they nor the British consumer get much out of it and the British farmer definitely loses: on the other hand the organisations that handle the produce are few in number but very efficient and prosperous: and they are favoured by the circumstance that the average publicist treats the problem as one of inviolable sentiment and not as a business proposition. In consequence, the British farmer finds himself in the difficult and trying position that bountiful years like 1928 and 1929 have involved him in heavy financial losses. Potatoes that cost £3 or more per ton to grow are rotting in clamps because there are no buyers even at £1 per ton, the street hawker of the old days having almost disappeared. Wheat and barley are unsaleable at any remunerative price, and both are being fed on the farm. The situation of the arable farmers is more difficult than that of the grass men, and in consequence there is a marked tendency to get away from arable farming and take up grass land.

Certain branches of farming are, however, in a better position than the rest: milk production, poultry, fresh meat (lamb, pig meat and beef) and sugar beet. All these are "sheltered" industries, to borrow an industrial phrase: and two of them, milk and sugar beet, have the further advantage that they are grown on contract: the farmer knows before he begins operations what price he will be paid and he can not only frame his plans accordingly, and take full advantage of the results of experiment stations, but he is saved the time and worry that would otherwise be spent on marketing. There seems little doubt that an extension of the contract system would be of great value in setting farming up again. Contract prices have meaning only in relation to agricultural wages, and the two would need to be fixed together. Further, any particular price would be profitable on some but not on other land; thus at a basic wage of 32/- per week there could be considerable production at the following contract prices, yet some farmers would not succeed while others would be doing well:—

	Basic Wage, 32/- per week
Milk ...	1/2 (Summer); 1/6 (Winter) per gallon
Wheat	50/- per quarter
Barley	40/- ,, ,,
Sugar Beet	50/- per ton
Potatoes	£5 ,, ,,

Higher contract prices would justify higher wages, as also would reductions in cost of production and of marketing.

The agricultural conditions of Great Britain differ from those of various other countries in that they do not, and for years past have not, stimulated the British farmer to increase his yields per acre. During the writer's visits overseas the question almost always asked by farmers is, "Can you tell us how to get more produce out of our land?" But it is rarely asked here. The desire to create wealth in the countryside, which was a potent factor in the life of the 19th century, seems less operative now. "I can't profitably sell what I grow now, so what is the use of growing more?" is the usual comment. The movement for increased yields overseas is well illustrated by the following average yields per acre of fodder crops :—

	Mangolds, tons per acre		Swedes and turnips, tons per acre		
Average during	England	Denmark	England	Denmark Swedes	Denmark Turnips
1889–1893	17.48	17.44	13.29	17.79	15.21
1899–1903	19.54	16.56	11.83	17.12	14.45
1909–1913	19.00	20.46	12.77	18.75	16.00
1923–1927	19.36	21.58	12.88	20.66	17.12

Instead of seeking information about increased yields, farmers usually ask how to reduce costs of production. The most important problems now in agricultural production are those associated with grass land, winter fodder crops and highly priced crops such as sugar beet, potatoes and malting barley. To these problems, therefore, considerable attention is now being paid at Rothamsted.

CHANGE IN THE SYSTEM OF MANAGEMENT OF THE ROTHAMSTED FARM.

Considerable change has recently been made in the management of the farm as distinct from the experimental plots. When it was taken over in 1911 it was used to grow cereals, roots and hay for sale to cow-keepers, from whom dung was purchased in exchange. The system suited us very well, it was neither costly nor laborious to run, and it gave for experiment a considerable area of land in sufficiently low condition for testing the value of fertilisers. It was therefore continued with some modification until 1920. Then came the great fall in prices and it became impossibly expensive. A new system was therefore started which has now been completely installed. Much of the land has been laid down to grass: a grass flock of 150 half-bred ewes (Cheviot ewe by Border Leicester ram) is kept and crossed with Suffolk and Hampshire rams: the lambs mainly miss the early market and are therefore kept on to be finished on sheep-feed grown on the arable land. In addition, 20 Wessex Saddleback sows are kept and mated with a pure Wessex or a Large White boar: they live mainly on the grass, but are brought in for a few weeks before and after farrowing. The pigs are sold for London pork when about 4½ to 6 months old and weighing about 110 to 130 lb. alive, or 80 to 100 lb. dead. Young cattle are bought in late winter to consume whatever food the sheep and pigs will not require, and they are sold in spring as forward stores, or in early summer as fat cattle, according as best suits prices and food supplies. The ordinary arable land is run on a five course rotation, each break consisting of 12 acres : fodder crops : barley : seeds : wheat : winter oats ; experiments are distributed over them as occasion requires. A new experimental field of 24 acres (Long Hoos) has been divided into 6 parts, 5 cropped on a rotation including wheat, barley, oats, seeds and forage crops, while the sixth forms an experimental six course rotation of potatoes, wheat, sugar beet, barley, seeds, oats : these areas are devoted entirely to experiment: another experimental rotation of 3 acres has been started in Hoos Field.

The division of the land is therefore as follows:—

		Prior to 1924 acres	Present Time acres
ARABLE.	Classical experiments* ...	$42\frac{1}{2}$	$42\frac{1}{2}$
	New permanent experiments ...	—	27
	Other experiments and non-experimental ...	$182\frac{1}{2}$	60
GRASS	... ...	$27\frac{1}{2}$	123
Roads, buildings, small enclosures		$27\frac{1}{2}$	$27\frac{1}{2}$
	Total	280	280

* Including 7 acres grass.

LAYING DOWN OF LAND TO GRASS.

With the laying down of land to grass there came an opportunity of watching the behaviour of the plants sown. Several mixtures were used, including perennial and italian rye-grasses, cocksfoot, timothy, rough-stalked meadow-grass and the clovers. Botanical surveys were made after the plants were established and again at the end of the drought. The figures at the end of the first year are given in Table I. The most striking results are:—

(1) 30 per cent. of the land is still bare in spite of generous seeding and manuring.

(2) the rye-grasses have increased considerably.

(3) the clovers, especially wild white clover, have increased considerably.

(4) cocksfoot, timothy and meadow fescue have become established, but cover decidedly less ground than corresponds with the seed sown.

(5) meadow foxtail and rough-stalked meadow-grass have failed to become established.

An investigation has been commenced by Messrs. A. R. Clapham and F. J. Richards on competition between various species of grass and clover. Careful growth measurements were taken of some of the common grasses grown singly and in pairs. Species of large growth habit lower the tillering and growth rate of species of smaller growth habit; thus italian rye-grass behaved as an "aggressor" to perennial rye-grass, cocksfoot, timothy and rough-stalked meadow-grass. Although it prevented these others from making their full growth, it did not by itself make its full growth. Indeed, larger weights per plant were obtained when it was grown in admixture with perennial rye-grass and specially with rough-stalked meadow-grass.

THE MANURING OF GRASS LAND.

(1) *Grazing Land.* The difficulties of a grazing experiment were described in the last Report: as no satisfactory way round has yet been discovered we propose keeping this method for demonstration purposes only, restricting its use to cases where the differences are large. In 1929 the effect of phosphatic manure was studied by mowing the grass repeatedly during the season and finding the weight and composition of the cuttings. As in previous experiments, high solubility proved to be of great importance:

TABLE I.—Areas covered by the various plants, compared with Numbers of Seeds sown.
SAWYER'S GRASS LAND. Sown April 25, 1928.

Name of Species.	PLOT 1. Percent. of Total No. of Seed sown Apl. 25, 1928	PLOT 1. Percentage Area Covered 1929 July	PLOT 1. Oct.	PLOT 2. Percent. of Total No. of Seed sown Apl. 25, 1928	PLOT 2. Percentage Area Covered 1929 July	PLOT 2. Oct.	PLOT 3. Percent. of Total No. of Seed sown Apl. 25, 1928	PLOT 3. Percentage Area Covered 1929 July	PLOT 3. Oct.	PLOT 4. Percent. of Total No. of Seed sown Apl. 25, 1928	PLOT 4. Percentage Area Covered 1929 July	PLOT 4. Oct.	PLOT 5. Percent. of Total No. of Seed sown Apl. 25, 1928	PLOT 5. Percentage Area Covered 1929 July	PLOT 5. Oct.	PLOT 6. Percent. of Total No. of Seed sown Apl. 25, 1928	PLOT 6. Percentage Area Covered 1929 July	PLOT 6. Oct.
Perennial rye-grass, *Lolium perenne*	15.7	22.8	49.9	—	—	—	8.4	30.9	48.4	—	—	—	23.5	27.5	46.1	56.7	34.9	61.1
Italian rye-grass, *Lolium italicum*	—	—	—	7.1	21.7	31.7	6.8			5.2	19.7	35.3	—	—	—	—	—	—
Cocksfoot, *Dactylis glomerata* ..	25.2	5.8	8.2	35.4	5.7	10.0	16.8	5.4	9.7	15.5	8.6	7.2	29.5	10.0	9.7	37.8	10.1	10.5
Timothy, *Phleum pratense* ..	15.7	3.6	3.4	14.7	1.9	4.6	16.8	1.5	3.6	26.0	2.5	5.2	29.5	3.8	7.7	—	0.1	1.3
Tall fescue, *Festuca elatior* ..	—	—	—	3.1	4.0	2.1	—	—	—	—	—	—	—	—	—	—	—	—
Meadow fescue, *Festuca elatior var. pratensis*	2.7	—	0.1	—	—	—	7.4	1.1	2.4	11.2	5.3	6.3	—	0.1	—	—	0.1	0.2
Meadow foxtail, *Alopecurus pratensis*	—	—	—	—	—	—	16.8	—	—	7.8	—	—	—	—	—	—	—	—
Rough-stalked meadow-grass, *Poa trivialis*	25.2	0.5	—	14.3	1.0	—	13.6	—	—	20.8	0.4	—	5.9	—	—	—	—	—
Late and early flowering red clover, *Trifolium pratense* ..	5.8	7.5	5.1	6.4	8.2	5.5	8.4	14.8	4.9	6.5	16.8	7.2	7.4	13.9	4.9	—	4.1	0.3
Wild white clover, *Trifolium repens*	4.5	24.0	6.2	5.1	13.9	5.3	4.9	15.0	1.5	3.8	8.0	4.5	4.2	11.1	3.2	5.5	18.1	0.9
Alsike clover, *Trifolium hybridum*	—	—	—	5.1	5.9	—	—	—	—	—	—	—	—	—	—	—	—	—
Trefoil, *Medicago lupulina* ..	—	—	—	—	—	—	—	1.2	—	3.2	8.0	—	—	—	—	—	—	—
Chicory, *Cichorium intybus* ..	5.2	4.9	0.8	5.8	5.4	4.7	—	—	—	—	—	—	—	—	—	—	—	—
Weeds	—	2.2	0.6	—	1.1	2.8	—	0.8	0.4	—	2.1	0.5	—	5.3	0.4	—	5.4	1.3
Bent grass, *Agrostis alba* ..	—	0.2	5.5	—	0.8	0.7	—	—	—	—	—	—	—	—	—	—	—	—
Covered with vegetation ..	—	72.2	79.8	—	69.8	67.4	—	70.8	70.9	—	71.9	66.2	—	71.2	72.0	—	73.2	75.6
Bare patches	—	27.8	20.2	—	30.2	32.6	—	29.2	29.1	—	28.1	33.8	—	28.8	28.0	—	26.8	24.4
Total area	—	100	100	—	100	100	—	100	100	—	100	100	—	100	100	—	100	100

Average, 10 samples, area 1 square foot.

superphosphate gave the best results, followed by high soluble basic slag: low soluble slag was less effective and mineral phosphate still less: indeed in none of our experiments has mineral phosphate proved effective. The results are as follows:—

	Solubility (Warren Method)	Increased yield over Control. Dry matter.	Phosphoric oxide (P_2O_5)	
			per cent. in dry matter.	Total uptake when super. =100
Superphosphate..	90	100	1.15	100
High soluble slag	53	62	0.98	84
Low soluble slag	18	22	0.96	80
Gafsa phosphate	14	5	0.93	76
No phosphate ..	—	—	0.89	74

The figures for yield are to be taken only as showing the order and not the precise amounts. The figures for phosphorus uptake have more significance: they show that in comparison with the phosphate of low solubility, the high soluble fertilisers not only gave more herbage, but more nutritious herbage, containing per ton more of the phosphate essential to the animal. This experiment is being repeated on a more extensive scale in 1930.

(2) *Hay Land.* The slag experiments were continued in Somerset on old hay land and in Norfolk on new hay land: both are in their fourth year after the dressing and the effect is beginning to wear off.

The yields have been in cwt. of hay per acre:—

	Control.	Basic Slag. Low Soluble.	Medium.	High Soluble.
Somerset (Old Grass)				
Average 3 years, 1926-28..	20.9	23.6	26.0	24.9
1929	20.0	22.5	23.5	22.1
Norfolk (New Grass)				
Average 3 years, 1926-28..	26.5	29.8	32.7	36.7
1929	10.9	12.6	13.6	13.9

SOLUBILITY AND EFFECTIVENESS OF BASIC SLAG.

The experiments described above form part of an extended series carried out by the Rothamsted staff during the past eight years, largely under the ægis of the Ministry of Agriculture Basic Slag Committee, to discover the agricultural values of the different kinds of slag on the market.

There are three types of slag in common use:—

	Type 1.	Type 2.	Type 3.
Per cent. Phosphoric oxide	16 to 18	8 to 17	8 to 15
Equivalent to tricalcic phosphate ..	35 to 39	17.5 to 37	17.5 to 33
Per cent. of total phosphoric oxide soluble in 2% citric acid	80 or more	80 or more	40 or less
Process of production	Bessemer	Open Hearth	Open Hearth with addition of Fluorspar

https://doi.org/10.23637/ERADOC-1-111

In this country the Bessemer process of steel manufacture is not at present used, and Bessemer slags on the British market are entirely of foreign origin. So far as solubility is concerned, the slags fall into two groups only, few if any samples having solubility between 45% and 75%.

In practically all our experiments the high soluble slag has given the better results and there is no question that it is of greater value to the farmer. It acts more quickly and gives larger increases than the low soluble slag. Recent changes in steel making have tended to increase the output of this high soluble material, which is all to the good: and, further, the manufacturers are now prepared to offer slag of less than 45% solubility in the old official citric acid test at lower unit price than they ask for slag of 75% or higher solubility.

While the low soluble slags are inferior to those of high solubility as a source of phosphate, nevertheless they have value in certain humid conditions; fortunately these occur near the works where the slags are obtainable cheaply.

A further result of the investigation has been to show the limits of value of the old citric acid test which had fallen into some disrepute. The grading of the slags into two classes is almost entirely satisfactory, and the analysis is sufficiently easy and rapid.

The method is not, however, of a high order of accuracy, and it fails to place slags in their proper order within each class: a slag of 90% solubility may be less effective as a fertiliser than one of 75%. Occasionally it appears even to class a slag wrongly: it puts into the low soluble group a new type of slag which is said to have high agricultural value, and which is now being tested by the Rothamsted staff. A method has been worked out by Mr. R. G. Warren at Rothamsted (extraction with sodium chloride solution) which places the slags within each class more in accordance with their agricultural value; it is, however, less convenient than the citric acid method and is better suited to an experimental station than to an analysts' laboratory.

LUCERNE.

The inoculation process developed in the Bacteriological Department has proved very successful: in 1929 the issue of cultures to farmers again exceeded the previous records, and sufficed to sow 1,300 acres. The demand rose above our power to supply, and accordingly some of the leading biochemical firms were invited to tender for the taking over of the business. Arrangements were finally made with Messrs. Allen & Hanbury, of Bethnal Green, London, E. 2, to prepare cultures under Rothamsted tests and to supply them to farmers at the rate of 3/- for one acre of land. These arrangements have been in force for some months and are working satisfactorily: the demand has been greater than ever. Dr. Thornton has also devised a method for transmitting the cultures over great distances: cultures sent to Western Australia arrived in good condition and successfully increased yields of lucerne there.

The relationship of the nodule organisms to the plant has been further studied; Dr. Thornton has shown that they do not normally enter the plant until the true leaves begin to form: then there is extruded from the root a substance which facilitates or even determines their entry. The nature of this substance is not yet determined, but it does not appear to be made in the leaf. When the organisms are in the root they increase greatly in number, and they stimulate the plant cells to multiply, forming the well-known nodules. Around the colony of bacteria a network of conducting vessels develops as an offshoot from the main circulating system of the plant, and, this close connection being established, the bacteria take sugar from the plant, causing an increase in growth. If the supply of sugar is cut off by keeping the plants in the dark, or by stopping the development of the conducting vessels (which can be done by withholding the trace of boron needed for this purpose) the bacteria turn to the root tissue for food and begin to consume it: they thus change from being beneficial into harmful parasites. If the supply of air is restricted the bacteria fix less nitrogen, but they do not become parasitic.

POTATOES.

The potato experiments were conducted on much the same general lines as last year. The yields, however, were low, as the result of the very dry March and April: the plants were not able to start growing till May.

The increases given by fertilisers were, in cwt. per acre :—*

	1929			Average 1925–28 †		
Sulphate of Ammonia cwt. per acre	0	1.5	3	0	2	4
Sulphate of Potash cwt. per acre 0	–	12	15	–	20	24
,, ,, ,, 1	7	15	18			
,, ,, ,, 2	2	16	21	15	49	71
,, ,, ,, 4				16	55	75
	Basal crop 4.52 tons per acre.			Average Basal crop 6.62 tons per acre.		

* In all years except 1925 farmyard manure was also applied.
† In 1928, the weights of fertilisers used were as in 1929.

The increases are thus less than usual, nevertheless they cost less than £2 per ton. Taking the four years 1925-28, the expenditure in pence on manure per cwt. of additional crop has been :—

	1925–28		
Sulphate of Ammonia	0	2	4
Sulphate of Potash 0	0	13	21
,, ,, ... 2	21	12	12
,, ,, ... 4	39	16	15

The results show, as before, that neither sulphate of ammonia nor sulphate of potash acts best by itself : the gain in crop is small and the cost is high. The best results are obtained when both act together: these fertilisers are closely linked. Further, the total effect is more than the sum of the separate effects: 2 cwt. of sulphate of ammonia increased the yield by 20 cwt., and 2 cwt. of sulphate of potash increased it by 15 cwt., but when the sulphate of ammonia and sulphate of potash acted together the increased yield was 49 cwt. per acre: 4 cwt. sulphate of ammonia alone gave additional crop at a cost of 21 pence per cwt., and 4 cwt. sulphate of potash alone at a cost of 39 pence per cwt., but the two together gave it at a cost of 15 pence, while 4 cwt. sulphate of ammonia and 2 cwt. sulphate of potash gave it a cost of 12 pence per cwt. As a rule at Rothamsted our best results are obtained by a combination of 3 or 4 cwt. sulphate of ammonia with about 2 cwt. sulphate of potash: this corresponds to a ratio of 3 or 4N : 5 K_2O, a larger amount of potash than is usually provided in compound fertilisers.

The effects of the fertilisers are modified by the season. The responses in cwt. per acre to sulphate of ammonia in increasing dressings in presence of sufficient sulphate of potash, super. and dung have been :—

	Yield tons per acre. No Nitrogen.	Increase for 1st dose Sulphate of Ammonia cwt.	Further increase 2nd dose Sulphate of Ammonia cwt.	Further increase 3rd dose Sulphate of Ammonia cwt.	Quantity of Sulphate of Ammonia in single dose.	Basal dressing. cwt. per acre.
1925	7.92	52	8	(a) –9	2 cwt.	No dung, 3 super. 4 Sulphate of Potash
1926	7.79	24	29	(b) 38	1 cwt.	Dung, do. do.
1927	6.90	16	–5	(c) —	2 cwt.	,, ,, ,,
1928	7.06	35	37	(c) —	1½ cwt.	,, ,, and 2 Sulphate of Potash
1929	5.18	7	19	(c) —	1½ cwt.	Dung, 3 super. 2 Sulphate of Potash

(a) Basal potash was 6 cwt. sulphate of potash.
(b) Treble dose was 4 cwt. sulphate of ammonia.
(c) No experiment.

Except in 1927 and 1929, the average response per cwt. sulphate of ammonia is of the order of 20 cwt. potatoes, as usual in the earlier experiments. The second cwt. has in some years done better than the first.

The response to potash has been more variable, but the bad years were also 1927 and 1929: in 1927 the potatoes were planted late (May 24th) and 1929 was a dry and sunny season.

https://doi.org/10.23637/ERADOC-1-111

The responses to sulphate of potash* in presence of sufficient sulphate of ammonia, super. and dung have been :—

Year	No Potash Yield. Tons per acre.	Increase for 1st dose. Potash cwt.	Further increase for 2nd dose. cwt.	Further increase for 3rd dose. cwt.	Quantity of Sul. Potash in single dose.	Basal dressings. cwt. per acre
1925	6.45	75	7	0	2 cwt.	No dung, 3 super, 4 Sulphate of Ammonia
1926	9.53	32	9	14	1 ,, †	Dung do. do. do.
1927	7.16	14	−8	—	2 ,,	do. do. do. do.
1928	8.26	56	−8	—	1 ,,	do. do. 3 Sulphate of Ammonia (Mean of all potassic fertilisers)
1929	5.94	−1	11	—	1 ,,	Dung, 3 super, 3 Sulphate of Ammonia

* Except 1928 when there were very few plots owing to frost damage.
† The 3rd. dose was 4 cwt. Sulphate of Potash.

The highest yields in each year and the manurings given were :

Yield given by best manurial treatment.		
Year.	Tons.	Manuring (cwt. per acre) : Super +
1925	10.96	4 Sulphate of Ammonia : 4 Sulphate of Potash
1926	12.34	4 Sulphate of Ammonia : 4 Sulphate of Potash
1927	7.96	4 Sulphate of Ammonia : 4 Muriate of Potash
1928	11.05	3 Sulphate of Ammonia : 1 Sulphate of Potash
1929	6.82	3 Sulphate of Ammonia : 1 Potash Salts

The three potassic fertilisers, sulphate, muriate and potash manure salts, all gave similar increases in 1929; the differences recorded in 1927 did not appear.

The effect of phosphate has again been clearly marked, and again it has depended on the other fertilisers given : superphosphate at the rate of 3 cwt. per acre (0.4 cwt. P_2O_5) gave the following increases in cwt. per acre :—

		1929			1928		
Sulphate of ammonia : cwt. per acre ..		0	1.5	3	0	1.5	3
Sulphate of potash : cwt. per acre ..	0	5	8	11	10	7	5
	1	3	13	17	1	Nil.	26
	2	5	9	19	10	13	18
Basal yields tons per acre ..		4.5 to 5.6			.. .. 6.1 to 9.7		

The superphosphate acted best when combined with the most effective mixtures of sulphate of ammonia and sulphate of potash. In these conditions it gave its extra yield at an expenditure of :—

1929		1928	
8	...	6	pence per cwt. of potatoes obtained.

The effect of superphosphate, however, depends very much on the soil. At Woburn, no response was obtained in 1927 or on the average in 1929 when yields were low (4 to 5 tons per acre), but there was a good response in 1928 when the crop grew better : a yield of 12.25 tons per acre was raised by 3 cwt. of super to 13.4 tons and by 9 cwt. to 14.7 tons per acre, the gains thus being 23 cwt. and 50 cwt. respectively, at an expenditure of 7 pence and $9\frac{1}{2}$ pence respectively per cwt. of potatoes obtained.

The 1929 experiment was on a more elaborate scale than in 1927, and brought out a curious result: the superphosphate increased the crop so long as no nitrogen was given, but it apparently decreased the crop in presence of nitrogen and potash. At the outside centres the effects of superphosphate have varied, again mainly as the result of soil variations. There was a gain at Wisbech of 6.6 cwt. potatoes per cwt. of superphosphate used as compared with 4 cwt. potatoes per cwt. of super. at Rothamsted, but no gains at Bangor, Sutton Bonington or Owmby Cliff.

The work this year has been extended to include a full examination of the influence of manuring on the cooking and keeping qualities of the crop. Nearly four hundred samples were examined by Dr. Lampitt, of Messrs. Lyons' laboratories, and the very extensive data are being worked up. Certain results are already emerging: chipped potatoes were not affected in any uniform or definite way either in colour, flavour or consistency, but boiled potatoes were improved by potassic fertilisers in colour both "outside" and "mashed." Muriate of potash gave the best results, sulphate came second, and potash manure salts third: at times, indeed, the latter was somewhat harmful. For flavour the potassic fertilisers came out in the same order, but only the best of the samples were equal to those grown without potash, and the others were inferior.

Number of Plants per acre. The potatoes are planted 15 inches apart in rows which are 27 inches apart. The total possible number of plants per acre is 15,490. Actually the numbers found per acre in 1929 at Rothamsted were:—

Number found per acre, no artificials ...	14,480
,, ,, ,, complete artificials..	14,870
Average of all plots	14,593
Total possible	15,490

There is thus very little variation in number on the plots, though the numbers were all less than was expected. At Woburn, the numbers were smaller owing to depredations of pheasants.

SUGAR BEET.

The sugar beet experiments again emphasised the need for new varieties better suited to English conditions than those now grown. With no scheme of manuring is it possible to obtain the impressive yield increases given by mangolds or potatoes; the leaves respond but the roots do not, and it is not yet possible to control the leaves so as to make them send more material into the root. One ton of leaf may give from a few hundredweights up to about 3 tons of root, but rarely more, and the factors determining this are not in our control. Certain consistent features stand out. Nothing is gained by the large dressings of farmyard manure or of artificials sometimes given on the Continent,* the fertiliser must

* As an example: The Bernburg investigators find that the best manuring for sugar beet gives 400 dz. per hectare or 16 tons per acre. This manuring is:—

	Kgm per ha.	lb. per acre	Fertiliser per acre
N	160	143	9 cwt. nitrate of soda
P_2O_5 ..	60	54	3 cwt. superphosphate
K_2O ..	180	160	320 lb. sulphate of potash

in general be complete; potash and nitrogen are closely linked and each acts best in the presence of the other. The nitrogen should go on early. Potash manure salts are more effective than the sulphate or the muriate, and salt has a special value additional to that of potash. But when it comes to detailed recommendations the position is more difficult, as fertilisers behave differently towards different varieties.

Thus, in 1929 at Rothamsted, Kuhn on the whole did better than Kleinwanzleben, but it responded rather differently to fertilisers : it did better with sulphate of ammonia (along with salt, super. and muriate of potash) than with nitrate of soda, while Kleinwanzleben did better with nitrate of soda than with sulphate of ammonia. Cyanamide has given more promising results at the western than at the eastern centre.

The nitrogenous manures tend to depress the sugar content, but not by much, and so long as the dressings are not too high the loss is more than offset by the gain in yield. Salt and potash manure salts both slightly increase the sugar content. So long as additional fertiliser increases the yield of roots it does not, in our experience, have much effect on the sugar content, and our advice to farmers is to aim at yield and not worry about sugar. When, however, too much nitrogen is given, the excess that does not increase the yield lowers the sugar content. Apart from this, season has more to do with sugar content than manuring.

Owing to the high value of the tops as stock food, they have to be taken into account in assessing the value of fertilisers. 1 cwt. nitrate of soda or sulphate of ammonia has not infrequently given us an extra ton of tops which, as food for sheep, would have not much less value than a ton of turnips and for cattle more value than a ton of mangolds.* They must however be kept free from dirt and should therefore be raked up in heaps before carting of roots begins, so as to avoid damage by the carts.

Our experiments are not yet sufficiently advanced to indicate definite fertiliser recipes, and in view of the fact that some varieties respond better than others to manuring, we are always hoping that new varieties will be discovered that will respond still better and will therefore pay for more intensive manuring. For the present we suggest as a basis for trial: 10 tons farmyard manure ploughed under in autumn, $1\frac{1}{2}$ cwt. sulphate of ammonia or nitrate of soda, $2\frac{1}{2}$ cwt. superphosphate, 2 cwt. potash manure salt, and 1 cwt. salt per acre applied at or before the time of seeding. It is almost certain the mixture would need modification in different regions of different soil and climatic conditions: for example, where the soil is known to be rich the whole dressing could be reduced and the mixture given at the rate of 4 or 5 cwt. only per acre instead of the 7 cwt. here suggested.

The effect of fertilisers on the yield of roots in 1929 is shown in the following summary of the Rothamsted results in tons per acre :—

* The Cambridge workers put five tons of tops as equal to eight tons of mangolds.

		NO NITROGEN		SULPHATE OF AMMONIA		NITRATE OF SODA	
		No Phosphate	Phosphate	No Phosphate	Phosphate	No Phosphate	Phosphate
No Potash	Klein	6.42	6.78	7.14	7.41	7.18	6.97
Muriate of Potash	Klein	6.83	6.44	7.19	7.31	7.34	7.78
No Potash	Kuhn	7.16	7.90	7.80	7.85	7.76	8.58
Muriate of Potash	Kuhn	7.00	7.04	7.50	8.84	8.08	8.10
				Standard Error = 0.193			

The complete fertiliser gave the best results and its action was improved by a dressing of salt:—

	Roots	Tops	Sugar %
No Salt	7.33	5.24	18.33
Salt	7.54	5.58	18.40
Standard Error	0.055	0.033	0.02

It is very easy to go wrong about the manuring of sugar beet. Taking all our experiments together, there have been many occasions when manuring did not pay, when indeed it depressed the sugar content and sometimes even the yield. The numbers of gains and losses have been:—

Manures.	Weight of Roots.			Weight of Tops.			Sugar per cent.			No. of times when financial result was:		
	Increase.	Decrease.	No Change.	Increase.	Decrease.	No Change.	Increase.	Decrease.	No Change.	Gain.	Loss.	No Change.
Nitrogenous *	26	6	0	25	0	0	3	19	1	20	12	0
Potassic ..	17	8	1	15	10	1	10	6	10	13	13	0
Potash Manure Salts ..	6	1	0	5	1	1	4	2	1	5	2	0
Phosphatic ..	7	6	1	7	7	0	6	4	4	6	8	0

* Up to 3 cwt. per acre but not more.

Using reasonably good fertiliser mixtures the gains per cwt. of fertiliser have been:—

	Sulphate of Ammonia or Nitrate of Soda.	Potash Manure Salts.	Salt.	Super-phosphate.
Roots, cwt.	6– 9	3–9	3–5	2
Tops, cwt.	12–17	Nil.	4–10	2
Sugar, per cent. ..	—0.15	+ 0.10	+ 0.05	Nil.
Cash Increase ..	7/– to 18/–	10/– to 18/–	8/– to 14/–	Nil.

These figures show the need for improving our varieties and methods.

The care of the plant is more important than the manuring: proper seeding on a good seed-bed and proper care at singling are absolutely essential. There should not be much loss of plant: in 1929 we obtained about 85-90% of what was expected from the setting out, though in 1928 we had obtained only 70%. The figures are:—

Spacing as set out	*Rothamsted.* 1928 24-inch rows. 10-inch singling.	1929 22-inch rows. 8-inch singling.	*Woburn.* 1929 I 22-inch rows. 8-9-inch singling.	1929 II 22-inch rows. 8-9-inch singling.
No. of plants expected ..	26,000	36,000	35,000	35,000
No. harvested ..	17,715	30,350	31,800	32,700
Plants obtained as percentage of what was expected ..	68%	83%	88%	94%
Yield tons per acre average ..	9.15	7.43	8.07	8.23
Average weight per root (lb.) ..	1.16	0.55	0.57	0.56

MANGOLDS.

The Barnfield mangold experiments bring out clearly the harmful effects of failure to balance nitrogenous manure with potash. So long as the complete fertiliser is given the plant grows well and responds to heavy dressings of manure: when potash is omitted, however, the leaves lose efficiency, they make much less root and tend to become diseased, and the whole plant is weakened so that the mortality is considerable. The plants are grown in rows 26½ inches apart: there are on the completely manured plots some 30,000 to 34,000 per acre. But where high nitrogen manuring is not balanced by potash the number of plants is much less and the roots are smaller.

This is shown in the following table:—

Barnfield Mangolds, 1924-29.

No. of plants and yield per acre *Roots* and *Leaves*.

Year	Heavy Nitrogenous Manuring with Potash (Plot 4 A.C.)			Heavy Nitrogenous Manuring without Potash (Plot 5 A.C.)		
	No. of Plants	Roots Yield per acre tons	Leaves Yield per acre tons	No. of Plants	Roots Yield per acre tons	Leaves Yield per acre tons
1924 ..	3328	34.16	5.62	2573	15.81	4.83
1925 ..	3201	22.43	6.05	2356	6.30	4.51
1926 ..	3035	25.77	4.12	1996	8.29	2.25
1927* ..	3423	13.42	3.89	3263	12.79	3.59
1928 ..	2978	29.22	5.01	2225	9.55	2.83
1929 ..	3075	20.67	3.94	1741	4.71	2.09

* Swedes.

BARLEY.

In 1929 comparisons were made between sulphate of ammonia, muriate of ammonia, cyanamide and nitrate of soda. Of these, nitrate of soda gave the largest increase, possibly as the result of the dry conditions; the others, however, came out practically alike. One cwt. of sulphate of ammonia gave its usual return of 6 bushels of barley, a second cwt. gave an additional 4 bushels. It has been our usual experience that cyanamide does as well as sulphate of ammonia. This year, in common with muriate of ammonia, it was, if anything, rather better. At Woburn also, muriate of ammonia was superior to sulphate of ammonia. For nitrate of soda the increased yields were 11 bushels of barley for the first cwt. and an additional 4 bushels for the second.

The figures are:—

Barley, yield of grain, cwt. per acre.

Size of Dressing.	No Nitrogen	Sulphate of Ammonia	Cyan-amide	Muriate of Ammonia	Nitrate of Soda	Urea.
Single	20.1	23.1	23.6	23.6	25.6	—
Double		25.2	26.3	26.2	27.8	25.4
Increase over no Nitrogen : 1st dose ..		3.0	3.5	3.5	5.5	5.3
Additional for 2nd dose ..		2.1	2.7	2.6	2.2	

At Rothamsted in 1929 potassic manures slightly depressed the yield of barley, as had also happened in 1924: the effect is most clearly seen with the double dressing of nitrogen; the figures were obtained by the sampling method and represent, in cwt. per acre :

	GRAIN		STRAW	
WITH DOUBLE NITROGEN	No Phosphate	Phosphate	No Phosphate	Phosphate
No Potash	27.3	27.4	27.6	27.9
Potash	25.7	25.8	26.1	26.0
Standard Error ...	.57		.63	
WITH SINGLE NITROGEN				
No Potash	24.0	23.3	24.7	23.4
Potash	23.0	23.6	23.6	24.5
Standard Error ...	.70		.78	
WITH NO NITROGEN				
No Potash	19.5	21.5	19.1	21.6
Potash	21.5	20.1	21.6	20.4
Standard Error ...	1.40		1.57	

On the light soil at Woburn, sulphate of potash markedly increased the yield where there was no nitrogenous fertiliser, and somewhat increased it where muriate of ammonia was given, but not where sulphate of ammonia was used; superphosphate had no effect however.

On another light soil, the Lincoln Heath at Wellingore, superphosphate increased the yield of grain and of straw so long as nitrogen was applied. In absence of added nitrogen, it depressed the yield.

Yield of barley, light loam on Oolitic Limestone, Wellingore.
Grain, cwt. per acre.

	No Nitrogen.		Nitrogen.	
	No Phosphate.	Phosphate.	No Phosphate.	Phosphate.
No Potash	18.8	18.0	19.5	22.4
Potash	20.7	17.0	20.6	25.1
	Standard Error = 0.89 cwt.			
	Straw in cwt. per acre.			
No Potash	16.3	16.4	17.9	20.8
Potash	18.1	14.8	19.7	24.1
	Standard Error = 0.59 cwt.			

https://doi.org/10.23637/ERADOC-1-111

The barley at Woburn was attacked by a common fungus disease, *Fusarium culmorum*, which did, as usual, a certain amount of damage. Dr. Mann devised a system of marks to denote the severity of the attack and obtained the following results :—

	No Potash.	Sulphate of Potash.	No Phosphate.	Superphosphate.
Severity of attack	47	31	39	39

Potash thus reduced the attack of the disease; phosphate and nitrogen did not. This is a usual property of potassic fertilisers.

Effect of Chlorides. Pot experiments showed that chlorides delayed the rate of ripening of the straw, giving a lower percentage of dry matter than was obtained with sulphates. When the ears were ripe for cutting, the straw of the plants manured with chlorides contained 40.9 to 44.5 per cent. of dry matter, while those manured with sulphates contained 54.3 to 57 per cent. The total weight of straw, however, was substantially the same with both groups of fertilisers.

The Quality of the Barley. The valuers put the barleys in the following order of merit :—

I. 43/- *to* 44/- *per quarter.*	Muriate of ammonia both dressings, urea.
II. 41/- *to* 42/- *per quarter.*	Nitrate of soda, sulphate of ammonia and cyanamide in the double dressing.
III. 35/- *per quarter.*	Nitrate of soda, sulphate of ammonia and cyanamide in the single dressing. No nitrogen.

The nitrogenous manures this season increased the production of carbohydrates sufficiently to maintain the balance with the nitrogen taken up. In consequence, the percentage of nitrogen in the grain was hardly affected: the results were :—

Nitrogen per cent. in Barley Grain.

	No Nitrogen	Sulphate of Ammonia	Cyan-amide	Muriate of Ammonia	Nitrate of Soda	Urea
Single Dressing ..	1.461	1.456	1.480	1.469	1.470	
Double Dressing ..		1.477	1.470	1.485	1.532	1.498

It is slowly becoming possible to form a mental picture of the relationship between growth and quality in barley. The total nitrogen in the plant depends on the amount of nitrate in the soil at the time of sowing and during the following few weeks: the greater the amount in the soil the greater the uptake by the plant. The different varieties of barley compared by Dr. Bishop took up much the same amount of nitrogen, but they produced different amounts of carbohydrate: those that produce most give the highest yields and contain the lowest per cent. of nitrogen, and *vice versa*. For any given variety, however, the total carbohydrate in the plant is not constant, but depends on the other soil conditions, the supply of potash and phosphate, and the length of the vegetative period.

Soon after the grain begins to form, the carbohydrates and the nitrogen compounds move into it together, and the proportions in which they go remain almost constant throughout the whole process of grain formation. Not quite constant, however, for drought seems to check the flow of carbohydrate more than that of nitrogen, and therefore to raise the percentage of nitrogen in the grain.

For the maltster one of the most important properties of barley is the amount of extract obtainable from the malt. Hitherto, this has been determined by a laborious malting test. Dr. Bishop has shown that it is simply related to the moisture content, the percentage of nitrogen and the 1,000 corn weight of the barley grain: he has constructed a slide rule by means of which the chemist, knowing these three easily ascertained quantities, can read off at once the number of pounds of extract obtainable from a hundredweight of barley.

A study of the nitrogen compounds during malting has shown that hordein and glutelin both break down rapidly from the third to the sixth day on the floor to give salt-soluble compounds, chiefly non-protein nitrogen. After this there is an approximate balance due to a resynthesis in the embryo equal in amount to the breakdown in the endosperm. No marked changes take place as a result of the subsequent kilning process, nor are the proportions much altered by variations (within limits) in the amount of moisture supplied to the germinating grain, or in the time of flooring.

Calcium Cyanamide. Reference to the detailed tables shows that calcium cyanamide has given as good results as sulphate of ammonia for barley, and distinctly good results for sugar beet at the western centre. Both these crops require lime. On the other hand, in our earlier experiments it did not give as good results for potatoes, a crop which does not in general benefit by lime. We are following up this distinction and it may help in deciding the conditions in which the expert could advise the use of cyanamide. On the Continent farmers are sometimes advised to apply cyanamide a few days after the sowing of the seed wherever it is impossible to adopt the better plan of applying it several days before the sowing. We found no advantage in this course: no harm was done when 1 or 2 cwt. was sown with the seed, though 4 cwt. proved distinctly injurious.

WINTER WHEAT.

The experiments with wheat were somewhat weakened by the circumstance that some of the plants died during winter and the survivors were too irregularly distributed to form good experimental material. This winter mortality probably explains the higher standard errors per plot as compared with those obtained in experiments on spring sown cereals (pages 46-7).

The results agreed with those of 1927 in that the early dressing of sulphate of ammonia was better than the late: they thus differed from the results of 1926 and 1928. Muriate of ammonia, however, gave better results late than early, again in accordance with 1927 and in opposition to 1926 and 1928.

In each year Square-Head's Master has the highest nitrogen content, Yeoman II. follows closely: then come Million III. and

Swedish Iron. In neither year did the nitrogenous dressing appreciably affect the percentage of nitrogen in the grain: though the muriate appeared to give a lower percentage than the sulphate in Square-Head's Master, as it usually does in barley. Nor did time of application have any effect. The results are shown in Table II.

Table II. Percentage of Nitrogen in dry matter of wheat grain.
Rothamsted 1928 *crop.*

	Square-Head's Master.			Yeoman II.		
	Early Dressing	Late Dressing	Early and Late Dressing	Early Dressing	Late Dressing	Early and Late Dressing
Sulphate of Ammonia ..	2.00	2.01	1.99	1.99	2.01	2.00
Muriate of Ammonia ..	1.96	1.97	2.01	2.00	2.05	1.99
No Nitrogen ..		2.02			1.98	
	Million III.			Swedish Iron.		
Sulphate of Ammonia ..	1.84	1.85	1.81	1.77	1.76	1.89
Muriate of Ammonia ..	1.78	1.84	1.95	1.77	1.85	1.84
No Nitrogen ..		1.83			1.80	

Note that the figures given on page 32 of the 1928 Report are for grain containing 15% moisture and not for dry grain, as there stated.

1929 *Crop.*

	Square-Head's Master.			Yeoman II.		
	Early Dressing.	Late Dressing.	Early and Late Dressing.	Early Dressing.	Late Dressing.	Early and Late Dressing.
Sulphate of Ammonia ..	1.80	1.79	1.76	1.75	1.76	1.71
Muriate of Ammonia ..	1.75	1.76	1.72	1.74	1.67	1.67
No Nitrogen ..	—	1.76	—	—	1.73	—
	Million III.			Swedish Iron.		
Sulphate of Ammonia ..	1.66	1.60	1.64	1.44	1.58	1.51
Muriate of Ammonia ..	1.65	1.55	1.62	1.49	1.51	1.55
No Nitrogen ..	—	1.55	—	—	1.60	—

WINTER OATS.

There was a serious loss of plant during the winter and, in consequence, many weeds appeared in spring. As not infrequently happens in these circumstances, the effect of nitrogenous manure was to increase the growth of the weeds as well as of the crop: in the end there was an increase in the straw (including the weeds) but not in the grain, indeed there was evidence that sulphate of ammonia lowered the yield of grain.

https://doi.org/10.23637/ERADOC-1-111

RELATION OF WEATHER CONDITIONS TO YIELD OF WHEAT AND BARLEY.

The Statistical Department is investigating the relationships between weather and crop yield under different fertiliser treatments. Of the weather factors, rainfall is at Rothamsted the most important in determining total yield, both the amount and distribution having great effect. For wheat, winter rainfall is harmful: for barley it is beneficial at Rothamsted, but not, apparently, on the lighter soils of East Anglia. Spring rainfall, January and February on light soils in East Anglia, and March and April on the heavy soil at Rothamsted, is harmful to barley but not to wheat, July rainfall benefits barley but not usually wheat. The effects, however, depend on the manurial treatment, and indeed one of the practical results of the investigation is to show the kind of treatment that would be most effective in seasons of various characters.

Up to the time of ripening, temperature is less important so far as the total growth is concerned, and hours of sunshine still less. Plant physiological work in the laboratories has partly explained the relatively small effect of temperature on the total growth of the plant: it appears that low temperatures tend to increase the size of the leaf but to reduce the amount of plant substance each unit area can make, while the higher temperatures tend to reduce the size of the leaf but to increase the amount of plant substance made by each unit area: as a result of this compensating action the yield varies less than might be expected from changes in temperature.

The position is altered however as soon as ripening begins: vegetative growth then slackens greatly or entirely ceases. High temperature hastens the setting in of this change, and if it comes early it may cut short a period of very active growth, so lowering the yield: for example, high temperatures in May and June reduce the yield of barley.

LOSSES FROM ARABLE LAND.

Weeds. Of all losses of arable crops those due to weeds are the most serious: there is no surer way of reducing yields than by allowing weeds to grow. Fallowing is a recognised method of keeping weeds down, but it is complicated by the fact that weed seeds can lie in the ground for some time without germinating. Dr. Brenchley and Miss K. Warington show that many of them have a period of natural dormancy during which they will not germinate even if the conditions are favourable. Poppy *(Papaver rhoeas)* for example has a long dormancy period and can survive for several years, so that it cannot be eliminated even in a whole year fallow: black bent *(Alopecurus agrestis)* has a short dormancy and can be eradicated by a short fallow. Comparatively few weeds germinate freely throughout the year, most of them do it best in autumn rather than in spring or summer.

Soil Acidity. The great importance of soil acidity has stimulated chemists to devise methods for measuring it and one of these, the quinhydrone method, has come into general use because of its convenience and simplicity. Dr. Crowther and Miss Heintze have found a serious flaw in it that has hitherto not been suspected. Some soils from the Gold Coast had been sent for a report on their suitability for cacao growing: the acidity test was applied and gave results difficult to understand. Attempts to clear up the mystery showed that the quinhydrone was reducing manganese dioxide present in the soil, forming manganous hydrate, which neutralised some of the soil acid and so upset the measurement. It was then recalled that many of our own soils contain manganese dioxide: these were re-examined and showed the same action. The International Society of Soil Science has recognised the importance of this discovery and has set up a special Committee to re-examine the European soils which had been tested by the quinhydrone method. Many of these were found also to contain manganese dioxide and, therefore, to be subject to the same error. Experiments are now in hand to get over the trouble.

DECOMPOSITION OF STRAW AND OTHER PLANT RESIDUES.

Artificial Farmyard Manure. The restriction of the area under corn in this country has reduced the output of straw, while the increase in number of cattle has tended to increase the demand for it. At present, therefore, farmers as a rule have barely sufficient straw for their needs, and the whole of it is converted by the animals into farmyard manure. Out in the Empire, however, the case is different and considerable use is being made of the Rothamsted process for making straw and other plant residues into artificial farmyard manure without the use of animals merely by encouraging its decomposition by the micro-organisms already present.

As we do not wish at Rothamsted to be concerned with business operations the process was handed over for commercial exploitation to a non-profit making syndicate, Adco, whose activities now extend to many countries. Shipments of the necessary material were made in 1929 to Africa, Australia, British Columbia, Borneo, Egypt, Fiji, Malaya, Mauritius, Newfoundland, New Zealand, Nigeria and West Indies, the last named being particularly interested because of the great value of the process in making a useful manure for sugar cane plantations out of the "trash." The largest increased consumption was in Natal; but Kenya and Tanganyika also showed marked increases. The Adco officers inform us that the 1929 shipments abroad were 40% greater than in 1928. While the commercial side is left to Adco, the scientific problems arising out of the decomposition of the straw are investigated at Rothamsted. The chemistry of the process is slowly being worked out. The first constituents of the straw to be decomposed are the hemicelluloses, then the cellulose goes, excepting in so far as it is protected by a resistant layer of lignin: it is interesting that cellulose, while fairly resistant to chemicals, is easily broken down by certain micro-organisms. These, however, do not appear to attack the lignin, so that this constituent is left mainly undecomposed but not altogether unchanged. The ratio of cellulose plus hemicelluloses to lignin seems to be the dominant factor in determining the rate of decomposition of the straw, provided sufficient available nitrogen be present. The xylan associated with the cellulose is not unavailable, but is decomposed only as fast as it is exposed by removal of the encrusting cellulosic layers. The small amount of pectin present in straw is not removed during normal decomposition, but only if acid conditions set in.

Considerable progress has been made with the study of the organisms effecting the decomposition of the straw. In the main they are fungi, including several aspergilli *(fumigatus, nidulans, niger, terreus)*, several actinomycetes, a *Trichoderma* and a thermophilic organism *Sepedonium*: all these act at relatively high temperatures, the last named has its optimum temperature at 45° to 50° C., and it still survives at temperatures exceeding 60° C., these being far above the usual range: most organisms have their optimum at about 22° C. and fail to grow above about 35° C.

These organisms are not only thermophilic but are strongly thermogenic, and when inoculated on to sterile straw they decompose it so effectively that they rapidly raise the temperature to 40° C. or more.

In the soil, however, there is a much wider range of possibility, as at least three groups of the soil organisms can decompose cellulose : fungi, including actinomycetes; spirochaetes; and bacteria. The reaction of the soil determines which of these groups predominates. In acid soils (pH 4 to 5) the fungi and actinomycetes are most active: at any rate they multiply most when cellulose is added to the soil; in less acid conditions (pH 5.5 to 6.5) *Spirochaeta cytophaga* is most active, multiplying most extensively; and in neutral conditions the short rod-like cellulose-decomposing bacteria appear to be the chief agents: a number of these have been isolated and studied by Dr. Kalnins. This change in the cellulose-decomposing flora with the reaction was observed both in Rothamsted and in tropical and in warm temperate soils, and was independent of soil type. Dr. Jensen found evidence that a portion of the soil humus was formed from fungus mycelium, but that only certain species of soil fungi had the property of yielding humus when decomposed.

Among the bacteria isolated by Dr. Kalnins is one which has the interesting property of converting the cellulose into glucose or a sugar closely resembling it, a change that may prove of great technical value.

All these organisms require nitrogenous and phosphatic foods and they freely absorb nitrates and phosphates from the soil, thus competing with plants. Preliminary experiments at Rothamsted have shown that unrotted straw ploughed into the ground may actually reduce yields of non-leguminous crops: only after the rotting is well advanced is the effect beneficial. It is possible that earlier ploughing in of the straw might be better and, in view of the great importance of the subject, Lord Iveagh is providing funds for a twenty-year field experiment, in which ordinary farmyard manure, artificial farmyard manure and unrotted straw shall be compared with artificial fertilisers over a rotation which is to be repeated several times. The chief factor appears to be the absorption of nitrates from the soil by the cellulose-decomposing organisms. Leguminous crops, which gather their own nitrogen, did not suffer, indeed broad beans benefited from chaff ploughed in and enriched the soil so much that the succeeding wheat also benefited. Apparently the nodule organisms derive some advantage from the straw, for in pot experiments both soy beans and broad

https://doi.org/10.23637/ERADOC-1-111

beans carried more nodules as the result of adding chaff to the soil. Where there are no nodules, the beans suffered from the addition of straw, just as a non-leguminous crop would have done.

This work is being developed simultaneously with the study of the closely allied subject of green manuring. The Woburn experiments show that green manuring does not increase the yield of crops as much as was expected, and tares proved even less effective than mustard. 1929 has been the only exception: in all other years the green crop, whether fed off by sheep or ploughed under, has failed to increase the succeeding crop. One factor is the very small amount of nitrate and ammonia in the soil; even on the folded land the average contents of nitrate nitrogen in the top soil after tares and mustard respectively, were only 1.3 and 1.0 parts per million. Addition of nitrate of soda pushed up the yields considerably.

The decomposition process is very complex and cannot be understood from a study of one section only. Bacteria play a great part, which is not yet, however, fully known. Dr. Thornton's improved method of counting them shows that they are far more numerous than was formerly supposed. Their numbers are not constant, but fluctuate with amazing rapidity from hour to hour during the day. The fluctuations are not clearly related to temperature or soil moisture changes: they may have something to do with the method of reproduction of the organisms, but this is not known. The amount of decomposition effected by the bacteria increases with their numbers, but not proportionally: the efficiency of the individual organisms falls off as their numbers increase. The position is somewhat altered when amoebæ are present: the production of carbon dioxide is then depressed in media relatively rich in nitrogen compounds, such as sand cultures containing peptone, but it is increased in media poor in nitrogen and containing glucose or soil extract.

Perhaps the most striking discovery in the Microbiological Department this year has been that of a group of nitrifying organisms producing nitrites from various ammonium salts, but differing completely from the only forms previously known, *Nitrosomonas* and *Nitrosococcus*, in that they thrive in the presence of organic matter. They were first found in the effluent from the Colwick sugar beet factory, where we have been studying the problems of effluent purification: Mr. Cutler has since found them commonly distributed in the soil.

Effluent from Sugar Beet Factories. For the past three years the Fermentation and Microbiological Departments have been studying methods of purifying the effluent from sugar beet factories so as to render it harmless to the rivers into which it is poured, and their work has been so successful that a 90% purification was obtained in 1929 in the large scale experiment at the Colwick factory. This exceeds the required standard. The essential feature of the method is to pass the effluent over a clinker filter so that the sugar may oxidise completely before it enters the river. More time is needed than for sewage purification, hence a finer grade of clinker is needed. There still remains the difficulty that the mud suspended in the water may choke the filter before the end of the campaign, but this, too, can be overcome.

There is now no justification for pollution of rivers by sugar beet factories: they can either set up a purification plant or they can obviate the difficulty by using their water over and over again, as is already done by some processes.

Two detailed reports on this work have been presented to the Water Pollution Research Board of the D.S.I.R., and these have been circulated, for official use only, as Papers No. 36 and 41, under dates 22.11.28 and 21.3.29, respectively. A brief account of the investigation, supplied by the Department, was published in "The Times" of the 28th October, 1929.

SOIL CULTIVATION.

The investigations on soil cultivation are carried out by the staff of the Soil Physics Department. Their underlying purpose is to reduce the art of cultivation to a science, just as the chemists and plant physiologists of the period 1800 to 1840 reduced the old art of manuring to a science and so paved the way for the introduction of artificial fertilisers as the result of the early Rothamsted experiments.

The work is developing in three directions: the effect of cultivation on the soil, the physical properties of the soil, and new methods of cultivation, are all under investigation.

Methods have been devised for estimating the degree of breaking up of the soil, *i.e.*, its comminution, also for estimating the surface. The effect of ploughing in breaking up the soil and increasing its surface is shown by the following results:—

RELATIVE SURFACE OF SOIL.

	Before Cultivation	After Ordinary Ploughing	After Rotary Cultivation
(*a*) Soil compact	320	475	530
(*b*) Soil looser ...	440	420	—

Relative sizes of soil particles in (*a*): Percentage distribution.

Large ...	60	45	30
Medium	33	40	55
Small ...	7	13	13

Dynamometer measurements are taken of the amount of work done in cultivating the soil, and the records are studied in relation to the physical properties involved. The figures are closely related to the "static rigidity" of the soil, *i.e.*, the energy needed to set flowing a paste made up from the soil. This has led to some interesting developments in the study of the plasticity of the soil, and in order to forward the work the Rockefeller Foundation gave Mr. Scott Blair a Fellowship, enabling him to spend a year in the United States working with Prof. Bancroft, who is studying cognate problems in the Cornell Laboratories.

The experiments on rotary cultivation were continued to see whether it gave as good a seed-bed as the ordinary processes for barley after roots. It proved to be equally effective; indeed, for germination and initial growth it was better, and, of course, it was quicker and cheaper, as it made the seed-bed complete in one operation. This result we have had in the preceding trials, excepting where rotary cultivation caused a "cap" to form on the soil, and then its effect was not so good. It seems probable, however, that this tendency can be overcome.

PLANT PATHOLOGY.

Fungi. In the Mycological Department, the fundamental physiological and genetical work on fungi is continuing. Strains of *Botrytis cinerea*, apparently identical in structure and cultural reactions, differed markedly in pathogenic properties, and, conversely, strains different in structure and cultural reactions had similar pathogenic properties: for example, one strain is parasitic on Nicandra, oats, sweet pea, and harmless to sugar beet, tobacco and broad beans; while another, indistinguishable in appearance and culture relations, is harmless to Nicandra and oats, but parasitic on sweet pea and sugar beet: it is harmless also to tobacco and broad beans. Much work is needed to clear up the difficulties of this complex subject.

The biological relationships of these strains are being studied in view of the fact that two or more of them frequently grow intermingled on a host plant. Certain things happen when the hyphæ meet, the phenomena differing with the different strains. Numerous sclerotia of particular strains have been grafted on to sclerotia of other strains, and in a percentage of cases organic union has apparently been effected. The sclerotia have then been germinated in the attempt to derive from the line of junction conidiophores and single spores containing both parental strains. Up to the present all conidia have given rise to either one or the other parental type.

In studying wart disease of potatoes, certain new hosts were discovered: *Solanum dulcamara* var. *Villosissimum*, and var. *alba*: *S. nudiflorum*: *S. Villosum*: *Nicandra physalodes*: in some of the host plants the fungus occurred in the tissues, but showed little or no signs of its presence.

Bacteria. The Black Arm Angular Leaf spot disease of cotton has been closely studied. The causal organism, *B. malvacearum*, is capable of wide variations in shape and size according to its conditions of growth, it has also methods of reproduction quite different from the usual simple vegetative division. It can even change into an entirely new cultural type; one of the forms is possibly identical with the common yellow saprophyte of cotton : this is only slightly virulent, but under certain conditions it appears to be capable of reverting to the normal or even a more virulent type.

In a cytological study of the organism, evidence has been found of the presence of nuclei which undergo division more or less simultaneously with the division of the cell body; also they divide during the formation of the coccal forms, and one-half of the structure passes into the newly formed body.

The relation of the organism to the plant is being studied in special chambers allowing of the growth of cotton plants under controlled conditions. Primary infection from inoculated seed occurred at all temperatures from 17° to 35° C. (the highest so far used), but was greatest at 24°-25° C. No infection was found when the seed from the Sudan had been externally sterilised; some occurred with untreated seed; a higher percentage with seed soaked in a suspension of the organism and a still greater occurrence (reaching 100% at the intermediate temperatures) when the organism had been introduced within the seed coat. Neither soil temperature nor amount of primary infection had any influence on the incidence of secondary infection brought about by spraying a suspension of the organism on to the plant.

Experiments in the chambers are at present in progress on the influence of air temperature and of humidity on secondary infection.

Virus Diseases. The Imperial Agricultural Conference of 1927 recommended that "funds should be provided for the more extended study of the fundamental nature of virus diseases in plants." The Empire Marketing Board thereupon provided the means for a considerable development of the virus investigations at Rothamsted which are under the general charge of Dr. Henderson Smith. Three scientific posts were created, Dr. John Caldwell being appointed to the post of Virus Physiologist, Dr. Frances Sheffield to that of Virus Cytologist, and Miss Marion Hamilton to that of Virus Entomologist. Grants were provided for equipment and maintenance during a period of five years.

Dr. Henderson Smith has studied localised forms of the disease found in *Datura stramonium* and *Lycium chinense* where certain parts of the plant only are affected, the rest being free not only from symptoms but also from the virus, so that the juices can be inoculated into highly susceptible plants without result. This is unusual: in other instances the disease affects the whole plant.

The remarkable bodies present in the cells in infected plants have also been studied. They are protein in nature, but probably not alive, as has been repeatedly asserted of similar inclusions both in animal and plant virus disease. Their progressive development from small particles carried in the protoplasmic streaming up to the stage of the completed body has been watched in individual cells of detached infected leaves.

Entomology. The Entomological work is largely concerned with the parasites of insect pests, they being among the most important agencies for effecting control in nature. As an example: meadow foxtail is liable to attack by gall-midges. In 1928 the attack in a particular instance was slight: there was 38% parasitism. In 1929, in the same experiment, the attack was heavy: there was only 3% parasitism. A new parasite of the frit fly has been found: a Chalcid *Callitula bicolor*. Another important observation is the greatly increased prevalence of *Loxotropa tritoma* during 1929, and decline of the Chalcid *Halticoptera fuscicornis*, two phenomena which are apparently related.

Another method of control now being tested is to alter the cultivation of the crop so as to make it less suitable to the insect. Thus, by delaying the flowering of meadow foxtail grass till after the main flight period of the midges was over—as can be done by early cutting or grazing—the attack was reduced from 80% to just over 10%. Control of the frit fly is obtained, as is well known, by earlier sowing of the oats.

Dr. Barnes has closely studied the gall-midges that infest the willow and cause much loss to the osier industry. Under experimental conditions, the "Harrison" variety of osier has been found to be immune to attack by the button top midge. The usual method of classifying the midges according to the type of gall produced has proved unsound, as one and the same species of midge can produce different types of gall. Of much greater biological interest, however, is the discovery that the fertilised females of the midge *Rhapdophaga heterobia* H: Lw. produce, as offspring, unisexual families only—a phenomenon unknown previously among insects, except in the Mycetophilidæ studied by Metz in America.

The breeding of stocks of insects for weed control in New Zealand was continued, and further consignments of insects attacking bramble, ragwort and gorse were sent out, including 15,260 *Tyria jacobææ*, 23,300 *Apion ulicis* and 350 root stocks containing *Coræbus rubi*. They arrived safely and in sufficient numbers to permit the New Zealand staff to take up their part of the investigation. As this work has now passed out of the research stage, it has been handed over to the Farnham Royal Laboratory of the Imperial Bureau of Entomology, which is specially equipped for the breeding and supplying of large quantities of insects.

Dr. Davidson having been appointed to the Waite Research Institute, South Australia, the investigations on aphides, with which he was associated, have been discontinued.

The insecticide investigations have been mainly concerned with pyrethrum, one of the most promising of vegetable products, as it can apparently be grown satisfactorily in this country.

Bees. The investigations on bees have followed the lines of previous years, and the accumulated data are being worked up in conjunction with the Statistical Department. The relative advantages and disadvantages of the "warm way" and "cold way" of arranging the frames, of having double walls for the hives, and of packing them in winter with insulating material, are studied. Feeding tests have so far shown no differences in effect between cane sugar and beet sugar as winter food, nor anything to justify the preference for the cane sugar. The "brood food" swarming hypothesis is being tested, and valuable information obtained, by the study of marked bees, about the ages at which they are engaged upon specific activities.

THE ACCURACY OF THE FIELD EXPERIMENTS.

The advantage of the modern Rothamsted field technique is that the results can be checked. The "standard error" per plot can be calculated; the degree of trustworthiness is therefore known. Usual standard errors per plot on our present methods of good working are:—

USUAL STANDARD ERRORS PER PLOT FOR GOOD WORKING

	Weight per acre	Per cent. of yield
Potatoes ...	0.4 tons	7
Sugar Beet...	0.5 ,,	9
Barley: Grain	1.3 cwt.	9
,, Straw	2 ,,	7
Oats: Grain	2 ,,	8
,, Straw	2 ,,	6

The standard error precisely measures the accuracy of the experiment and it includes errors of working, inequalities due to variable natural agencies, such as weather, birds, insects, diseases, and also soil variations within the individual plots, but not the large variations between plot and plot which are eliminated by the method of arranging the experiment. It is not, however, an absolute measure, since it depends to some extent on the size and arrangement of the plots. Thus, a standard error of 0.4 tons per acre of potatoes in a latin square experiment is not strictly comparable with a standard error of 0.4 tons in a randomised block experiment having more plots. Nevertheless, it is a useful guide to the experimenter as showing the standard of performance he is attaining in his work. The standard error is much the same whether the crop is large or small, so that a heavy crop has a lower percentage error than a light one.

There are several plots of each treatment, and the standard error of the final result is much less than these figures of errors per plot; it is usually now at Rothamsted about 2 to 4 per cent. of the mean yield.

Examination of the standard errors showed that the degree of accuracy attained at Rothamsted is also attained at the outside centres where supervision is exercised by the Rothamsted staff; Woburn, however, does not reach the same standard, not through the fault of the staff, but mainly through soil irregularities and the depredations of pheasants and hares. We are hoping to overcome this latter trouble.

The standard errors of our experiments are collected in Tables III and IV. An examination of the Broadbalk data during the past 78 years has brought out the interesting fact that the standard errors, so far as they can be calculated, have varied at different periods, but except for one year they are no greater now than in the past. For the past 200 years it has been commonplace among agricultural speakers and writers that the farm worker is not what he used to be: it is satisfactory to know that the Rothamsted plots, at any rate, are as well cared for as ever. The possibility of improvement is constantly being tested. Inequalities arise through irregularities in sowing seed and applying manure, especially farmyard manure, where this is used; in the distribution of weeds; the attacks of insect and fungus pests, birds, vermin and game; damage by storm and many other causes. The chief sources of trouble are, however, irregularities in seeding and manuring, and in weed distribution. We are constantly striving to improve in these directions.

TABLE III.

Standard Errors of field experiments per plot.

Weight per acre.

Rothamsted.

Year	Potatoes.	Swedes.		Sugar Beet.		Barley.		Wheat.		Oats.	
	tons.	Roots. tons.	Tops. tons.	Roots. tons.	Tops. tons.	Grain. cwts.	Straw. cwts.	Grain. cwts.	Straw. cwts.	Grain. cwts.	Straw. cwts.
1925	0.4	—	—	—	—	—	—	—	—	2.1	1.5
	0.7	—	—	—	—	—	—	—	—	—	—
1926	0.4	0.7	—	0.6	1.0	1.9	1.9	2.3	4.6	2.3	6.2
	1.0	—	—	—	—	—	—	—	—	1.7	1.7
1927	0.4	0.5	0.3	0.3	1.2	1.7	2.1	2.9	4.2	—	—
		—	—	—	—	0.9	0.8	—	—	—	—
1928	0.8	1.0	0.1	0.9	1.1	1.7	2.7	3.1	5.2	—	—
	—	—	—	—	—	1.2	2.2	—	—	—	—
1929	0.4	—	—	0.5	0.3	1.9	2.4	4.0	4.0	—	—
	—	—	—	—	—	0.9	1.6	—	—	1.5	2.0

In a mangold experiment in 1925 the standard error was 2.5 tons for roots and 0.6 tons for leaves.

Woburn.

Year.	Potatoes tons.	Sugar Beet. Roots. tons.	Sugar Beet. Tops. tons.	Barley. Grain. cwts.	Barley. Straw. cwts.
1926	0.4 —	0.6 2.4	0.9 1.8	— —	— —
1927	0.5 0.2	0.4 —	0.8 —	— —	— —
1928	0.9 0.5	1.3 —	1.9 —	4.1 —	4.6 —
1929	0.6 —	1.5 0.7	1.7 1.7	2.8 —	4.8 —

Outside Centres.

Year.	Potatoes. Tons.				Sugar Beet. Tons.				
	Norfolk (Stow-bridge).	Wis-bech.	Aber. (Bangor).	Owmby.	Colchester. Roots.	Colchester. Tops.	Welshpool. Roots.	Welshpool. Tops.	Wye. Roots.
1927	—	—	—	—	0.6	—	—	—	—
1928	1.4 0.7	0.5 —	0.7 —	0.5 —	0.6 —	— —	1.2 —	1.7 —	— —
1929	— —	0.4 —	0.3 —	0.3 —	0.5 0.4	— 0.3	0.5 —	1.9 —	— 1.0

TABLE IV.

Standard error per plot : Per cent. of Yield.

Rothamsted.

Year.	Potatoes.	Swedes. Roots.	Swedes. Tops.	Sugar Beet. Roots.	Sugar Beet. Tops.	Barley. Grain.	Barley. Straw.	Wheat. Grain.	Wheat. Straw.	Oats. Grain.	Oats. Straw.
1925	4.9 8.6	— —	— —	— —	— —	— —	— —	— —	— —	8.9 —	4.8 —
1926	3.8 11.0	6.5 —	— —	3.5 —	4.1 —	9.0 —	5.0 —	14.0 —	10.4 —	7.9 6.4	12.5 4.4
1927	6.1 —	3.2 —	5.2 —	10.2 —	10.9 —	10.3 8.5	10.7 4.1	11.6 —	8.6 —	— —	— —
1928	9.4 —	4.8 —	12.1 —	9.6 —	10.0 —	10.1 7.7	8.9 7.2	— 12.5	— 15.6	— —	— —
1929	8.2 —	— —	— —	6.3 —	5.2 —	8.5 3.8	10.0 6.3	— 22.5	— 15.1	— 11.1	— 7.9

Mangolds in 1925, 14.8% for roots and 10.8% for tops.

Woburn.

Year	Potatoes	Swedes Roots	Swedes Tops	Sugar Beet Roots	Sugar Beet Tops	Barley Grain	Barley Straw	Wheat Grain	Wheat Straw	Oats Grain	Oats Straw
1926	6.1	—	—	4.3	8.5	—	—	—	—	—	—
	—	—	—	14.5	15.0	—	—	—	—	—	—
1927	7.4	—	—	13.7	17.2	—	—	—	—	—	—
	5.2	—	—	—	—	—	—	—	—	—	—
1928	7.1	—	—	9.3	15.1	22.5	19.4	—	—	—	—
	4.0	—	—	—	—	—	—	—	—	—	—
1929	11.6	—	—	18.0	21.0	9.6	12.3	—	—	—	—
	3.4	—	—	8.9	23.0	—	—	—	—	—	—

Outside Centres.

Year	POTATOES				SUGAR BEET				
	Norfolk (Stow-bridge)	Wisbech	Aber	Owmby	Colchester Roots	Colchester Tops	Welshpool Roots	Welshpool Tops	Wye Roots
1927	—	—	—	—	7.4	—	—	—	—
1928	15.4	3.4	4.4	6.6	8.6	—	11.0	9.5	—
	6.7	—	—	—	—	—	—	—	—
1929	—	3.3	2.4	4.1	7.6	—	3.4	8.3	—
	—	—	—	—	5.4	5.3	—	—	10.5

THE EFFECT OF FALLOWING: HOW LONG DOES IT LAST?

In 1925 the Broadbalk wheat field became badly infested with weeds in spite of much stubble cleaning, and as there seemed no hope of coping with them during the growth of the wheat, it was decided to fallow the field. It was, however, important to maintain continuity of cropping, there having been no break since 1843. The field was therefore divided into five parts: the eastern two-fifths continued to grow wheat as usual, but the western (top) three-fifths were fallowed from October, 1925, to October, 1927, when the western two-fifths were sown with wheat, leaving the central fifth bare. The eastern two-fifths and the central fifth were then fallowed from October, 1927, to October, 1929, the western two-fifths being meanwhile cropped. Then in October, 1929, the whole field was sown with wheat.

Thus a crop was grown each year, but during the years 1926 and 1927 it was on the eastern part only, during 1928 and 1929 on the western part only, the remainder being fallowed, the end two-fifths for two years and the central fifth for four years.

The 1928 crop, after the fallow, was remarkable, the yields being high and the proportion of grain to straw unusually high. The 1929 crop on the same land was, however, nothing like so good: the yield of straw remained high but the grain fell off, and was, indeed, somewhat below the average for the 74 years preceding the fallow, excepting on Plot 10 (sulphate of ammonia only) and Plot 19 (rape cake), where it was above: on most plots, however, the yields are above those on the same ground for 1925. In part, the fall is due to the return of the weeds: *Alopecurus* (black bent) was bad on Plots 10, 11 and 12, and *Alopecurus* and *Stellaria* (chick weed) on Plots 2, 7, 8 and 16. There were few signs of the former serious weeds, *Papaver* (poppy), *Tussilago farfara* (coltsfoot), *Sonchus arvensis* (sow thistle), *Equisetum arvense* (horsetail) and *Cirsium arvense* (thistle). Already, however, they are appearing, and it is more difficult than formerly to cope with them, as we can no longer count on hand-hoeing in spring, owing to shortage of labour.

Typical yields were as follows:—

	Plot No.	Yield before fallow.		Yield after fallow.	
		Average 74 Years 1852–1925.	1925.	1st Year 1928.	2nd Year 1929.
Farmyard manure	2B	33.5	15.1	48.4	30.0
Artificials.					
Complete (Nitrate of Soda) ..	9	18.8†	16.3	56.1	21.6
,, (Sulphate of Ammonia)	6	21.7	10.1	47.3	17.7
Complete Double Nitrogen:					
(Nitrate of Soda) ..	16	29.9†	21.2	56.1	26.3
(Sulphate of Ammonia)	7	30.4	18.6	67.4*	20.9
No Nitrogen	5	13.5	6.8	35.2	9.1
No Manure	3	11.7	6.7	27.9	9.1

† 41 years only, 1885–1925. * Estimated from half plot.

The value of the fallow has soon gone, but the fault does not seem to be with the weeds. We are not yet able to give a satisfactory explanation.

WINTER FOOD FOR ANIMALS: HOME GROWN FEEDING STUFFS.

The increased number of livestock now kept on the farm enables us to investigate one of the most important of present-day agricultural problems: the provision of cheaper winter food for livestock. The present position is that "starch equivalent" can be purchased for 1d. per lb., while "protein equivalent" costs 1½d. per lb. On the other hand, fertilisers are cheap and are readily converted into foods. At what expenditure on fertilisers can a farmer produce these food substances on his own farm?

The results of the last 10 years' field experiments have shown the kind of increased crop that can reasonably be expected from a dressing of 1 cwt. per acre sulphate of ammonia on land where sufficient phosphate and potash is given during the rotation. The composition of the increase is also known. The yields in terms of food units are as follows:—

Increases expected from 1 cwt. sulphate of ammonia per acre, in presence of sufficient phosphate and potash.

					Produced by 1 cwt. Sulphate of Ammonia.			
		Usual increase per 1 cwt. Sulphate of Ammonia.	Protein equivalent per cent.	Starch equivalent per cent.	Protein equivalent lb.		Starch equivalent lb.	
Potatoes ..		20 cwt.	.6	18	13		405	
Mangolds ..		32 ,,	.4	7	14		250	
Swedes ..		20 ,,	.7	7	16		157	
Barley :	Grain	6½ bu.	8.5	71	31	36	258	420
	Straw	6¼ cwt.	.7	23	5		162	
Oat :	Grain	7 bu.	7.6	60	22	28	176	310
	Straw	6 cwt.	.9	20	6		134	
Wheat :	Grain	4½ bu.	9.6	72	26	32	194	267
	Straw	5 cwt.	.1	13	6		73	
Meadow Hay ..		9 ,,	4.6	37	46		374	
				Mean	26		312	

Barley stands out as one of the most efficient transformers of cheap fertilisers into food: meadow hay runs it closely when 9 cwt. additional crop can be obtained without loss of quality by the use of 1 cwt. sulphate of ammonia or nitrate of soda: this does not always happen on permanent grass land: the other figures however are usually reached. The average result is that for an expenditure on fertilisers of between 10/- and 20/- it is reasonable to expect a return of

26 lb. protein equivalent, worth about ... 3/2; and
312 lb. starch equivalent, worth about ... 26/6.
In all, food substance worth about ... 29/8.

During the present season, 1930, we have started experiments on fodder mixtures with the view of finding, if possible, even more efficient transformers of fertilisers into food. Four fodder mixtures are tested, containing beans, peas or vetch, barley or oats: they are:—

1	2	3	4	Seeding per Acre.
Beans.	Beans.	Beans.	Beans.	1 bushel.
Peas.	Peas.	Vetches.	Vetches.	2 bushels.
Barley.	Oats.	Barley.	Oats.	2 bushels.

There are 36 plots of each mixture, devoted to 12 fertiliser treatments, these being combinations of

0, 1, 2 cwt. per acre sulphate of ammonia.
0, 3 cwt. per acre superphosphate.
0, 1 cwt. per acre muriate of potash.

Each treatment is triplicated.

SCIENTIFIC PAPERS

Published 1929 and in the Press.

CROPS, PLANT GROWTH AND FERTILISER INVESTIGATIONS.

(Botanical, Bacteriological, Statistical and Fermentation Departments; and the Imperial College Staff.)

I. W. E. Brenchley and K. Warington. *"The Weed Seed Population of Arable Soil. I: Numerical Estimation of Viable Seeds and Observations on their Natural Dormancy."* Journal of Ecology, 1930. Vol. XVIII, pp. 235-272.

Counts have been made of the seedlings germinating from soil samples of known area taken from fields undergoing specified schemes of fallowing. Poppy was the most plentiful weed, an average of 113 millions per acre being recorded.

Most species exhibited a periodicity in germination, the majority of seedlings appearing in the autumn or winter. Many weeds showed a period of "natural" dormancy, during which they failed to germinate in spite of favourable conditions.

An association was found between the weed flora and the manurial treatment of the soil when the same manuring is repeated for a large number of years.

II. T. Eden and R. A. Fisher. *"Studies in Crop Variation, VI. Experiments on the response of the Potato to Potash and Nitrogen."* Journal of Agricultural Science, 1929. Vol. XIX, pp. 201-213.

While rather precise comparisons were obtained on the qualitative question by means of Latin squares in 1925-26, the reality of the depression ascribable to chloride could not be demonstrated in these years, but became clearly apparent when, in the following year, the qualitative experiment was merged with the quantitative one.

In the earlier quantitative experiments, although satisfactory responses were obtained, the precision of the results left much to be desired, since only four replicates could be used. When, by merging the experiments, this was increased to nine replicates, much smaller responses were clearly measurable.

The large and complex type of experiment finally adopted thus supplied more precise information on both heads than could previously be obtained, and led in addition to a more thorough exploration of the different combinations possible.

III. H. G. Thornton. *"The Effect of Fresh Straw on the Growth of Certain Legumes."* Journal of Agricultural Science, 1929. Vol. XIX, pp. 563-572.

In pot experiments with *Glycine hispida* and *Vicia faba* L., fresh chaff incorporated with the soil caused a significant increase in the number of nodules produced on inoculated plants, this increase being augmented by the further addition of phosphates.

Fresh chaff, added at the time of sowing and inoculation, had more effect than chaff which was allowed to decompose in the soil for a month. Fresh chaff increases the multiplication of the nodule organism in sterilised soil.

In soy beans without nodules, the chaff depressed the growth of the tops, but this depression did not occur either with soy or broad beans where nodules were present.

In a field experiment made at Rothamsted, chaff, freshly ploughed in, increased the growth of broad beans and also of wheat sown the next season on the same ground.

IV. A. G. Norman. *"The Chemical Constitution of the Gums, Part I. The Nature of Gum Arabic and the Biochemical Classification of the Gums."* Biochemical Journal, 1929. Vol. XXIII, pp. 524-535.

Gum arabic is built up of varying amounts of a nucleus acid, consisting of galactose, and a uronic acid (probably galacturonic), to which is linked by glucosidic linkages the pentose, arabinose, which is, in consequence, more easily split off than the other components.

There seems to be no essential difference in structure and composition between gums and hemicelluloses, both consisting of hexose and pentose sugars linked to uronic acids. On the basis of sterical similarities, it is suggested that it is by the protracted mild oxidation of linked hexose, and in particular galactose units that pectin, and the hemicelluloses and gums are formed.

V. F. G. Gregory and F. J. Richards. *"Physiological Studies in Plant Nutrition, I. The Effect of Manurial Deficiency on the Respiration and Assimilation Rate in Barley."* Annals of Botany, 1929. Vol. XLIII, pp. 120-161.

The use of the katharometer for the measurement of respiration and assimilation rates of leaves is discussed; methods are indicated of overcoming some of the difficulties in its use.

The effect of deficiency in nitrogen, phosphorus and potash on water content and weight per unit area of successive leaves of barley, as compared with those of fully manured plants, are studied; they lead to the conclusion that leaf area is a better basis than is dry weight for the expression of water content of leaves.

Respiration rates for successive leaves of nitrogen, phosphorus and potash deficient plants, as compared with fully manured plants, are given. In all the deficient series, the rate of respiration falls to a minimum, with a subsequent rise; while in the case of the fully manured plants the rate falls rapidly at first, becoming constant later. Nitrogen starved plants are shown to have a consistently lower respiration rate than fully manured, potash a consistently higher rate, and phosphate to be unaffected. The differences found are as follows :—

	Differences of Means
Fully Manured—Nitrogen Deficient ...	$+0.489 \pm 0.127$
Fully Manured—Phosphate Deficient ...	-0.106 ± 0.127
Fully Manured—Potash Deficient ...	-1.574 ± 0.127

Analysis of Variance shows that the effect of age of plant and manurial deficiency are both very significant (P $>$ 100 :1).

Assimilation rates at known high and low light intensities are given for successive leaves of fully manured plants, and also for each of the deficient series.

It is shown that changes in assimilation rate are due to the action of two factors, namely, age of plant and manurial deficiency. By Analysis of Variance the following facts were established :—

(i.) At low light intensity, the effect of age is quite insignificant, but the manurial effect is almost significant, due predominantly to the value of the potash deficient series.

(ii.) At high light intensity, the effect of age is very highly significant (P $>$ 100 :1), and the manurial effect is also very significant.

The bearing of these results on the nature of the "internal factor" in photosynthesis is discussed. It is shown that two types of subnormality occur, namely, that due to age and that due to manurial deficiency. Subnormality of later formed leaves, as compared with earlier, is found in all the series.

Subnormality due to manurial deficiency is found to be specific in effect for the various constituents. The results obtained may be summarised thus :—

	Respiration.	Assimilation.	
		Low Light Intensity.	High Light Intensity.
Fully Manured ..	Normal ..	Unaffected by age of plant.	Falling with age of plant.
Nitrogen Deficient ..	*Subnormal*	Normal ; unaffected by age of plant.	Subnormal ; falling with age of plant.
Phosphate Deficient ..	Normal ..	Slightly supernormal. *Falling with age.*	Slightly supernormal. *Falling with age.*
Potash Deficient	*Supernormal*	*Subnormal.*	*Subnormal.*

The subnormality due to potash deficiency is further discussed, and its theoretical bearing indicated.

VI. F. G. Gregory and F. Crowther. *"A Physiological Study of Varietal Differences in Plants, Part I. A Study of the Comparative Yields of Barley Varieties with Different Manurings."* Annals of Botany, 1928. Vol. XLII, pp. 757-770.

The experiment described establishes the existence of a differential response of varieties of barley to various types of manuring.

Five varieties were grown with eleven types of manuring, including deficiency of nitrogen, of phosphate, and of potash. Seven replicates of each variety for each manuring were used, requiring the use of 385 pots in all.

The resulting dry-weight data are treated by the "Analysis of Variance" method, and significant values are obtained for the differential response of the varieties to manuring.

The varieties are compared in pairs to indicate the particular varietal differences contributing to this differential response.

The agricultural importance of the results is indicated.

VII. F. R. Tubbs. *"Physiological Studies in Plant Nutrition, II. The Effect of Manurial Deficiency upon the Mechanical Strength of Barley Straw."* Annals of Botany, 1930. Vol. XLIV, pp. 147-160.

The paper deals with the results of an investigation of the effect of manurial deficiency upon the strength and anatomical structure of barley straw. The force in grm. weight required to crush 1 cm. length of stem radially is taken as a measure of strength.

The strength of succeeding internodes of fully-manured plants falls off rapidly. Nitrogen and phosphorus deficiency results in a large increase in the strength of the lower internodes, while potassium starvation decreases the strength of the lower and increases that of the middle internodes. The effects of manurial deficiency are most marked in the lower internodes, the upper ones approximating to the normal.

The variation in the thickness of the mechanical tissues follows that of strength, but is not sufficient to account for the large differences observed. Total and partial linear correlations between strength and the morphological status of the internode, and between strength and the thickness of the three tissues, sclerenchyma, lignified parenchyma, and unlignified parenchyma, have been calculated. The conclusion is reached that the observed fall in strength of succeeding internodes is due both to decrease in the efficiency of the mechanical tissues and also to decrease in their actual amount.

Equations connecting strength and the morphological status of the internode are found to give a good fit in the fully-manured, nitrogen-deficient and phosphate-deficient series. The relation between strength and internode number is logarithmic, the strength of each internode being a constant fraction of that next below, within the limits of the error of the experiment, the value of the fraction being dependent on the type of manuring applied.

The ratio of the external radius to the internal radius of the mechanical tissues is found to be constant for internodes of the same status, independent of manuring. It appears that the mechanical function of the elements composing them is determined at a very early stage.

It is suggested that the observed effects of mineral deficiency are explicable on the assumption that potassium is essential to the production of an efficient mechanical tissue.

VIII. W. O. JAMES. *"Studies of the Physiological Importance of the Mineral Elements in Plants, I. The Relation of Potassium to the Properties and Functions of the Leaf."* Annals of Botany, 1930. Vol. XLIV, pp. 173-198.

In order to investigate the physiological importance of potassium, field experiments were carried out upon certain attributes and functions of potato leaves. Number, area, weight, water content, and rates of starch formation, translocation, and senescence were examined. The primary data were subjected to statistical analysis, and the following conclusions arrived at.

The number of leaves formed on an average per plant was found to be significantly reduced by the application of potassium sulphate or "potash manure salts," a low grade fertiliser. Potassium chloride could not be shown to have any effect.

Area of a selected leaflet. The area of the penultimate pinnæ of the fourth leaf, from the stem apex, was not affected in adult plants by the addition of potassium sulphate, but addition of "potash manure salts" or potassium chloride caused an increase of surface. This is ascribed to the action of the chloride ion present in both the latter fertilisers. Taken in conjunction with the reduced leaf number, the lack of effect of the sulphate suggests that potassium itself tends to decrease rather than increase the total leaf area of the plant. There is, however, some evidence of an increase in the earliest stages of growth.

Leaf water content, expressed as water weight/dry weight showed no significant response to potassium manuring. The presence of chlorides, however, again caused an increase. It is shown that a very high correlation exists between leaf area and the water weight/dry weight ratio, and the increase of leaf area due to chlorides is probably brought about by an increase of water content.

Dry weight of the selected leaflet was found to be unaffected by the addition of potassium compounds.

Starch formation per unit leaf area showed a significant increase in response to potassium, particularly when in the form of sulphate. There was little or no response to the presence of chlorine.

Translocation could not definitely be shown to be affected by the same treatment, but reasons are given which make it probable than an acceleration in its rate is brought about.

Senescence, as indicated by the yellowing of the leaves, was delayed by the addition of one or two cwt. of potassium sulphate per acre. Four cwt. per acre did not have a similar effect. In all these concentrations, there was no detectable effect on the colour of healthy green leaves. "Coppering," a characteristic spotting of young foliage, was shown to be clearly related to a deficiency of potassium.

These points are discussed, and it is shown that one important effect of potassium in leaves is an increase of catalytic activity, leading to greater efficiency in three of the four stages of starch formation. It is further suggested that loss of potassium is a casual factor in leaf ageing.

STATISTICAL METHODS AND RESULTS.
(Statistical Department.)

IX. A. J. PAGE. *"On the Annual Revision of Forecasting Formulas based on Partial Regression Equations."* Journal of the American Statistical Association, 1929. Vol. XXIV, pp. 123-126.

A simple labour-saving formula is developed, by means of which multiple regression equations may be modified appropriately for the inclusion of a new set of observations. The process is recommended as a routine measure for official crop forecasts and other purposes, in which it is important to keep the prediction formula employed up to date, and to make use of all available information.

X. R. A. FISHER. *"Tests of Significance in Harmonic Analysis."* Proceedings of the Royal Society (A), 1929. Vol. CXXV, pp. 54-59.

Considerable discrepancy exists among meteorologists and others as to the test of significance to be applied to real or imaginary periods apparent in the data. Schuster's test is correct for testing the significance of a Fourier submultiple chosen in advance, if the variance of the individual values is known *a priori*. Walker's test is appropriate to the largest amplitude among the Fourier submultiple periods. In practice, the variance must be estimated from the observations, and formulæ are given for both cases in which exact allowance is made for the sampling errors of the estimate.

XI. J. O. IRWIN. *"Note on the χ^2 Test for Goodness of Fit."* Journal of the Royal Statistical Society, 1929. Vol. XCII, pp. 264-266.

A critical note on two different methods of applying the χ^2 test of goodness of fit. In the first, no allowance is made for the reduction of the number of degrees of freedom when estimates of the population parameters are made from the sample. In the second, the allowance is made. The author points out the differences between the hypotheses on which the two methods are based and gives his reasons for preferring the second method.

XII. J. O. IRWIN. *"On the Frequency Distribution of any Number of Deviates from the Mean of a Sample from a Normal Population and the Partial Correlations between them."* Journal of the Royal Statistical Society, 1929. Vol. XCII, pp. 580-584.

An extension of a result which had previously been obtained only for one or two deviates.

XIII. J. WISHART. *"The Correlation between Product Moments of any Order in Samples from a Normal Population."* Proceedings of the Royal Society of Edinburgh, 1929. Vol. XLIX, Part 1, pp. 78-90.

It is shown that by means of a new method of attack, devised by R. A. Fisher, problems on the correlation between product moments, which had hitherto been solved only to a limited extent and by approximate methods, can be worked out in their full generality. The correlation between the t^{th} semi-invariant estimates is shown to be equal to the t^{th} power of the correlation between the variates in the normal population considered, while that between any two estimates of the product semi-invariants is also worked out.

XIV. A. R. Clapham. *"The Estimation of Yield in Cereal Crops by Sampling Methods."* Journal of Agricultural Science, 1929. Vol. XIX, pp. 214-235.

Cereal plots were sampled for yield by three different methods. In one, the location of units (metre-lengths of drill) was wholly systematic, in a single regular pattern : in the second, five drills were selected at random, but six units were cut at different intervals along each row : and in the third, ten units were selected at random from each third of the plot. The results were subjected to statistical analysis, and the disadvantages of the first two methods were clearly demonstrated. These disadvantages were further emphasised in an analysis of earlier data on sampling methods, which made it evident that a direct estimate of sampling error is greatly superior in accuracy to an indirect estimate. It is important, therefore, when carrying out investigations on the precision of such methods, and on possible means of increasing the precision, to ensure that a direct estimate shall be obtainable. This is achieved only by securing some element of random location of units.

By the use of a random sampling method, such as the third (whose superiority to the second depends on the greater representativeness of the sample), the variance due to sampling errors can be made a satisfactorily small fraction of the total variance of cereal experimental plots about 1/40th acre in area.

XV. J. Wishart and A. R. Clapham. *"A Study in Sampling Technique: the Effect of Artificial Fertilisers on the Yield of Potatoes."* Journal of Agricultural Science. 1929. Vol. XIX, pp. 600-618.

Methods for sampling cereal crops have already been discussed. Certain modifications of these are necessary in the case of a root crop such as potatoes, owing to the fact that the variability usually met with in the spacing makes the individual plant the logical unit, while for ease in working, a systematic method of selecting the plants is to be preferred. The statistical requirements are satisfied by a simple systematic distribution within the sampling unit, provided at least two randomly chosen sampling units are taken from each plot to constitute the sample. An analysis is made of the yields of part of the Rothamsted potato experiment of 1928, both as estimated by a sampling method and as determined by large scale lifting. It is concluded that a larger proportion of plants than were actually taken is necessary to give a sampling error as small as 4 per cent., and that it would then be profitable only to sample plots of 1/20th acre or more in area.

THE SOIL.

(Chemical and Physical Departments.)

(*a*) Physical Properties.

XVI. B. A. Keen and G. W. Scott Blair. *"Plastometric Studies of Soil and Clay Pastes."* Journal of Agricultural Science, 1929. Vol. XIX, pp. 684-700.

The laboratory study of the physical properties of soil and clays can conveniently be divided into three stages: (*a*) moisture content comparable to that under field conditions; (*b*) thick pastes; (*c*) weak suspensions. This paper deals with the results of work on the intermediate or thick paste stage. The experimental method has already been described (Paper XLI, Report 1927-28, p. 70). Certain constants defining the material can be obtained from the experimental data. The two of immediate interest are the pseudo-viscosity (analagous to the viscosity of true fluids) and the static rigidity, which measures the energy required just to cause the paste to flow. The latter is a measure of the solid cohesive properties of the system and is found to be related to other physical measurements made under very different conditions; examples of such measurements are (i) the resistance of soil to the passage of cultivation implements (Paper XXXI, Report 1925-26, p. 66); (ii) the effect of chalk on soil resistance; and (iii) the moisture content at which a well-kneaded mass of soil is about to become sticky (Paper XXXV, Report 1927-28, p. 66).

(*b*) Physical Chemistry.

XVII. E. M. Crowther and J. K. Basu. *"Note on a Simple Two-Compartment Electrodialysis Cell for the Determination of Exchangeable Bases."* Transactions of the Second Commission of International Society of Soil Science, Budapest, 1929. Part A, pp. 100-102.

Bradfield's two-compartment cell for the determination of exchangeable bases has been modified to enable the bases to be obtained in a smaller volume of solution. The soil is placed on the bottom of a wide Alundum thimble resting on a perforated nickel kathode, and the anode is a perforated platinum disc close to the surface of the soil. With this arrangement, the whole of the soil, but none of the uncovered membrane, lies immediately between the electrodes. The ratio of endosmotic flow to ionic transport is reduced to a minimum.

XVIII. S. G. Heintze and E. M. Crowther. *"An Error in Soil Reaction Determination by the Quinhydrone Method."* Transactions of the Second Commission of International Society of Soil Science, Budapest, 1929. Part A, pp. 102-111.

In several series of soils from West Africa, Siam and England, the pH values obtained by the quinhydrone electrode occasionally exceeded those by the hydrogen electrode by more than 1.0. Such erratic soils could be detected by the fact that in potassium chloride suspension the soil paste gave a higher pH value than the clear supernatant liquid when both were measured by quinhydrone. The reduction in acidity is clearly shown when quinhydrone is added to a mixture of an erratic soil with an indicator solution. It is ascribed to the production of manganous hydroxide by an interaction of quinhydrone with manganese dioxide associated with the soil colloids.

THE SOIL POPULATION AND ITS BEHAVIOUR.

(Bacteriological and General Microbiological Departments.)

(*a*) Bacteria.

XIX. P. H. H. Gray. *"Vibrio (Microspira) Agar Liquefaciens."* Gray and Chalmers. Annales de l'Institute Pasteur, 1929. Vol. XLIII, p. 1058.

A reply to a criticism in a previous number of the above journal as to the cultural purity of the organism described by Gray and Chalmers in 1924.

(*b*) Protozoa.

XX. D. Ward Cutler and L. M. Crump. *"Carbon Dioxide Production in Sands and Soils in the Presence and Absence of Amoebæ."* Annals of Applied Biology, 1929. Vol. XVI, pp. 472-482.

Experiments are described on carbon dioxide production from soil and sand cultures containing a species of bacterium with and without amoebæ. The following results were obtained :—

1. Carbon dioxide production and bacterial numbers are correlated provided that amoebæ are not present, or are present in very small numbers.

2. The bacteria are more efficient as producers of carbon dioxide when their numbers are not rising, and less efficient when their numbers are increasing. This does not hold for young cultures. Also each bacterium becomes less efficient as the density of the population increases.

3. The amoebæ cause a decrease in carbon dioxide production in sands containing peptone, but an increase in sands containing mineral salts solution with glucose or soil extract.

THE PLANT IN DISEASE; CONTROL OF DISEASE.

(Entomological and Mycological Departments.)

(*a*) Insect Pests and Their Control.

XXI. A. D. Imms. *"Some Methods of Technique applicable to Entomology."* Bulletin of Entomological Research, 1929. Vol. XX, pp. 165-171.

Describes methods of technique applicable to entomology that have been used by the author in the course of a number of years' experience. It deals with methods of mounting, staining, preserving and rearing insects adapted for different lines of investigation, and has been written with a view to assisting research workers both in this country and in other parts of the Empire.

XXII. J. Davidson and H. Hensen. *"The Internal Condition of the Host Plant in Relation to Insect Attack, with Special Reference to the Influence of Pyridine."* Annals of Applied Biology, 1929. Vol. XVI, pp. 458-471.

Certain substances administered to the roots of broad beans are absorbed and transferred to the leaves and stems. Pyridine, applied in this way in suitable concentrations, exercises a marked detrimental effect upon the aphids : the exact conditions, however, are rather difficult to define : among the important factors are those governing absorption by the plant and the effect of the pyridine on the plant after absorption. In the sand experiments, the effect on the aphids was largely proportional to the amount of pyridine administered to the plant : pyridine, however, depressed the growth of the plant. In soil cultures, the pyridine had a less detrimental effect on the plants and on the aphids, though in sufficiently high concentration, higher than was needed in sand, it proved to be toxic.

XXIII. H. F. Barnes. *"Two Gall Midges (Cecidomyidæ) found in Stored Products."* Bulletin of Entomological Research, 1929. Vol. XX, pp. 119-122.

Describes two new species of gall midges affecting stored products on the Continent, both species probably being more or less beneficial, since their larvæ possibly prey upon mites.

(*b*) Fungus Pests and Their Control.

XXIV. W. B. Brierley. *"Variation in Fungi and Bacteria."* Proceedings of the International Congress of Plant Sciences, 1929. Vol. II, pp. 1629-1654.

An introductory survey of the present position is followed by a brief critique of genetic phenomena, concepts and terminology in groups of organisms other than bacteria and fungi. The two latter groups are then considered and a critical analysis is made of the phenomena of variation that have been described. These may be classified from two points of view; firstly, on a basis of morphological and physiological criteria which arranges the data in phenotypic values and, secondly, according to the factors of their appearance and their mode of behaviour, which arranges the data in genetic values. Correlations between the two systems of classification are discussed. The types of variation in fungi and bacteria classified on the genetic basis are treated in relation to processes of growth and reproduction in these groups of organisms : aberrant types of genetic phenomena are considered. Fungi and bacteria are compared with other groups of organisms in respect of the types of genetic phenomena exhibited, the interpretation and classification of these types, the genetic concepts which emerge and the terminology adopted. Finally, the directions of genetic research on fungi and bacteria, and the possibilities and limitations are considered.

XXV. M. S. Martin. *"Additional Hosts of Synchytrium endobioticum (Schilb). Perc."* Annals of Applied Biology, 1929. Vol. XVI, pp. 422-429.

Infection of numerous species of Solanaceæ by *Synchytrium endobioticum* has been obtained, using Glynne's "green wart" method. Plants grown in contaminated soil did not show infection. The following new hosts are recorded : *Solanum dulcamara* var. *villosissimum*, *Nicandra physalodes*, *Solanum dulcamara alba*, *Solanum nodiflorum* and *Solanum villosum*.

In certain hosts the fungus may occur in the tissues, with little or no external sign of its presence.

XXVI. M. 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 of Victoria, 1929. Vol. XLII, pp. 30-35.

This work was carried out by Miss Glynne during a visit to Australia.

A plot of land near Melbourne University, on which wheat had been grown for fourteen years, was reported to be so badly infested with fungi, causing foot and root-rot diseases in wheat, that a good crop could not be grown.

Soil treatment with sulphur gave large increases in crop, up to over 800% with sulphur as 0.15% of the soil.

In case sulphuric acid should reduce both crop and disease, treatment with acid was followed in some plots by an application of calcium carbonate after an interval for the acid to affect the fungus in the soil, before the wheat was sown. Increases in crop similar to those obtained with sulphur were obtained, both when sulphuric acid was applied alone and when it was followed by calcium carbonate.

A survey of the disease showed a relatively small amount present in controls and treated plots, and no significant difference between them.

The results indicate not an effect on disease, but a hitherto unsuspected sulphur deficiency or a deficiency in some other element or compound which is rendered available by the treatment.

An increase in crop obtained with ammonium sulphate, larger than that produced by the amount of sulphur contained in it, suggests also a nitrogen deficiency.

(*c*) BACTERIAL DISEASES.

XXVII. R. H. STOUGHTON. "*The Morphology and Cytology of* Bacterium malvacearum *E.F.S.*" Proceedings of the Royal Society (B), 1929. Vol. CV, pp. 469-484.

Studies have been made of the internal structure and the growth forms of *Bacterium malvacearum,* the organism causing the Black-arm or Angular Leaf Spot disease of cotton.

By means of a special technique, it has been shown that all the cells of the bacterium possess a centrally-placed structure which divides at the same time as the cell, one-half of the structure passing into each of the daughter cells. The details of this division have been followed and reasons for believing it to be a true bacterial nucleus adduced.

Apart from this central structure, cells in a young culture of the organism frequently produce very small deeply staining bodies, which are liberated from the cell either by simple extrusion or by growth on a long stalk. These bodies appear to be identical with the "gonidia" described by other workers for various species of bacteria.

A second growth form which has been described is a larger coccoid body, which is formed by a process of budding from the parent cell. The details of this process have been followed.

TECHNICAL PAPERS

CROPS, SOIL AND FERTILISERS.

XXVIII. E. J. Russell. *"Recent Agricultural Developments in Australia."* Geography, 1929. Vol. XV, pp. 267-273.

XXIX. E. J. Russell. *"Soils and Fertilisers."* Agricultural Research in 1928, pp. 131-162. (Royal Agricultural Society of England, 1929.)

XXX. E. J. Russell. *"Science and Crop Production."* Transactions of the Oxford University Junior Scientific Club, 1929. Fifth Series, pp. 54-59.

XXXI. E. J. Russell. *"Fertilisers."* "Yorkshire Post" Royal Show Agricultural Supplement, July, 1929.

XXXII. E. J. Russell. *"The Future of Agriculture."* Discovery, 1929. Vol. X, pp. 355-358.

XXXIII. E. J. Russell. *"The Conquest of the Waste Places: a Triumph of Modern Science."* The Realist, 1929. Vol. I, pp. 39-54.

XXXIV. E. J. Russell. *"Soil Fertility and its Control."* British Association, Report of South African Meeting, 1929, pp. 413-415.

XXXV. B. A. Keen. *"Physical Factors and their Control."* British Association, Report of South African Meeting, 1929, p. 415.

XXXVI. J. O. Irwin. *"Crop Forecasting and the Use of Meteorological Data in its Improvement."* Conference of Empire Meteorologists, 1929, H.M. Stationery Office.

XXXVII. H. L. Richardson. *"Agricultural Meteorological Work on Soils and Manures."* Conference of Empire Meteorologists, 1929, H.M. Stationery Office.

XXXVIII. J. Wishart and H. J. G. Hines. *"Fertiliser Trials on the Ordinary Farm."* Journal of the Ministry of Agriculture, 1929. Vol. XXXVI, pp. 524-532.

XXXIX. A. G. Norman. *"The Biochemistry of Pectin."* Science Progress, 1929. Vol. XXIV, pp. 263-279.

XL. R. K. Schofield and B. A. Keen. *"Rigidity in Weak Clay Suspensions."* Nature, 1929. Vol. CXXIII, pp. 492-493.

XLI. E. M. Crowther. *"Soils and Fertilisers: a Report on Recent Developments."* Annual Report of the Society of Chemical Industry, 1928. Vol. XIII, pp. 469-506.

XLII. H. Lloyd Hind and F. E. Day. *"The Fermentation Industries: a Report on Recent Developments (especially Yeasts and Barley)."* Annual Report of the Society of Chemical Industry, 1928. Vol. XIII, pp. 531-564.

https://doi.org/10.23637/ERADOC-1-111

BIOLOGICAL.

XLIII. W. B. Brierley. "*Science of the Year—1928. The Biological Sciences.*" The Annual Register for 1928. Vol. CLXX, pp. 37-41.

XLIV. W. E. Brenchley. "*The Dormancy of Weed Seeds in the Soil as affected by Cultivation and Fallowing.*" British Association, Report of South African Meeting, 1929, pp. 417-418.

METEOROLOGICAL OBSERVATIONS.

Meteorological observations have been systematically made at Rothamsted for many years. The deviation of sunshine, mean air temperature and rainfall from their average monthly values for the season ending September, 1929, is shown in the diagram on the following page, an excess being recorded above the horizontal line and a deficiency below.

The records now taken at Rothamsted are as follows :—

Continuous self-registering records of:—

Barometric pressure. (Negretti and Zambra barograph.)

Radiation. (Callendar recorder.)

Sunshine. (Campbell Stokes recorder.)

Wind direction and velocity. (Negretti and Zambra anemo-biagraph.)

Rainfall. (Negretti and Zambra hyetograph.)

Drainage through 20-inch, 40-inch and 60-inch gauges. (Negretti and Zambra special design.)

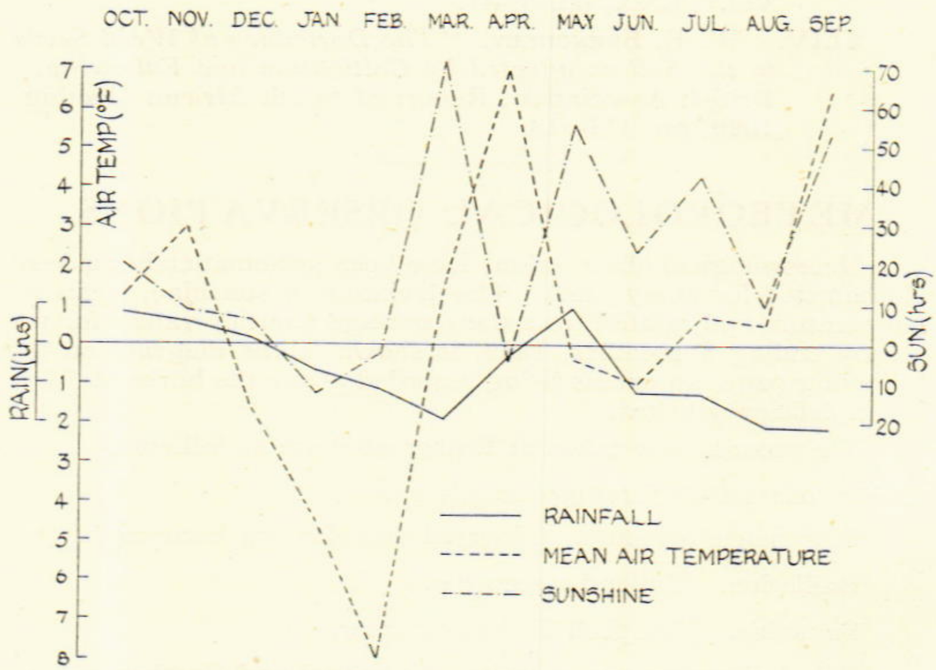
Air temperature. (Negretti and Zambra thermograph.)

Soil temperatures at 4-inch, 8-inch and 12-inch depths, both under grass and in bare soil. (Negretti and Zambra recording thermometers and Cambridge Instrument Company electrical resistance recording thermometers.)

Records taken at stated hours each day.

In addition to the above, the usual barometer, air and soil temperatures and rainfall readings are taken at 9 a.m.; these are supplemented by further readings at 3 p.m. and 9 p.m. of certain selected factors—wet and dry bulb for relative humidity and dew-point, soil temperature at 4-inch and 8-inch depths. A daily reading is also made of a simple atmometer, to obtain a measure of the amount of evaporation from a wet surface during the preceding 24 hours. Full notes are also made of the general weather conditions.

The detailed information obtained from these records and observations is employed by the Statistical Department in interpreting the crop records, and is also used, together with phenological notes and observations of crop growth, in drawing up the monthly statement for the purpose of the Crop-Weather Report of the Ministry of Agriculture. The continuous self-registering records are used by the Physical Department in their studies of border-line problems in Meteorology and Soil Physics.



Deviation from average monthly values of sunshine, mean air temperature, and rainfall—Season 1928-29.

THE FARM & CROP RESULTS

OCTOBER, 1928 — SEPTEMBER, 1929.

I. Weather.

The two outstanding features of the weather this year were the exceptional frost in February and the long Summer drought. The mean temperature for February was only 30.7°F., 8° below the 51-year average; the minimum daily temperature was under 20°F. on six days, and went as low as 13°F. on the 14th. This frost was accompanied by a period of drought, which persisted into May. During the four months, January to April, there were 4.089 ins. less rain than the 78-year average. Two thunderstorms in May brought relief, started crops growing vigorously, and ensured a good hay crop; but for the remaining months there was a total deficiency of 5.753 ins.

It was a particularly sunny year, there being 272 hours of sunshine in excess of the 36-year average. March alone accounted for 72 hours of this excess, for as soon as the cold spell finished, a period of bright drying weather began, culminating in a Summer-like Easter week-end. The months from May onwards had 56.6, 23.7, 42.5 and 9.2 hours of sunshine above the 36-year average.

Unlike 1928, the weather was conducive to a splendid Spring tilth, and, once the frost went, enabled cultivation to proceed without interruption. Like 1928, this was a year favourable for fallowing, except for annuals such as *Alopecurus agrestis* (Black Bent), whose seeds remained dormant in the soil throughout fallowing operations, and germinated only after the Autumn cereals had been sown. Like 1928 again, conditions during hay-time and harvest were excellent. It was a poor season for grass, however. The early Summer flush was soon over, and for the rest of the year pastures remained burnt and bare.

II. Crops. (For dates, yields and other information, see Table on pp. 79-80.)

Wheat and Winter oats were sown under favourable conditions, the wheat after potatoes, sugar beet and clover seed, the Winter oats after wheat. Wheat wintered well in spite of the loosening effect of frost on the soil, but most of the Winter oats, having been badly eaten by pheasants, were killed by the severe cold. They had to be patched in the Spring with Spring oats, and three acres were re-sown with barley. The Winter was particularly favourable to Black Bent, which came up very thickly on Broadbalk, despite the 1926-27 fallowing, and also in the Winter oats on Long Hoos II. The fallowing of the lower three-fifths of Broadbalk was completed this year, and the whole field was sown, for the first time since 1925, in October, 1929.

With a good manuring and rolling in March, wheat came on well, and both Little Hoos and Gt. Harpenden turned out dense and successful crops. Gt. Harpenden was under-sown with Italian Rye Grass and Broad Red Clover, but the drought and the heavy wheat crop gave these little encouragement and most of the clover failed, though sufficient grass was left for next year's hay crop.

Barley was sown early under favourable conditions, and despite the drought, grew well and gave a heavy yield. The barley in Sawyer's and Gt. Harpenden was under-sown with a permanent grass seeds mixture, as detailed in the previous report (1927-28, p. 101), thereby completing the grass programme. Charlock in Long Hoos was again controlled by spraying.

Barley in Hoos Field was sown in drills 24 inches apart to facilitate cleaning operations. Two varieties were used, in alternate strips, and these were drilled at right angles to the usual direction of sowing.

Harvest was again free from laid grain, except the usual Broadbalk plots and a small trial plot of barley after swedes in Gt. Harpenden, where sheep had been folded on the roots. This showed clearly that if sheep are folded on arable land on this farm, they must be followed by a crop other than barley.

Potatoes were planted by 17th April in Long Hoos I. The yield was light and the crop was lifted under perfect conditions. Sugar beet sown in the same field, Section V., on 4th May, was slow in coming away, and was also a light crop. Barn Field mangolds were sown on 24th-27th April, with the land in good order.

A heavy hay crop was cut from Foster's and Long Hoos III, and immediately after both fields were ploughed by tractor and bastard fallowed. After a good crop of mustard had been ploughed into Gt. Knott, this also was fallowed, the weather offering little prospect of growing a successful second green crop. Both fields were ready for wheat sowing by September, and this was done before the end of the month, before the drought broke.

Immediately after the carting of the corn from Pastures, the field was dunged at the rate of 15-16 tons per acre, using mechanical dung spreaders, and a rye and vetch mixture was sown.

III. Stock.

Twenty-four Angus-cross cattle were purchased in February and kept on the grass from then onwards. They are now being fattened off, either in the stalls or on the grass.

No fattening lambs in addition to those raised on the farm were bought in the Autumn, on account of the poor condition of the grass. Fifty half-bred ewe lambs were secured in August, however, to bring into the ewe flock, this being more profitable at present than the purchase of either ewe hoggs or gimmers.

Three good Wessex sows were purchased to help in building up the herd of pigs, and a number of home-bred gilts are being saved.

IV. Grass.

The new grass fields had an unfortunate time after June, with the hot, dry Summer and a considerable head of stock on them. This prevented their filling up in the way they would otherwise have done. Gt. Harpenden (Autumn sown, 1928) provided the earliest grass in the Spring, although the Winter killed many of the tender clover seedlings. New Zealand looked poor throughout the season and had many weeds. Of the older grass, Little Knott was easily the best, but in spite of its dense covering of clover and grass, it produced little more after June than the younger fields. Wild white clover and good grasses showed a distinct increase in Great Field. All the grass was topped as soon as flowering heads developed, and received 1 cwt. sulphate of ammonia at the end of the drought to help its recovery.

THE WOBURN EXPERIMENTAL FARM

RECENT CHANGES.

In 1876 the Duke of Bedford started and carried on for many years an experimental farm at Woburn, on a light sandy soil, at which the Rothamsted experiments on wheat and barley were repeated in a modified form. Three other investigations were included: the effect of lime on an acid soil, the manurial value of cake and corn fed to farm animals, and the effect of green-manuring on a light soil. The Royal Agricultural Society was responsible, through their chemist (Dr. A. Voelcker till 1890, after that Dr. J. A. Voelcker), for the conduct of the experiments, and in 1912 took over the farm entirely. In 1921 they gave it up, and Dr. J. A. Voelcker then carried it on with the aid of a grant obtained through Rothamsted: in 1926 it was taken over entirely by Rothamsted, the laboratory was refitted and the pot culture station put into full work. Since 1927, Dr. H. H. Mann has been in charge, with Mr. T. W. Barnes as assistant. A grant has been obtained from the Royal Agricultural Society enabling us to make a statistical examination of the whole of the data assembled during the entire period. This is proceeding and is promising interesting results. It is too early to discuss the crop relationships, but some of the effects of fertilisers on the light sandy soil are being discovered by Dr. Crowther and his colleagues. There is no evidence that the addition of lime has increased the availability of the potash, nor that potassic and phosphatic manures have used up the lime (the exchangeable calcium): nitrate of soda, indeed, has a slightly conserving effect; sulphate of ammonia, on the other hand, exhausted it and made the soil acid, not, however, as acid as it might become, because as the acidification progressed so the loss of lime by leaching became less. It is interesting that superphosphate, even when applied every year for 50 years, has no tendency to make the soil acid, although the Woburn soil contains little or no calcium carbonate and readily becomes acid. Sulphate of ammonia did not reduce the exchangeable potassium. The work has been simplified by certain modifications in procedure designed by Mr. Basu and Dr. Crowther.

For the first time since 1905, the Lansome Field green-manuring plots gave good yields, and tares proved better than mustard; we cannot at present offer an explanation for this.

REPORT FOR 1929.

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

The early part of the season was rainy, and followed by a cold and windy January and February, 1929. Fairly dry weather prevailed until May, and from June onwards there were continued spells of drought until harvest time. This enabled the corn harvest to be gathered in well, but roots, green crops, and potatoes suffered, and grass grew only moderately.

RAINFALL.

Month.		Inches.	No. of Days where 0.2 mm. or more fell
October	1928	3.69	19
November	,,	2.35	21
December	,,	2.43	17
January	1929	1.16	17
February	,,	.72	9
March	,,	.10	5
April	,,	1.85	15
May	,,	1.68	10
June	,,	.87	12
July	,,	1.10	12
August	,,	.42	10
September	,,	.17	2
		16.54	149

FIELD EXPERIMENTS.

1.—CONTINUOUS GROWING OF WHEAT AND BARLEY (STACKYARD FIELD), 51st SEASON.

Wheat.

After the cleaning fallows of 1927 and 1928, "Million" wheat was sown on October 31st, 1928, withholding all manures, to ascertain the effects of fallowing and the residual manurial influences. It came up well. At first, plot 11b (farmyard manure) looked best. In December, plots 4 (minerals only) and 5 (lime) looked well; 2a (sulphate of ammonia) was the worst and nearly bare; 2b was better; and 2bb better still.

The wheat grew only slowly, but by January it covered the ground and had suffered little damage from game or rabbits.

In January, 11b and 4 no longer stood out; 2a and b, however remained the worst. By mid-April, 4 once more stood out superior to 1 and 7 (unmanured), and 2, 5 and 8 superior to 3, 6, 9: possibly, however, because the soils of 2, 5 and 8 appeared drier than those of 3, 6, 9. In May, the limed plots 8aa and bb were remarkably superior to the unlimed, and 3a (double nitrate of soda) to 3b (single nitrate of soda); 11b, however, was no longer superior to the rest.

https://doi.org/10.23637/ERADOC-1-111

The summer drought checked the wheat, and numerous weeds appeared : mayweed on unmanured and mineral plots, spurry on sulphate of ammonia plots, and coltsfoot, poppy and vetch on the remainder. Evidently on this weedy light land, two years' intensive cleaning is insufficient.

In the winter the soil on the nitrate of soda plots was noticeably darker, and wetter in appearance, than that on the sulphate of ammonia plots.

The yields are given in Table I. The yield of the unmanured plots (1 and 7) exceeded that of the previous 12 crops, being about equal to the 50-year average. In spite of the appearance of the crop, residual effects were produced by farmyard manure and minerals, especially potash, and by lime, but none by sulphate of ammonia and nitrate of soda.

Barley.

The longer interval available for cultivations had kept this crop cleaner than the wheat, and the two years' fallow was very effective. The yields obtained (Table II) were the best for the past 20 years, although some spurry again appeared and the crop looked yellow on the unlimed plots. Throughout growth the best plot was the farmyard manure plot (11b); the worst were sulphate of ammonia without lime (2a, 5a, 8a, 8b). The awns of the barley were darker on those plots where no phosphate had been given than on the rest.

TABLE I.

CONTINUOUS GROWING OF WHEAT, 1929.
(After 2 years' fallow.)

Stackyard Field—Produce per acre.

Plot.	Manures Applied Annually. (Before the Fallow). For amounts see Report 1927-28. No Manures in 1929.	Dressed Corn per acre. bushel.	Total Corn per acre. cwt.	Weight per bushel. lb.	Straw, Chaff, etc., per acre. cwt.
1	Unmanured	11.1	5.98	59.2	11.11
2a	Sulphate of Ammonia	0.3	0.14	—	0.61
2aa	As 2a, with Lime, Jan., 1905, repeated 1909, 1910, 1911	1.7	0.89	—	1.54
2b	As 2a, with Lime, December, 1897	1.1	0.57	—	1.25
2bb	As 2b, with Lime, repeated Jan., 1905	5.4	2.82	—	4.21
3a	Nitrate of Soda	12.8	6.86	58.5	8.30
3b	Nitrate of Soda	9.5	4.93	57.0	6.53
4	Mineral Manures (Superphosphate and Sulphate of Potash)	17.8	9.71	60.6	16.38
5a	Mineral Manures and Sulphate of Ammonia ..	10.9	5.84	58.7	8.32
5b	As 5a, with Lime, Jan., 1905	13.3	7.04	57.7	12.13
6	Mineral Manures and Nitrate of Soda	12.8	6.72	57.7	9.88
7	Unmanured	8.5	4.62	59.5	7.50
8a	Mineral Manures and, in alternate years, Sulphate of Ammonia	2.7	1.39	—	2.79
8aa	As 8a, with Lime, Jan., 1905, repeated Jan., 1918	7.9	4.14	—	5.86
8b	Mineral Manures and Sulphate of Ammonia (omitted in alternate years)	2.9	1.50	—	2.61
8bb	As 8b, with Lime, Jan., 1905, repeated Jan., 1918	9.4	4.89	—	7.04
9a	Mineral Manures and, in alternate years, Nitrate of Soda	17.2	9.30	59.5	13.43
9b	Mineral Manures and Nitrate of Soda (omitted in alternate years)	17.0	8.96	58.4	10.89
10a	Superphosphate and Nitrate of Soda	9.3	4.98	58.5	6.93
10b	Rape Dust	5.6	2.86	—	5.05
11a	Sulphate of Potash and Nitrate of Soda	16.5	8.84	59.0	14.27
11b	Farmyard Manure..	21.3	11.48	59.2	20.95

TABLE II.

CONTINUOUS GROWING OF BARLEY, 1929.
(After 2 years' fallow.)

Stackyard Field—Produce per acre.

Plot.	Manures Applied Annually. (Before the Fallow). For amounts see Report 1927-28. No Manures in 1929.	Dressed Corn per acre. bushel.	Total Corn per acre. cwt.	Weight per bushel. lb.	Straw, Chaff, etc., per acre. cwt.
1	Unmanured	20.4	9.54	50.4	12.42
2a	Sulphate of Ammonia	2.7	1.21	—	2.61
2aa	As 2a, with Lime, Mar., 1905, repeated 1909, 1910, 1912, and 1923	14.9	7.07	—	10.36
2b	As 2a, with Lime, Dec., 1897, repeated 1912 ..	24.9	11.37	49.5	15.10
2bb	As 2a, with Lime, Dec., 1897, repeated Mar., 1905	20.0	9.29	49.7	11.50
3a	Nitrate of Soda	33.4	16.21	51.7	18.89
3aa	As 3a, with Lime, Jan., 1921	16.0	7.82	51.5	7.82
3b	Nitrate of Soda	27.2	12.82	51.0	14.89
3bb	As 3b, with Lime, Jan., 1921	18.3	8.61	49.7	9.61
4a	Mineral Manures (Superphosphate and Sulphate of Potash)	21.1	9.93	50.4	12.84
4b	As 4a, with Lime, 1915	24.8	11.17	48.7	14.05
5a	Mineral Manures and Sulphate of Ammonia ..	5.8	2.34	—	4.14
5aa	As 5a, with Lime, Mar., 1905, repeated 1916 ..	15.0	7.18	—	8.79
5b	As 5a, with Lime, Dec., 1897, repeated 1912 ..	24.2	11.29	49.5	14.46
6	Mineral Manures and Nitrate of Soda	30.6	14.36	52.0	15.31
7	Unmanured	20.2	9.19	50.1	12.12
8a	Mineral Manures and, in alternate years, Sulphate of Ammonia	1.1	0.57	—	0.43
8aa	As 8a, with Lime, Dec., 1897, repeated 1912 ..	29.2	13.46	50.0	18.41
8b	Mineral Manures and Sulphate of Ammonia (omitted in alternate years)	3.7	1.81	—	0.85
8bb	As 8b, with Lime, Dec., 1897, repeated 1912 ..	30.3	14.50	51.5	18.38
9a	Mineral Manures and, in alternate years, Nitrate of Soda	33.9	16.05	51.4	17.80
9b	Mineral Manures and Nitrate of Soda (omitted in alternate years)	36.0	17.23	52.0	20.68
10a	Superphosphate and Nitrate of Soda	21.1	10.11	51.1	10.16
10b	Rape Dust	5.4	2.75	—	4.46
11a	Sulphate of Potash and Nitrate of Soda	29.1	14.39	52.2	16.02
11b	Farmyard Manure	34.7	16.87	52.9	16.79

2. ROTATION EXPERIMENT.

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

Series C.

The small clover aftermath of 1928 was not fed off, but ploughed in with a tractor plough. This possibly explains the growth of veronica, chickweed and groundsel in the young wheat, and the thistles that came later. Hand-hoeing was effective, but the crop, as usual, was poor :—

Wheat (after Red Clover, 1928) Produce per acre.

Plot.	Head Corn.		Tail Corn. Weight.	Straw, Chaff, &c.
	Bushels.	Wt. per Bushel.		
		lb.	lb.	cwt.
1 (Corn)	19.6	59.3	19	13.5
2 (Cake)	17.0	59.2	16	12.0

WOBURN EXPERI

DATES OF SOWING AND HARVE

Field.	Acres.	Crop and previous one.	Cultivation.	Manuring. cwt. per acre.	Date of Manuring.*
Lansome Piece	3	Sugar Beet after Grass	Ploughed March 12. Roll, cultivated and harrowed May 20, on 22 ins. ridges	Bedford refuse 10 tons per acre ..	May 22
	3	Early Potatoes, after Barley (Eclipse) ..	Stubble, tractor cultivated in autumn and ploughed. Ploughed, harrowed and cross cultivated March 26. Bouted up April 1-2, 27 ins... ..	3 Super., 2 S/Amm. 2 M/Pot. ..	Apr. 1
	1	Potatoes (own seed, Ally) ..		15 tons Bedford dung	Mar. 20
	3	Soiling crop after Potatoes, 3 bush. Rye, 1 bush. Vetches, 1 bush. Beans	Cross cultivated after Potatoes and drilled ..	2 tons Lime ..	Sept. 19
Great Hill	10½	Rye and Vetches (3:1) after Spring Oats. Barley after Rye and Vetches (Plumage Archer)	Stubble ploughed and harrowed. Ploughed April 11-20, harrowed and drilled	1 M/Amm. 2 tons Lime .. 1 S/Amm., 2 Super. 1 M/Pot. ..	Jan. 4 Feb. 24 May 23
Road Piece	4	Grass after Barley	Harrowed	2 S/Amm., 2 Super. 1 M/Pot. ..	Apr. 11
	4	Forage after Grass	Ploughed, cross cultivated and harrowed. Drilled ..	—	—
	5	Kale: 3 acres after Mustard (eaten off by sheep). 2 acres after Forage ..	Ploughed, rolled, harrowed, and drilled ..	2 S/Amm., 3 Super.	July 8
	5	Rye: 3 acres after Mustard, 2 acres after Forage ..	Tractor ploughed, rolled, harrowed, drilled ..	—	—
Butt Close	7	Potatoes after Barley	Stubble cultivated Oct. 3. Twice ploughed and cultivated. Bouted 27 ins.	2 tons Lime, 2 S/Amm., 2 Super., 2 M/Pot., 12 tons Bedford dung ..	Jan. Apr. 29 Apr. 21
	1½	Sugar Beet after Barley	Stubble cultivated Oct. 3. Twice ploughed and cultivated. Bouted 27 ins. ..	2 S/Amm., 3 Super, 3 Kainit	May 23
Butt Furlong	8½	Barley after Sugar Beet and Potatoes	Beet tops ploughed in, Dec.	1 S/Amm., 2 Super., 1 M/Pot.	May 16
		Barley after Swedes	—	As above, with 12 tons dung	Jan.
Warren Field	4	Fallow	3 times ploughed, cultivated and harrowed ..	2 S/Amm., 3 Super.	July 30
Warren Field	10	Wheat after Fallow	Fallow ploughed, by steam tackle, and cultivated with horses. Twice horse cultivated and twice tractor cultivated and harrowed	1 S/Amm. 2 Super. 1 M/Pot.	May 14

* All 1929 except where otherwise stated.

https://doi.org/10.23637/ERADOC-1-111

NTAL STATION
ING, AND YIELD PER ACRE, 1929

ate and rate of sowing.*	Any further Cultivation.	Harvest.	Carted.	Thrashed.	Yield per acre.	Notes.
May 23 16 lb. per acre	Four horse hoeings Two hand hoeings	Oct. 22-31	Oct. 22-31	—	see p. 111	
Apr. 4-5 20 cwt. per acre ..	Chain harrow and horse hoe. Twice bouted up ..	July 15 ..	—	—	35 cwt.	
	Ditto	Sept. 16 ..	—	—	5 tons	
Sept. 26 .. 3 bush. per acre						
	—	—	—	—	—	
Sept. 28-29 (1928) 2½ bush. per acre						
April 21 3 bush. per acre	Thistles cut out ..	Aug. 17 ..	Aug. 27 ..	Nov. 17	13 cwt. ..	
—	—	June 28 ..	July 9 ..	—	2 tons	
—	—	—	—	—	—	Oats failed in forage crop, so half ploughed up, remainder eaten off by sheep
July 6 ..	Horse hoed ..	—	—	—	Eaten off by sheep ..	
Sept. 26 ..	—	—	—	—	—	
May 1-6 ..	Potatoes twice harrowed & rebouted	Sept. 14-18	Sept. 16-18	—	see p. 108	
June 1 ..	Rolled, twice horse hoed, once hand hoed	Oct. 2 ..	Oct. 2 ..	—	3 tons ..	Drought prevented germination
Mar. 26 ..	—	Aug. 12 ..	Aug. 19-20	Nov. 18	see p. 106	Grass seeds sown but failed owing to drought
3 bush. per acre ..	—	—	—	—	—	
—	—	—	—	—	—	Forage crop sown at end of drought
Nov. 5-6 ..	Flat rolled. 1 acre killed by frost and ploughed up ..	Aug. 22 ..	Aug. 30 ..	Nov. 20	15 cwt.	

NOTE.—See p. 76 for particulars of permanent experiments on Stackyard and Lansome Fields.

https://doi.org/10.23637/ERADOC-1-111

These results show, in common with earlier reports, that the extra nitrogen on the cake-fed plot has no effect on the subsequent wheat crop.

Series D.

Swedes followed the 1928 wheat, and, in spite of drought, aphis attack, and damage from rabbits on Plot 2, gave a fair yield with no sign of "finger and toe." The yields were :—

Swedes (after Wheat, 1928) Produce per acre.

Plot.	Roots.	Tops.
	tons.	cwt.
1 (Corn)	7.25	17.5
2 (Cake)	4.10	12.5

The produce was divided equally over the area and fed off by sheep, which received also corn and cake as follows :—

Corn-Fed Plot: Barley and oats equivalent to 24.6 lb. nitrogen per acre.

Cake-Fed Plot: Linseed and cotton cake equivalent to 56.5 lb. nitrogen per acre.

The land was ploughed in February, 1930, in preparation for barley.

3. GREEN CROP AND GREEN-MANURING EXPERIMENTS.

(a) *Stackyard Field—Series A.*

Upper Half : Wheat after Green Crops fed off by sheep.

Following the tares and mustard crops of 1928, wheat was sown. As usual, it showed the initial superiority over the adjoining Permanent Wheat plots, followed in May by poor later growth and low yields :—

Wheat after Green Crops fed off : Produce per acre.

Plot.	Head Corn.		Tail Corn. Weight	Straw, Chaff, etc.
	Bushels.	Weight per Bushel.		
		lb.	lb.	cwt.
1, after Tares fed off	8.7	59.3	20	8.3
2, as 1, Limed 1923	5.5	58.5	12	7.0
3, after Mustard fed off	8.0	58.7	12	7.4
4, as 3, Limed 1923	5.4	58.9	12	5.5
5, adjoining land (Potato plot)..	8.0	58.8	—	6.3

These results are similar to those of previous years, and show also a further drop on the limed plots, Nos. 2 and 4. The possibility that lack of readily available nitrogen is responsible for the low yields is now under investigation in both field and laboratory.

Early and late applications of nitrate of soda, singly and together, were given to small plots on this area, and produced an increased growth of a better colour. This result is being closely followed up.

Lower Half : Green Crops fed off by sheep.

Twitch was prominent in the wheat stubble of 1928, and necessitated vigorous operations before mustard and tares were sown. In spite of the drought, a fair crop was obtained, which was fed off by sheep, receiving in addition 3cwt. per acre cotton cake. The land was then ploughed in preparation for wheat.

(b) *Lansome Field.*

Wheat : after Green Crops ploughed in.

Wheat was drilled after the mustard and tares were ploughed in. It came up well, grew vigorously, and gave very satisfactory results. This result is in marked contrast with the series of wheat failure on this field in previous years. The results were :—

Wheat after Green Crops ploughed in. Produce per acre.

Plot.		Head Corn. Bushels.	Head Corn. Weight per Bushel.	Tail Corn.	Straw, Chaff, etc.
			lb.	lb.	cwt.
Old Plots.	1, after Mustard	28.5	53.3	64	22.9
	2, after Tares	38.5	54.1	78	29.8
New Plots.	3, after Mustard	25.0	53.0	21	20.0
	4, after Tares	30.6	57.8	32	29.6
	5, Control (no green-crop) ..	18.1	57.3	42	23.9

The table clearly shows the increased yield compared with the control, and—for almost the first time—the yield after tares exceeds that after mustard.

4. MANURING AND LIMING OF GRASS LAND.

Broad Mead.

Plot 1 (basic slag and once kainit) has now been included in an intensive grazing area. The remaining five plots were grazed by ewes and bullocks; the limed plot (4) was closely grazed, while the herbage on the farmyard manure plot (5) was coarse, with but little clover; it was very rough on the unmanured plot (3). The limed plot again showed abundant growth of daisy and contained much clover. Plot 2—basic slag and sulphate of potash—was fresh and green, while Plot 1—super. and sulphate of potash—was dried up.

5. REPLICATED EXPERIMENTS.

The results of the replicated experiments will be found on pp. 106-114.

https://doi.org/10.23637/ERADOC-1-111

DATES OF SOWING AND HARVESTING, PERMANENT EXPERIMENTS, 1929

Field.	Crop.	Variety.	Date of Sowing.	Date of Cutting.	Carting Dates.	Yield per acre.
Stackyard Field—						
Permanent Wheat..	Wheat ..	Million	Oct. 31 (1928) ..	August 20	August 29-30 ..	see p. 70
Permanent Barley..	Barley ..	Plumage Archer ..	March 21 ..	August 20	August 24-26 ..	see p. 71
Series A (*a*) ..	Green Crops ..	Tares	May 30	Fed off August 1-3		—
		Mustard	May 30	Fed off July 30-August 1		—
Series A (*b*) ..	Wheat ..	Million	Nov. 1 (1928) ..	August 28	September 3 ..	see p. 74
Series B	Spring Oats ..	Tartar	May 6	August 14 for Hay		—
Series C	Wheat ..	Million	Nov. 1 (1928) ..	August 23	September 3 ..	see p. 71
Series D	Swedes ..	Garton's Magnificent	May 24	Fed off between Dec. 12 and Feb. 1 (1930)		—
Lansome Field ..	Wheat ..	Million	Nov. 6 (1928) ..	August 13	August 22	see p. 75

YIELDS OF EXPERIMENTAL PLOTS

1929

https://doi.org/10.23637/ERADOC-1-111

THE USE OF THE SUMMARY TABLES

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

An experimental yield will differ from its true value either in excess or deficit by an amount exceeding its standard error almost as frequently as once in 3 trials; it will, however, be wrong by more than twice its standard error only about once in 22 trials, and by more than three or four times its standard error once in 370 or 15,780 trials respectively. The odds against an error of any size having occurred thus increase very rapidly in a small range of multiples of the standard error. Whereas experimental differences of less than twice their standard error might always be ascribed to chance, and are, therefore, for safety, ignored as "insignificant," differences only slightly greater than these 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 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.

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, 1929.

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring. cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
Great Harpenden	Wheat ..	Million III...	After Potatoes ploughed, Oct. 25-27. Nov. 2-3 harrowed and drilled then harrowed in ..	1½ S/Amm.	Nov. 2-3			
			After Beet ploughed, Nov. 8-12, harrowed, drilled, then harrowed	—	Nov. 14 (grass Apr. 18)	Aug. 16-17	Aug. 22-23	7 qrs.
	Barley ..	Standwell ..	Mar. 8-12, ploughed and harrowed and cultivated.	1 S/Amm. 1 M/Pot. 2 Super. ..	Mar. 15 (grass Apr. 4)	Aug. 12 ..	Aug. 20 ..	see pp. 97-8
	Grass ..		Mar. 21, horse rolled	1 Nitro-Chalk ..	Aug. 24 (1928)	—	—	—
Pastures	Winter Oats patched with Spring Oats and Barley	Grey .. Victory .. Standwell ..	Tractor sub-soiled Sept. 10. Sept. 19, Tractor harrowed and rolled. Mar. 20-21, horse rolled. Apr. 2-4, harrowed and rolled.	2 S/Amm. 2½ Super. 1 M/Pot...	Sept. 20 (1928) Mar. 29 (Spring oats) Apr. 2. .. (Barley)	Aug. 7 .. Aug. 13 ..	Aug. 19-20 Aug. 27-28	5½ qrs.
	Forage Mixture ..	1 bush. Beans, 1 bush. Tares, 3 bush. Winter Oats (rate 3 bush. per acre)	Ploughed Sept, 1929.	15-16 tons dung ..	Sept. 24-25, 1929.. ..	For	sheep feed in	Spring.
Little Hoos	Wheat ..	Million III ..	Oct. 22-24, tractor ploughed and harrowed. Oct. 26, harrowed in. Mar. 20-21, horse rolled.. ..	2 Super. 1½ S/Amm. 1 M/Pot...	Oct. 25 (1928)	Aug. 16 ..	Aug. 21-22	6½ qrs.
Broadbalk Acre ..	Swedes ..	Garton's Magnificent	Tractor ploughed, horse harrowed and rolled. Bouted May 2 and 3, ridges split	15 tons "Adco" ..	May 28 (1st sowing, May 9, destroyed by fly)	—	Nov. 16-21	15 tons
	1 Year's Seeds ..		April 16-17, tractor rolled .. Ploughed up July 4-15 .. .. Cultivated July 24	2½ Super. 1½ S/Amm. 1 M/Pot...	—	June 22 ..	July 1-2 ..	38 cwts.
Fosters ..	3½ acres Italian rye grass and trifolium killed by frost replaced by forage mixture	1 bush. beans 1 bush. peas 2 bush. spring oats (rate 4 bush. per acre)	April 6, drilled and harrowed in. Apr. 8 rolled. Ploughed up July 24	ditto ..	Sept. 10 (failed) resown Apr. 6, 1929.. ..	July 13 ..	July 23 ..	2 tons.

https://doi.org/10.23637/ERADOC-1-111

DATES OF SOWING AND HARVESTING AND YIELD PER ACRE, 1929.

Field.	Crop.	Variety.	Principal Cultivations and Dates.	Manuring. cwt. per acre.	Sowing Dates.	Cutting Dates.	Carting Dates.	Yield per acre.
Great Knott	Mustard ..		Mar. 14-21, tractor ploughed. Apr. 16, Mustard sown and harrowed in by tractor. June 22-29 ploughed in by tractor, twice disc scarified (June 29, Aug. 1) (Aug. 28)	25 tons St. Albans town refuse	Apr. 16	—	—	—
Long Hoos 1	Potatoes ..	Ally ..	see p. 99	—	—	—	—	see p. 99
2	Winter Oats	Grey ..	see p. 93	—	—	—	—	see p. 93
3	1 Year's Seeds	—	— —	—	—	—	—	—
4	Barley ..	Spratt Archer..	— —	—	—	—	—	—
		Plumage Archer	see p. 89	—	—	—	—	see p. 89
5	Sugar Beet ..	—	see p. 102	—	—	—	—	see p. 102
6	Wheat ..	—	see p. 95	—	—	—	—	see p. 95
Great Field	Grazing ..	—	May 23, tractor rolled and light harrowed	—	—	June 28-29 grass cut after grazing	July 8 ..	12-15 cwt.
Little Knott	½ pig grazing ½ hay after early grazing	—	Nov. 24, chain harrowed ..	1 acre had 2 Super., 2 M/ Pot., 1 S/Am.	—	—	July 8-9	20 cwt.
New Zealand	Grazing ..	—	Apr. 16, seeds harrowed in (tractor) and horse rolled	6 Basic Slag	Sept. 4 (1928) Apr. 16 ..	—	—	—
Stackyard..	Cut for Hay after grazing	—	Apr. 18, tractor rolled	6 Slag .. 8 tons F.Y.M.	—	—	—	12-15 cwt.
Sawyers * ..	Grazing ..	—	— —	—	—	—	—	—
Outer Great Knott ..	Grazing ..	—	Apr. 16 tractor rolled	—	—	—	—	—
West Barnfield	—	—	Apr. 17, tractor rolled	6 Slag ..	Aug. 29 (1928)	—	—	—
Fosters Corners ..	—	—	Apr. 17, tractor rolled	6 Slag ..	—	—	—	—
Broadbalk..	Wheat ..	Square-Head's Master ..	— —	—	Oct. 9 (1928)	Aug. 9	Aug. 17	see p. 87
Hoos ..	Barley ..	Plumage Archer Spratt Archer..	— —	—	Apr. 17-18	Aug. 29-30	Sept. 4-5	see p. 88
Barnfield ..	Mangolds ..	Prize Winner .. Yellow Globe ..	— —	—	Apr. 24-27	—	Oct. 16-30	see p. 85
Agdell ..	Barley ..	Plumage Archer	— —	—	Mar. 15	Aug. 19	Aug. 26	see p. 84
Park ..	Hay ..	—	— —	—	—	July 1-6	July 10-11	see p. 86

* 4 acres sown with Barley and undersown with Grass. Yield 8 qrs.

https://doi.org/10.23637/ERADOC-1-111

CROP YIELDS ON THE EXPERIMENTAL PLOTS.

NOTES.—In each case the year refers to the harvest, *e.g.*, Wheat 1929 means wheat harvested in 1929. 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 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 2240 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	

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, 1929.

	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.
1929.	Inches.	No.	Inches.	Inches.	Inches.	Hours.	°F.	°F.	°F.	°F.	°F.
Jan. ..	1.759	16	1.154	1.378	1.220	39.5	36.2	30.0	34.4	53.3	27.1
Feb. ..	0.789	8	0.708	1.006	0.931	67.2	35.5	25.9	33.8	70.3	21.0
Mar. ..	0.065	2	0.000	0.017	0.013	184.7	53.2	32.5	37.2	99.1	26.4
April...	1.613	12	0.140	0.240	0.217	155.1	50.6	35.6	43.3	102.4	30.9
May ..	3.065	13	0.852	1.101	1.017	261.0	60.4	42.7	50.8	119.9	37.7
June ..	1.023	11	0.002	0.030	0.031	226.5	63.7	48.3	57.4	124.8	43.9
July ..	1.417	10	0.001	0.006	0.006	243.7	70.8	51.9	61.5	129.4	47.1
Aug. ..	0.633	12	0.000	0.000	0.000	196.7	69.2	51.5	60.4	126.1	46.7
Sept. ..	0.246	2	0.000	0.000	0.000	206.0	72.0	52.0	61.0	119.9	46.4
Oct. ..	4.516	15	1.895	1.891	1.343	120.1	55.7	42.3	50.4	98.9	38.1
Nov. ..	6.561	20	5.931	6.093	5.790	78.0	48.8	37.5	42.9	79.8	33.1
Dec. ..	6.018	22	5.559	5.780	5.490	75.3	46.3	36.4	40.8	71.7	32.3
Total or Mean	27.705	143	16.242	17.542	16.058	1853.8	55.2	40.6	47.8	99.6	35.9

RAIN AND DRAINAGE.
MONTHLY MEAN FOR 59 HARVEST YEARS, 1870-1—1928-9.

	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. ..	2.398	0.818	0.792	0.729	34.1	33.0	30.4	1.580	1.606	1.669
Oct. ..	3.148	1.817	1.784	1.658	57.7	56.7	52.7	1.331	1.364	1.490
Nov. ..	2.781	2.104	2.158	2.031	75.7	77.6	73.0	0.677	0.623	0.750
Dec. ..	2.818	2.397	2.496	2.382	85.1	88.6	84.5	0.421	0.322	0.436
Jan. ..	2.408	1.970	2.168	2.068	81.8	90.0	85.9	0.438	0.240	0.340
Feb. ..	2.051	1.532	1.645	1.571	74.7	80.2	76.6	0.519	0.406	0.480
March ..	2.007	1.070	1.200	1.135	53.3	59.8	56.6	0.937	0.807	0.872
April ..	2.023	0.655	0.735	0.699	32.4	36.3	34.6	1.368	1.288	1.324
May ..	2.046	0.475	0.544	0.510	23.2	26.6	24.9	1.571	1.502	1.536
June ..	2.246	0.547	0.576	0.555	24.4	25.6	24.7	1.699	1.670	1.691
July ..	2.725	0.725	0.753	0.700	26.6	27.6	25.7	2.000	1.972	2.025
Aug. ..	2.648	0.703	0.716	0.672	26.5	27.0	25.4	1.945	1.932	1.976
Year ..	29.299	14.813	15.567	14.710	50.6	53.1	50.2	14.486	13.732	14.589

Area of each gauge 1/1000th acre.

CHEMICAL ANALYSES OF FERTILISERS USED IN REPLICATED EXPERIMENTS.

Fertiliser.	% N	% water-sol. P_2O_5	% K_2O	% Cl.
Sulphate of Ammonia	20.7-21.2	—	—	—
Muriate of Ammonia	26.0	—	—	—
Nitrate of Soda	15.0	—	—	—
Urea	45.8	—	—	—
Cyanamide	21.0-21.3	—	—	—
Ammonium Phosphate	12.2	61.6	—	—
Superphosphate	—	16.5	—	—
Potassium Phosphate (K_2HPO_4)	—	40.8	54.0	—
Sulphate of Potash	—	—	50.8	—
Muriate of Potash	—	—	52.6	48.8
Potash Manure Salts (30%) ..	—	—	31.9	50.9
Potash Manure Salts (20%) ..	—	—	17.7	46.6
Potash Mineral	—	—	16.2	—
Agricultural Salt	—	—	—	57.2

https://doi.org/10.23637/ERADOC-1-111

FIRST SERIES: CLASSICAL EXPERIMENTS OF LAWES AND GILBERT.

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 and 1929.							
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

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

https://doi.org/10.23637/ERADOC-1-111

MANGOLDS – BARNFIELD, 1929.

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

PRODUCE PER ACRE.

	Strip	Strip Manures. (Amounts stated as per acre.)	1929.					50-Year Average, 1876-1928†				
			Cross Dressings.					Cross Dressings.				
			O	N	A	AC	C	O	N	A	AC	C
			None.	Nitrate of Soda (550 lb.)	Sulphate of Ammonia (412 lb.)	Sulphate of Ammonia (412 lb.) and Rape Cake.	Rape Cake (2,000 lb.)	None.	Nitrate of Soda (550 lb.)	Sulphate of Ammonia (412 lb.)	Sulphate of Ammonia (412 lb.) and Rape Cake.	Rape Cake (2,000 lb.)
ROOTS.			Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
	1	Dung only (14 tons)	10.79	18.14	13.53	12.46	14.82	17.47	26.16	21.70	23.58	23.53
	2	Dung, Superphosphate (3½ cwt.), Sulphate of Potash (500 lb.)	11.05	20.54	18.57	19.96	19.83	18.94	26.68	24.71	27.57	26.50
	4	Complete Minerals : Superphosphate and Potash as 2, Salt (200 lb.), Sulphate of Magnesia (200 lb.)	3.77	(a) 17.42* (b) 18.13	14.03	20.67	15.91	4.60	(a) 18.11 ** (b) 17.81	14.37	26.06	20.96
	5	Superphosphate only (3½ cwt.)	3.31	14.98	7.60	4.71	6.36	4.47	14.63	6.70	9.49	10.16
	6	Superphosphate (3½ cwt.), Sulphate of Potash (500 lb.) ..	3.64	15.13	13.17	16.60	12.62	4.03	15.12	13.50	22.55	18.14
	7	Superphosphate (3½ cwt.), Sulphate of Magnesia (200 lb.) and Sodium Chloride (200 lb.)	3.30	15.94	13.30	14.01	12.86	4.86	16.04	14.70	22.31	19.10
	8	No Minerals	2.97	10.85	6.32	5.53	4.46	3.34	9.61	5.32	8.52	8.89
	9	Sodium Chloride (200 lb.), Nitrate of Soda (550 lb.), Sulphate of Potash (500 lb.) and Sulphate of Magnesia (200 lb.)	16.31	—	—	—	—	—	—	—	—	—
LEAVES.	1	Dung only (14 tons)	1.99	3.51	2.61	2.19	3.17	3.04	4.65	4.93	5.25	4.54
	2	Dung, Superphosphate (3½ cwt.), Sulphate of Potash (500 lb.)	1.97	4.34	3.52	4.20	4.11	3.16	5.15	5.49	6.29	4.80
	4	Complete Minerals : Superphosphate and Potash as 2, Salt (200 lb.), Sulphate of Magnesia (200 lb.)	0.89	(a) 3.34* (b) 3.56	2.54	3.94	2.70	1.04	(a) 4.05 ** (b) 4.09	2.88	5.33	3.37
	5	Superphosphate only (3½ cwt.)	0.92	3.11	1.96	2.09	1.72	1.05	3.19	2.61	3.29	2.84
	6	Superphosphate (3½ cwt.), Sulphate of Potash (500 lb.)	0.98	2.76	2.00	3.11	2.12	0.93	3.04	2.81	5.20	2.87
	7	Superphosphate (3½ cwt.), Sulphate of Magnesia (200 lb.) and Sodium Chloride (200 lb.)	1.08	3.23	2.63	3.75	2.65	1.10	3.31	3.01	5.23	3.31
	8	No Minerals	0.83	3.05	1.93	1.83	1.61	0.98	3.19	2.52	3.30	2.84
	9	Sodium Chloride (200 lb.), Nitrate of Soda (550 lb.), Sulphate of Potash (500 lb.), and Sulphate of Magnesia (200 lb.)	2.79	—	—	—	—	—	—	—	—	—

* From 1904 onwards plot 4N has been divided, 4 (a) receiving Sulphate of Potash, Sulphate of Magnesia, Sodium Chloride and Nitrate of Soda, amounts as above, 4 (b) receiving 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.

HAY—THE PARK GRASS PLOTS.

Plot.	Manuring (amounts stated are per acre).		1929. Yield of Hay per acre. 1st Crop.	1929. Yield of Hay per acre. 2nd† Crop.	1929. Yield of Hay per acre. Total.	1929. Dry Matter per acre. 1st Crop.	1929. Dry Matter per acre. 2nd Crop.	1929. Dry Matter per acre. 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	2.8	0.5	3.3	243	42	285	1
		limed ..	12.1	0.6	12.7	1081	53	1134	
2	Unmanured (after Dung 8 years, 1856-63) ..	not limed	7.1	0.3	7.4	644	31	675	2
		limed ..	8.2	0.4	8.6	703	37	740	
3	Unmanured	not limed	6.3	0.3	6.6	535	27	562	3
		limed ..	6.9	0.3	7.2	591	29	620	
4-1	Superphosphate of Lime (3½ cwt.)	not limed	10.2	0.4	10.6	846	33	879	4-1
		limed ..	7.4	0.4	7.8	652	32	684	
4-2	Superphosphate of Lime (3½ cwt.) and double dressing (412 lb.) Sulphate of Ammonia (=86 lb. N.)	not limed	1.0	0.6	1.6	86	52	138	4-2
		limed ..	24.1	1.5	25.6	2363	133	2496	
5-1	(N. half) Unmanured following double dressing Ammonia Salts (=86 lb. N.) 1856-97 ..	not limed	2.3	0.8	3.1	207	72	279	5-1
5-2	(S. half) Superphosphate (3½ cwt.); Sulphate of Potash (500 lb.), following double dressing Ammonia Salts (=86 lb. N.) 1856-97 ..	not limed	8.5	0.8	9.3	783	75	858	5-2
6	Complete Mineral Manure as Plot 7; following double dressing Ammonia Salts (=86 lb. N.) 1856-68	not limed	15.3	1.8	17.1	1345	158	1503	6
7	Complete Mineral Manure: Superphosphate (3½ cwt.); Sulphate of Potash (500 lb.); Sulphate of Soda (100 lb.); Sulphate of Magnesia (100 lb.)	not limed	15.1	1.7	16.8	1351	157	1508	7
		limed ..	30.9	0.8	31.7	2910	73	2983	
8	Mineral Manure without Potash	not limed	8.3	0.9	9.2	704	79	783	8
		limed ..	7.5	0.3	7.8	632	24	656	
9	Complete Mineral Manure and double dressing (412 lb.) Sulphate of Ammonia (=86 lb. N.)	not limed	0.9	0.1	1.0	77	11	88	9
		limed ..	45.8	0.8	46.6	4117	71	4188	
10	Mineral Manure (without Potash) and double dressing Ammonia Salts (=86 lb. N.) ..	not limed	2.4	0.1	2.5	205	7	212	10
		limed ..	32.1	1.4	33.5	3158	127	3285	
11-1	Complete Mineral Manure and treble dressing (618 lb.); Sulphate of Ammonia (129 lb. N.)	not limed	1.1	1.1	2.2	90	99	189	11-1
		limed ..	48.3	1.6	49.9	4473	142	4615	
11-2	As Plot 11-1 and Silicate of Soda..	not limed	7.8	5.6	13.4	641	499	1140	11-2
		limed ..	47.6	2.7	50.3	4374	244	4618	
12	Unmanured	not limed	7.7	0.7	8.4	682	62	744	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	24.2	3.2	27.4	2107	289	2396	13
		limed ..	22.4	1.4	23.8	1945	122	2067	
14	Complete Mineral Manure and double dressing (550 lb.) Nitrate of Soda (=86 lb. N.) ..	not limed	39.8	2.4	42.2	3519	219	3738	14
		limed (sun)	40.3	1.4	41.7	3444	124	3568	
		lmd (shade)	34.4	0.7	35.1	3051	61	3112	
15	Complete Mineral Manure as Plot 7, following double dressing Nitrate of Soda (=86 lb. N.) 1858-1875	not limed	14.5	1.4	15.9	1222	125	1347	15
		limed ..	22.4	0.5	22.9	2081	45	2126	
16	Complete Mineral Manure and single dressing (275 lb.) Nitrate of Soda (=43 lb. N.) ..	not limed	23.1	1.8	24.9	2540	158	2698	16
		limed ..	23.6	1.4	25.0	2343	123	2466	
17	Single dressing (275 lb.) Nitrate of Soda (=43 lb. N.)	not limed	12.9	0.9	13.8	1071	78	1149	17
		limed ..	16.7	0.7	17.4	1471	65	1536	
18	Mineral Manure (without Superphosphate), and double dressing Sulphate of Ammonia (=86 lb. N.), 1905 and since; following Minerals and Ammonia Salts supplying the constituents of 1 ton of Hay, 1865-1904	not limed	2.7	0.3	3.0	236	27	263	18
		limed (6788 lb.)	36.9	1.1	38.0	3295	102	3397	
		limed (3951 lb.)	28.8	1.0	29.8	2542	92	2634	
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	16.5	1.3	17.8	1554	118	1672	19
		limed 3150 lb.)	15.2	0.7	15.9	1422	64	1486	
		limed (570 lb.)	16.5	0.9	17.4	1541	84	1625	
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	28.1	1.3	29.4	2676	117	2793	20
		limed (2772 lb.)	25.1	1.1	26.2	2287	94	2381	
		limed .. (570 lb.)	25.1	1.2	26.3	2328	112	2440	

Ground Lime was applied to the southern portion (Limed) of the plots at the rate of 2000 lb. to the acre in the Winters of 1903-4, 1907-8, 1915-16, 1923-24, 1927-28, and at the rate of 2500 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.

WHEAT—BROADBALK FIELD.

Plot.	Manurial Treatment. (amounts stated are per acre).	1929 (Upper or Western Part) second year after fallow.							74-year Average 1852-1925 (Prior to fallow).	
		Dressed Grain			Offal Grain per acre.	Straw per acre.	Total † Straw per acre.	Proportion of Total Grain to 100 of Total Straw.	Dressed Grain per acre.	Total Straw per acre.
		Yield per acre.	Weight per bushel.	Yield per acre.						
		bushels.	lb.	cwt.	lb.	lb.	cwt.		bushels.	cwt.
2A	Farmyard Manure (14 tons)	23.3	61.3	12.7	120	2557	28.9	47.7	26.8**	32.1**
2B	Farmyard Manure (14 tons)	30.0	63.0	16.9	95	3579	40.1	44.2	33.5	34.2
3	Unmanured since 1839	9.1	60.5	4.9	49	855	11.1	48.3	11.7	9.8
5	Complete Mineral Manure §§	9.1	60.5	4.9	40	762	9.4	56.4	13.5	11.5
6	As 5, and 206 lb. Sulphate of Ammonia	17.7	61.8	9.8	55	1730	19.0	54.4	21.7	20.3
7	As 5, and 412 lb. Sulphate of Ammonia	20.9	61.3	11.4	89	3585	39.1	33.6	30.4	32.1
8	As 5, and 618 lb. Sulphate of Ammonia	15.9	59.7	8.5	128	5288	57.6	17.3	34.5	39.8
9	As 5, and 275 lb. Nitrate of Soda	21.6	61.4	11.9	96	2905	31.5	40.4	18.8††	24.6††
10	412 lb. Sulphate of Ammonia	24.7	61.4	13.6	117	3048	33.6	43.6	18.7	17.8
11	As 10, and Superphosphate (3½ cwt.)	19.0	60.8	10.3	109	2600	29.2	39.3	21.3	21.4
12	As 10, and Super. (3½ cwt.) and Sulph. Soda (366 lb.) ..	22.9	61.1	12.5	124	3147	34.4	39.8	27.0	26.8
13	As 10, and Super (3½ cwt.) and Sulph. Potash (200 lb.) ..	25.6	61.6	14.1	103	3348	35.7	42.3	29.2	30.6
14	As 10, and Super. (3½ cwt.) and Sulph. Magnesia (280 lb.)	23.4	61.1	12.8	101	2949	32.2	42.9	26.7	26.8
15	As 5, and 412 lb. Sulphate of Ammonia all applied in Autumn	28.8	61.1	15.7	108	3262	36.6	45.5	27.8	28.2
16	As 5, and 550 lb. Nitrate of Soda	26.3	61.4	14.5	137	4079	44.8	36.3	29.9††	35.2††
17	Minerals alone as 5 or 412 lb. Sulphate of Ammonia alone	M 6.8	60.4	3.7	54	716	9.0	45.9	A27.8	27.7
18	in alternate years	A18.2	61.4	10.0	88	2236	24.5	44.5	M14.1	12.5
19	Rape Cake (1889 lb.)	26.1	61.6	14.3	97	2801	31.2	48.8	20.8‡	22.0‡
20	As 7, without Super.	29.9	61.5	16.4	84	3407	36.2	47.4	16.5§	18.6§

† Includes straw, cavings and chaff. 1929, bottom portion fallowed.
** 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, the upper part 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 was sown with wheat, and again in 1928, the yields for 1929 being given above.

PERMANENT BARLEY PLOTS.
Hoos Field, 1929.

Plot.	Manuring. (Amounts stated are per acre.)	Grain, per acre. Plumage Archer Cwt.	Grain, per acre. Spratt Archer Cwt.	76 Years' Average 1852-1928 Dressed Grain per acre bush.‖	Straw, per acre. Plumage Archer Cwt.	Straw, per acre. Spratt Archer Cwt.	76 Years' Average 1852-1928 Total Straw per acre cwt.†
1O	Unmanured	2.4	2.5	13.4	1.9	2.0	7.8
2O	Superphosphate only (3½cwt.) ..	5.0	4.8	19.0	3.8	3.7	9.8
3O	Alkali Salts only (200lb. Sulphate of Potash; 100lb. Sulphate of Soda; 100 lb. Sulphate of Magnesia).	3.9	3.8	14.3	3.2	3.4	8.7
4O	Complete Minerals; as 3O with Superphosphate (3½ cwt.)	6.2	7.3	19.0	5.4	5.9	11.2
5O	Potash (200 lb.) and Superphosphate (3½ cwt.)	3.0	2.9	15.5	3.7	4.3	9.4
1A	Ammonium Salts only (206 lb. Sulphate of Ammonia)	1.8	1.9	23.7	1.5	1.4	13.7
2A	Superphosphate and Amm. Salts ..	8.7	9.0	35.8	7.4	7.4	20.4
3A	Alkali Salts and Amm. Salts ..	3.6	2.3	25.8	3.9	2.4	16.0
4A	Complete Minerals and Amm. Salts	10.0	9.4	39.3	8.7	7.9	23.6
5A	Potash, Super. and Amm. Salts ..	4.4	4.4	33.8	5.5	4.5	21.7
1AA	Nitrate of Soda only (275 lb.) ..	3.5	2.7	24.3*	3.3	2.6	15.4*
2AA	Superphosphate and Nitrate of Soda	10.9	11.2	38.8*	8.0	10.4	23.1*
3AA	Alkali Salts and Nitrate of Soda ..	3.7	4.3	24.5*	3.7	4.3	16.6*
4AA	Complete Minerals and Nitrate of Soda	**10.1**	9.2	37.7*	**9.1**	8.8	23.6*
1AAS	As Plot 1AA and Silicate of Soda (400 lb.)	2.6	2.4	30.2*	2.4	2.3	18.2*
2AAS	As Plot 2AA and Silicate of Soda (400 lb.)	11.4	11.3	39.7*	8.0	8.0	23.9*
3AAS	As Plot 3AA and Silicate of Soda (400 lb.)	4.0	5.5	31.2*	4.1	4.9	19.9*
4AAS	As Plot 4AA and Silicate of Soda (400 lb.)	10.0	11.1	39.9*	10.3	9.9	25.4*
1C	Rape Cake only (1000 lb.).. ..	3.5	4.5	35.5	2.8	4.5	20.6
2C	Superphosphate and Rape Cake ..	8.1	9.8	38.1	7.5	8 7	22.0
3C	Alkali Salts and Rape Cake ..	5.4	6.2	33.7	5.0	5.3	20.4
4C	Complete Minerals and Rape Cake	8.1	11.0	37.5	9.3	9.8	22.6
7-1	Unmanured (after dung (14 tons) for 20 years 1852-71)	6.0	5.9	22.5‡	5.5	5.1	13.5‡
7-2	Farmyard Manure (14 tons) ..	14.8	15.1	44.6	14.3	13.4	28.1
6-1	Unmanured since 1852	2.6	3.7	14.7	2.8	3.2	8.6
6-2	Ashes from Laboratory furnace ..	2.7	3.3	15.7	2.3	3.1	9.3
1N	Nitrate of Soda only (275 lb.) ..	1.3	2.1	28.7§	2.5	3.1	17.8§
2N	Nitrate of Soda only (275 lb.) ..	3.8	4.2	31.7§§	4.0	4.2	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.

The field this year was sown across by the half-drill strip method in wide spaced drills to facilitate cleaning operations. Total sheaf weight only was taken and the Grain/Straw ratio determined in samples; Grain and Straw per acre being determined from this ratio. The sample for Plot 4AA (Plumage Archer) was lost, and the figures given in heavy type are derived from the (logarithmic) average Grain/Straw ratio for the seven remaining Plots in Series AA and AAS.

Second Series: Replicated Experiments.

Barley : Comparison of Nitrogenous Fertilisers, Sulphate and Muriate of Ammonia, Urea and Cyanamide, each used in single and double dressings.

Effect of Superphosphate and Sulphate of Potash.

Long Hoos (Section 4), 1929.

A. Single Dressing. W. **B. Double Dressing.**

I.	N	C	O	M	S	I.	N	U	M	S	C
II.	O	M	S	C	N	II.	S	C	N	M	U
II.	S	O	C	N	M	III.	M	S	U	C	N
IV.	M	S	N	O	C	IV.	C	N	S	U	M
V.	C	N	M	S	O	V.	U	M	C	N	S

System of Replication : 2 Latin Squares.
Area of Each Plot : 1/40th acre.
Testing Sulphate (S) and Muriate (M) of Ammonia, Cyanamide (C), Urea (U) and Nitrate of Soda (N).
Rates : 0.2 and 0.4 cwt. of N per acre. Single Urea replaced by No Nitrogen.
Each Plot divided into 4 sub-plots each 1/160th acre, for the treatments—(1) No Potash or Phosphate, (2) Sulphate of Potash (.6 cwt. K_2O per acre), (3) Superphosphate (.4 cwt P_2O_5 per acre), (4) Sulphate of Potash and Superphosphate.
Yields of sub-plots estimated by sampling method only.
Barley sown : March 12. Harvested : August 10.
Variety : "Plumage Archer" (3-4 bushels per acre). Manures applied : March 14-16.
Previous Crop : Barley.

Actual Weights in lb. Per Whole Plot.

	Grain.									
	Single Dressing.					Double Dressing.				
Row.	O	S	M	N	C	U	S	M	N	C
I.	51.50	64.50	62.25	75.50	56.75	64.25	59.50	66.00	79.25	63.00
II.	59.00	59.75	57.50	71.25	66.50	69.75	77.00	69.50	77.00	71.75
III.	55.75	66.25	75.25	64.50	69.75	75.50	71.50	82.75	72.75	75.50
IV.	63.00	61.75	66.50	76.50	75.00	66.00	77.50	69.50	80.50	79.25
V.	51.50	71.25	68.75	71.25	63.00	80.25	67.75	78.75	80.25	78.50
	Straw.									
I.	47.25	66.75	60.00	81.50	58.75	57.75	58.50	61.50	74.00	62.50
II.	62.00	57.50	57.25	79.75	65.50	70.25	70.75	71.50	81.75	71.75
III.	51.00	81.50	72.75	65.00	66.25	69.50	68.50	83.00	75.25	76.50
IV.	64.50	57.75	65.25	78.00	75.75	63.00	73.25	68.25	79.75	80.50
V.	59.75	70.75	68.25	70.00	62.75	76.00	77.75	72.75	73.00	67.75

Barley: Long Hoos, 1929 (contd.)

Summary of Results by the usual Threshing Method.—Nitrogenous Comparisons.

A. Single Dressing.

	No Nitrogen.	Sulphate of Amm.	Muriate of Amm.	Nitrate of Soda.	Cyana-mide.	Mean.	Standard Error.
Grain, cwt. per acre	20.1	23.1	23.6	25.6	23.6	23.2	0.88
Grain, per cent. ..	86.4	99.6	101.6	110.5	101.9	100.0	3.79
Straw, cwt. per acre	20.3	23.9	23.1	26.7	23.5	23.5	1.06
Straw, per cent. ..	86.4	101.6	98.3	113.7	100.0	100.0	4.49

Significant response to all nitrogenous manures with both grain and straw. The yield on the Nitrate of Soda plots was significantly better than the mean yield of the plots receiving the other three dressings.

B. Double Dressing.

	Urea.	Sulphate of Amm.	Muriate of Amm.	Nitrate of Soda.	Cyana-mide.	Mean.	Standard Error.
Grain, cwt. per acre	25.4	25.2	26.2	27.8	26.3	26.2	0.44
Grain, per cent. ..	97.0	96.3	100.0	106.3	100.4	100.0	1.68
Straw, cwt. per acre	24.0	24.9	25.5	27.4	25.6	25.5	0.71
Straw, per cent. ..	94.3	97.7	100.0	107.5	100.6	100.0	2.80

Plots treated with Nitrate of Soda gave significantly higher yield than all the others.

https://doi.org/10.23637/ERADOC-1-111

Summary of Results by Sampling Method.
Table of Separate Yields.

	A. Single Dressing.					
Grain, cwt. per acre.	No Nitrogen.	Sulphate of Ammonia.	Muriate of Ammonia.	Nitrate of Soda.	Cyanamide.	Standard Errors.
Without Phosphate and Potash	19.5	25.4	24.2	23.5	22.9	1.40
With Superphosphate	21.5	24.3	23.9	26.0	19.1	
With Sulphate of Potash ..	21.5	20.5	22.6	25.2	23.8	
With Potash and Phosphate ..	20.1	24.3	23.4	24.1	22.5	
Mean	20.7	23.6	23.5	24.7	22.1	0.57
Straw, cwt. per acre.						
Without Phosphate and Potash	19.1	25.7	25.7	23.6	23.7	1.57
With Superphosphate	21.6	24.3	23.3	26.4	19.6	
With Sulphate of Potash ..	21.6	20.5	22.6	27.2	24.0	
With Potash and Phosphate ..	20.4	24.3	24.7	25.7	23.1	
Mean	20.7	23.7	24.1	25.7	22.6	1.42

	B. Double Dressing.					
Grain, cwt. per acre.	Urea.	Sulphate of Ammonia.	Muriate of Ammonia.	Nitrate of Soda.	Cyanamide.	Standard Errors.
Without Phosphate and Potash	25.8	26.0	26.8	28.3	29.6	1.26
With Superphosphate	25.0	29.1	25.5	29.6	27.6	
With Sulphate of Potash ..	23.7	24.2	27.6	26.6	26.5	
With Potash and Phosphate ..	25.1	24.8	25.8	27.2	26.3	
Mean	24.9	26.0	26.4	27.9	27.5	0.83
Straw, cwt. per acre.						
Without Phosphate and Potash	25.5	25.4	25.9	28.9	32.1	1.41
With Superphosphate	25.1	29.3	24.4	29.6	30.9	
With Sulphate of Potash ..	24.0	23.2	27.1	28.3	27.9	
With Potash and Phosphate ..	26.3	24.3	24.3	27.6	27.4	
Mean	25.3	25.6	25.4	28.6	29.6	0.91

Barley: Long Hoos, 1929 (contd.)

Potassic and Phosphatic Comparisons.—(Yields Estimated by Sampling).

A. Single Dressing (including No Nitrogen).

GRAIN.	Average Yield in cwt. per acre.		Average Yield per cent.	
	Without Phosphate.	With Phosphate.	Without Phosphate.	With Phosphate.
Without Sulphate of Potash.. ..	23.1	23.0	100.8	100.2
With Sulphate of Potash	22.7	22.9	99.1	99.9

Mean—22.9.
Standard Error—0.63 or 2.74%

STRAW.	Average Yield in cwt. per acre.		Average Yield per cent.	
	Without Phosphate.	With Phosphate.	Without Phosphate.	With Phosphate.
Without Sulphate of Potash.. ..	23.6	23.0	100.8	98.6
With Sulphate of Potash	23.2	23.7	99.2	101.3

Mean—23.4. Standard Error—0.70 or 3.00%.

No significant effects of Phosphate or Potash with grain or straw.

B. Double Dressing.

GRAIN.	Average Yield in cwt. per acre.		Average Yield per cent.	
	Without Phosphate.	With Phosphate.	Without Phosphate.	With Phosphate.
Without Sulphate of Potash.. ..	27.3	27.4	102.8	103.0
With Sulphate of Potash	25.7	25.8	96.8	97.3

Mean—26.6. Standard Error—0.57 or 2.13%.

STRAW	Average Yield in cwt. per acre.		Average Yield per cent.	
	Without Phosphate.	With Phosphate.	Without Phosphate.	With Phosphate.
Without Sulphate of Potash.. ..	27.6	27.9	102.5	103.6
With Sulphate of Potash	26.1	26.0	97.1	96.8

Mean—26.9. Standard Error—0.63 or 2.34%.

With both grain and straw Potash has depressed the yield significantly, while Phosphate has been ineffective.

https://doi.org/10.23637/ERADOC-1-111

Winter Oats : Comparison of Nitrogenous Fertilisers, Sulphate of Ammonia and Cyanamide, in all combinations of Autumn and Spring dressings.

Long Hoos (Section 2), 1929.

W

A								B								C							
4	2	13	16	3	11	9	1	2	3	4	5	9	1	11	7	5	8	7	13	3	12	10	9
10	7	5	6	14	12	15	8	12	6	10	15	14	13	16	8	2	14	16	6	4	11	15	1

System of Replication :—3 randomised blocks of 16 plots each.

Area of Each Plot : 1/40th acre.

Unit dressing at a rate equivalent to $\frac{3}{4}$ cwt. Cyanamide per acre.

System of Manuring : All combinations of Sulphate of Ammonia and equivalent Cyanamide, applied in Autumn and Spring, as shown in key to treatments.

Sulphate of Ammonia applied : September 24, March 19.

Cyanamide applied : September 14, March 18.

Variety : Grey Winter.

Sown : September 24.

Harvested : August 7.

Previous Crop : Barley.

Key to Treatments.

Spring Dressings.

Autumn Dressings	None.	Sulphate.	Cyanamide.	Both.
None ..	1	4	5	10
Sulphate	2	6	7	12
Cyanamide	3	9	11	15
Both ..	8	13	14	16

Actual Weight in lb.—Total Grain.

Blocks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	37.75	34.75	34.75	32.50	35.75	37.25	34.50	31.50	43.00	25.00	41.50	26.00	37.00	34.00	32.50	40.50
B	42.50	40.75	39.50	36.75	40.25	30.75	44.50	45.00	38.50	32.50	51.25	31.00	37.25	29.75	41.50	40.50
C	39.25	42.75	34.75	38.25	40.50	30.75	37.50	37.75	31.00	27.00	40.50	31.25	38.00	44.00	32.50	37.25

Actual Weight in lb.—Total Straw.

Blocks.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	63.75	68.75	57.75	53.50	66.25	71.00	74.25	71.00	78.50	62.50	76.75	69.75	86.50	69.75	73.25	83.75
B	66.75	61.50	66.25	68.75	75.00	68.00	87.50	73.25	86.75	73.50	81.25	78.25	79.75	79.25	77.50	81.25
C	58.50	69.75	53.75	71.50	77.50	78.25	68.00	64.75	72.00	62.75	65.75	63.25	73.00	74.25	72.25	76.25

Summary of Results.

		Grain—cwt. per acre.					Grain—per cent.				
Average Yield.		Spring Dressings.				Mean.	Spring Dressings.				Mean.
		None.	Sulphate.	Cyanamide.	Both.		None.	Sulphate.	Cyanamide.	Both.	
Autumn Dressings.	None ..	14.2	12.8	13.9	10.1	12.7	108.4	97.5	105.7	76.7	97.1
	Sulphate ..	14.1	11.8	13.9	10.5	12.5	107.3	89.6	105.7	80.1	95.7
	Cyanamide ..	13.0	13.4	15.9	12.7	13.7	98.9	102.1	120.9	96.6	104.6
	Both ..	13.6	13.4	12.8	14.1	13.5	103.7	101.8	97.8	107.3	102.6
	Mean ..	13.7	12.8	14.1	11.8	13.1	104.6	97.8	107.5	90.2	100.0

Standard Error—0.84 cwt. or 6.39 per cent.

Winter Oats : Long Hoos, 1929 (contd.)

Straw—cwt. per acre. Average Yield.		Spring Dressings. None.	Sul-phate.	Cyan-amide.	Both.	Mean.	Straw—per cent. Spring Dressings. None.	Sul-phate.	Cyan-amide.	Both.	Mean.
Autumn Dressings.	None ..	22.5	23.1	26.0	23.7	23.8	88.1	90.3	102.0	92.6	93.2
	Sulphate ..	23.8	25.9	27.3	25.1	25.5	93.2	101.3	107.1	98.5	100.0
	Cyanamide	21.2	28.2	26.6	26.5	25.6	82.8	110.6	104.3	103.9	100.4
	Both ..	24.9	28.5	26.6	28.7	27.2	97.4	111.5	104.0	112.4	106.4
	Mean ..	23.1	26.4	26.6	26.0	25.5	90.4	103.4	104.3	101.9	100.0

Standard Error—1.16 cwt. or 4.56 per cent.

With grain there was a significant depression where Sulphate of Ammonia was applied in Spring, which was materially less on the plots that had had Autumn Cyanamide. The yield was depressed by the application of Spring Cyanamide to those plots which did not receive Cyanamide in the Autumn; those which had Autumn Cyanamide responded moderately to the Spring Cyanamide.

With straw there were significant responses to all four single dressings, but no further response to the double dressing. The interaction of Autumn Cyanamide and Spring Sulphate was significant, in that the response to Autumn Cyanamide only appeared on the plots that were dressed with Sulphate in the Spring, while on the other hand, the response to Spring Sulphate was only evident on the plots that had been previously dressed with Autumn Cyanamide.

https://doi.org/10.23637/ERADOC-1-111

WHEAT.

VARIETY TRIAL.

Nitrogenous Fertilisers as Top Dressing: Sulphate of Ammonia. Muriate of Ammonia.

Each in single and double dressings.

Long Hoos (Section 6), 1929.

W

	Ml, Sq, Y, Sw	Sw, Y, Sq, Ml	Sq, Y, Ml, Sw	Sq, Sw, Ml, Y	Ml, Sq, Y, Sw	Sw, Ml, Sq, Y	Y, Ml, Sw, Sq	Ml, Y, Sw, Sq
C	S, E & L	O1	O2	M, L	M, E & L	M, E	S, L	S, E
B	M, L	S, E	S, L	S, E & L	M, E	O1	O2	M, E & L
A	S, E	M, E & L	S, L	S, E & L	M, L	M, E	O1	O2

System of Replication: 3 randomised blocks of 32 plots each.
Area of Each Plot: 6/325th acre.
S=Sulphate of Ammonia } at the rate of 0.2 cwt.
M=Muriate of Ammonia } Nitrogen per acre.
O1, O2=No Top Dressing.
E=Early Application (March 18).
L=Late Application (May 13).
E & L=Early and Late Application, thus giving double dressing.

Strips running across the blocks were allotted to 4 varieties as indicated in plan.
Ml=Million III.
Y=Yeoman II.
Sq=Square-Head's Master.
Sw=Swedish Iron.
Wheat Sown: October 3. 1928.
Harvested: August 26, 1929.
Previous Crop: Barley.

Actual Weights in lb.—Total Grain.

Variety.	Blocks.	O1.	O2.	S.E.	S.L.	M.E.	M.L.	S. E. & L.	M. E & L.
Million III. ..	A B C	31.25 29.50 39.25	28.75 25.75 31.75	51.00 43.50 27.00	32.75 35.75 30.75	36.00 35.75 35.25	34.00 52.00 31.00	29.25 32.25 59.25	47.25 29.00 30.25
Average in cwt. per acre		15.0		19.6	16.0	17.2	18.9	19.5	17.2
Yeoman II ..	A B C	29.50 26.50 40.50	28.00 25.00 37.25	53.50 42.50 28.00	40.25 40.75 27.00	35.25 33.50 25.50	33.25 49.75 30.75	31.00 32.50 57.00	44.25 33.75 31.25
Average in cwt. per acre		15.1		20.0	17.4	15.2	18.3	19.4	17.6
Square-Head's Master ..	A B C	29.75 25.25 35.00	29.50 28.00 37.75	44.50 41.50 35.75	40.25 39.00 27.25	36.25 36.25 22.50	32.50 46.75 35.50	38.25 37.00 49.00	41.25 36.75 32.25
Average in cwt. per acre		14.9		19.6	17.2	15.3	18.5	20.0	17.8
Swedish Iron ..	A B C	34.00 32.25 41.00	34.00 31.50 35.25	54.50 47.00 34.00	40.00 43.75 35.00	35.25 31.25 32.00	31.50 51.25 36.75	37.50 36.75 55.50	56.75 35.25 25.75
Average in cwt. per acre		16.8		21.8	19.1	15.9	19.3	20.9	19.0

Wheat : Long Hoos, 1929 (contd.).

Actual Weights in lb.—Total Straw.

Variety.	Blocks.	O1	O2.	S.E.	S.L.	M.E.	M.L.	S. E & L.	M. E & L.
Million III ..	A B C	43.25 43.25 60.75	37.25 36.50 47.75	65.75 62.25 43.75	48.00 50.00 51.50	52.50 54.00 58.50	49.00 66.75 51.75	52.75 55.75 86.25	66.50 48.75 59.25
Average in cwt. per acre		21.7		27.7	24.1	26.6	27.0	31.4	28.1
Yeoman II ..	A B C	34.50 34.50 55.00	37.50 36.25 53.00	69.00 56.50 44.75	54.00 57.50 43.00	51.50 51.25 45.00	46.00 62.50 50.75	52.00 54.50 84.50	46.75 57.50 64.75
Average in cwt. per acre		20.2		27.4	24.9	23.8	25.7	30.8	27.2
Square-Head's Master ..	A B C	41.75 35.25 55.25	45.25 40.50 60.75	63.00 64.75 62.75	56.50 63.25 43.75	55.75 54.75 58.75	57.25 62.75 61.75	63.50 64.00 80.00	63.00 57.75 62.25
Average in cwt. per acre		22.5		30.7	26.4	27.3	29.3	33.4	29.5
Swedish Iron ..	A B C	45.75 43.00 57.25	47.25 41.25 52.25	81.00 66.50 54.25	55.25 60.00 57.25	50.00 48.00 56.50	40.75 69.50 59.50	61.25 63.75 86.50	79.75 58.00 56.50
Average in cwt. per acre		23.1		32.5	27.8	24.9	27.4	34.1	31.3

Summary of Results.—(a) Effect of Top Dressing.

Grain.	No Nitrogen	Sulphate Early	Sulphate Late.	Muriate Early.	Muriate Late.	Sulphate Early and Late.	Muriate Early and Late.	Mean.	Standard Error.
Cwt. per acre Per cent. ..	15.4 87.6	20.3 114.9	17.4 98.9	15.9 90.2	18.7 106.3	20.0 113.2	17.9 101.4	17.6 100.0	2.29 12.98
Straw.									
Cwt. per acre Per cent. ..	21.9 81.9	29.6 110.8	25.8 96.6	25.6 96.1	27.3 102.4	32.4 121.5	29.0 108.8	26.7 100.0	2.33 8.74

Summary of Results.—(b) Varietal Response.

Grain.	Million III.	Yeoman II.	Square-Head's Master.	Swedish Iron.	Mean.	Standard Error.
Cwt. per acre .. Per cent. ..	17.3 98.1	17.3 97.9	17.3 98.0	18.7 106.0	17.6 100.0	0.35 1.98
Straw.						
Cwt. per acre .. Per cent. ..	26.0 97.5	25.0 93.8	27.7 103.7	28.0 105.0	26.7 100.0	0.54 2.04

Yield of Swedish Iron significantly greater than that of other varieties in grain, while Square-Head's Master and Swedish Iron are superior in straw. Significant responses to both early and late top dressings in the case of straw, but with grain, while numerically large, the responses are insignificant on account of the high Standard Error. Sulphate appears to do better than Muriate, but the difference is not significant.

https://doi.org/10.23637/ERADOC-1-111

CULTIVATION EXPERIMENT.

Barley, Great Harpenden, 1929.

OLD SET.

E

I.				II.				III.				IV.			
A	B	C	D	B	D	A	C	C	A	D	B	D	C	B	A

TREATMENTS :—
A = Ridged Seed bed.
B = Simar rototiller, then ridged.
C = Simar rototiller, but left flat.
D = Simar rototiller, left flat, and Simar implement used again between rows in July.

SYSTEM OF REPLICATION : 4 randomised blocks of 4 plots each.
Area harvested of each Plot : 1/40th acre.
Barley sown : March 14.
Harvested : August 7-8.
VARIETY : " Standwell," 3-4 bushels per acre.

These were treatments in 1928—no further treatments in 1929. Whole ploughed March 12-13. All plots had dressing of 1 cwt. Sulphate of Ammonia, 2 cwt. Superphosphate and 1 cwt. Muriate of Potash per acre, applied March 27.
Previous Crop : Swedes.

Actual Weights in lb.

Blocks.	Grain.				Straw.			
	A	B	C	D	A	B	C	D
I. ..	74.50	69.75	76.25	79.00	97.50	85.25	102.75	125.00
II. ..	70.75	74.75	59.25	82.50	95.25	109.25	90.75	115.50
III. ..	75.00	75.50	69.25	83.25	97.50	111.50	85.75	114.25
IV. ..	84.50	85.25	73.50	73.25	101.50	111.25	96.50	106.75
Total ..	304.75	305.25	278.25	318.00	391.75	417.25	350.75	461.50

Summary of Results.

Average Yield.	1928 Treatment.				Mean.	Standard Error.
	Ridged.	Simar and Ridged.	Simar and Flat.	Simar flat and Simar.		
Grain, cwt. per acre ..	27.2	27.2	24.8	28.4	26.9	1.11
Grain, per cent. ..	101.1	101.2	92.3	105.5	100.0	4.13
Straw, cwt. per acre ..	35.0	37.2	33.5	41.2	36.7	1.71
Straw, per cent. ..	95.2	101.4	91.3	112.1	100.0	4.67

The plots doubly Simared in 1928 have given a significantly higher yield of straw than the others, but the advantage in grain is not significant.

CULTIVATION EXPERIMENT.

Barley, Great Harpenden, 1929.

NEW SET.

I.				II.				III.				IV.			
E	F	G	H	F	H	E	G	G	E	H	F	H	G	F	E

E

TREATMENTS :—
E and G = Ordinary Spring Cultivation, March 11.
F and H = Simar Spring Cultivation, March 11.
All plots had dressing of 1 cwt. Sulphate of Ammonia, 2 cwt. Superphosphate and 1 cwt. Muriate of Potash per acre applied March 27.
Previous Crop : Swedes.

SYSTEM OF REPLICATION :—4 randomised blocks of 4 plots each.
Area harvested of each plot : 1/40th acre.
Barley sown : March 14.
Harvested : August 7-8.
VARIETY : " Standwell," (3-4 bushels per acre).

Actual Weights in lb.

Blocks.	Grain.				Straw.			
	E	G	F	H	E	G	F	H
I. ..	91.75	83.25	80.50	77.75	128.25	134.75	109.00	137.75
II. ..	80.50	90.75	83.00	83.75	143.50	120.25	126.00	127.25
III. ..	84.50	76.50	84.25	85.25	122.00	109.50	111.25	122.75
IV. ..	89.75	86.50	90.75	85.25	124.25	124.00	129.25	116.25
Total ..	346.50	337.00	338.50	332.00	518.00	488.50	475.50	504.50
	683.5		670.5		1006.5		980.0	

Summary of Results.

Average Yield.	Ordinary Spring Cultivation.	Simar Spring Cultivation	Mean.	Standard Error.
Grain, cwt. per acre ..	30.5	29.9	30.2	0.57
Grain, per cent.	101.0	99.0	100.0	1.90
Straw, cwt. per acre ..	44.9	43.7	44.3	1.19
Straw, per cent.	101.3	98.7	100.0	2.69

The difference in yield is not significant.

POTATOES.

Nitrogenous Fertiliser: Sulphate of Ammonia.

Potassic Fertilisers: Sulphate and Muriate of Potash and Potash Manure Salts (30%).

Each in single and double dressings.

Superphosphate.

Long Hoos (Section 1), 1929.

W

		G			D			A		
	— 5M	9P —	— 8S	— 6M	— 8P	— 5P	9S —	4M —	— 7P	
	3 —	— 2	4P —	— 3	9M —	7S —	3 —	— 1	2 —	
	7M —	6S —	— 1	1 —	— 2	4S —	— 8M	6P —	5S —	
	— 4M	5S —	— 6P	— 6S	9P —	— 2	8P —	— 4S	3 —	
H	3 —	— 9S	8M —	— 8S	— 4P	— 5M	— 5P	1 —	— 6M	B
	— 2	7P —	1 —	— 3	1 —	7M —	2 —	— 7S	9M —	
	4S —	— 1	8P —	— 8M	— 3	— 6P	— 5M	8S —	2 —	
	5P —	9M —	6M —	— 1	— 9S	— 2	1 —	— 9P	— 4P	
	— 7S	— 2	3 —	— 4M	7P —	5S —	— 7M	3 —	6S —	
		I			F			C		

Key to Treatments.

Treatment No.	1	2	3	4	5	6	7	8	9
S/Ammonia	0	1	2	0	1	2	0	1	2
Potash ..	0	0	0	1	1	1	2	2	2

SYSTEM OF REPLICATION : 9 randomised blocks of 9 plots each. Each plot divided into 2 sub-plots.

AREA OF EACH SUB-PLOT : 1/90th acre.

TREATMENTS : Sulphate of Ammonia at the rate of 0, 0.3 and 0.6 cwt. Nitrogen per acre, and Potash at the rate of 0, 0.5 and 1.0 cwt. K_2O per acre in all combinations as shown in Key to Treatments.

S=Sulphate of Potash.

M=Muriate of Potash.

P=Potash Manure Salts (30%).

Superphosphate at the rate of 0.4 cwt. P_2O_5 per acre is applied to one out of each pair of sub-plots, indicated by the treatment symbol occurring on that half.

All plots received Farmyard Manure at the rate of 14 tons per acre, approximately, ploughed in January 5-9.

Artificials applied : April 12-15.

Potatoes planted : April 16-24. Lifted : September 23-25.

VARIETY : Ally.

Previous Crop : Barley.

Potatoes : Long Hoos, 1929 (contd.)

Actual Weights in lb.—Sub-Plots with Phosphate.

S/Amm.	Potash.	A	B	C	D	E	F	G	H	I
Quantities										
0	0	111.00	121.00	127.00	123.75	106.00	124.75	121.25	105.50	133.25
0	1	105.75	110.75	117.50	140.25	123.00	118.50	128.00	140.50	138.75
0	2	89.25	126.25	109.25	119.25	112.00	153.50	133.50	112.25	141.00
1	0	121.25	138.25	118.00	137.75	155.50	118.75	148.50	154.50	144.00
1	1	140.00	145.50	153.00	121.75	152.50	140.00	170.00	145.50	154.00
1	2	153.25	164.00	145.50	131.25	141.25	152.25	125.75	144.00	136.25
2	0	131.50	150.25	156.00	149.75	125.00	148.75	164.25	155.50	150.00
2	1	159.75	162.00	136.75	131.00	140.50	181.50	164.25	168.25	161.75
2	2	153.75	157.75	162.50	160.50	170.75	158.75	146.25	169.00	178.00

Actual Weights in lb.—Sub-Plots without Phosphate.

S/Amm.	Potash.	A	B	C	D	E	F	G	H	I
Quantities										
0	0	111.50	119.25	115.25	121.75	96.00	111.00	121.50	97.75	117.50
0	1	107.00	118.50	98.75	119.75	126.75	133.25	123.75	125.00	136.75
0	2	84.25	117.00	111.00	123.25	109.50	119.75	116.50	114.25	138.75
1	0	101.00	129.25	113.25	142.25	136.25	113.50	133.75	132.25	141.25
1	1	142.00	141.25	126.50	105.50	131.75	120.25	140.75	125.75	145.00
1	2	142.50	139.25	134.75	126.25	132.75	110.75	121.50	135.00	145.25
2	0	128.00	148.00	119.00	133.75	125.00	128.25	152.50	138.25	132.75
2	1	146.50	135.25	108.00	138.50	122.75	137.50	146.75	137.00	138.50
2	2	131.00	128.25	139.75	134.75	152.50	142.00	136.50	153.25	135.00

Summary of Average Yields.—Separate Treatments.

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		4.52	5.10	5.38	4.79	5.52	5.94
Single Potash	Sulphate	5.02	5.20	5.06	5.22	5.70	5.91
	Muriate	4.89	5.34	5.52	4.89	6.37	6.09
	Potash Salts	4.68	5.25	5.64	4.94	5.64	6.82
Double Potash	Sulphate	5.08	5.21	5.71	5.18	5.52	6.45
	Muriate	4.51	5.20	5.33	4.75	6.02	6.65
	Potash Salts	4.26	5.50	5.74	4.75	5.78	6.42

Summary of Significant Results.

	Average Yield, tons per acre.						
	Without Superphosphate.			With Superphosphate.			Standard Error.
	No Sulph. Amm.	Single Sulph. Amm.	Double Sulph. Amm.	No Sulph. Amm.	Single Sulph. Amm.	Double Sulph. Amm.	
No Potash	4.52	5.10	5.38	4.79	5.52	5.94	0.105
Single Potash	4.86	5.26	5.41	5.01	5.90	6.28	
Double Potash ..	4.62	5.30	5.59	4.89	5.77	6.51	

	Average Yield per cent.						
	Without Superphosphate.			With Superphosphate.			Standard Error.
	No Sulph. Amm.	Single Sulph. Amm.	Double Sulph. Amm.	No Sulph. Amm.	Single Sulph. Amm.	Double Sulph. Amm.	
No Potash	84.1	95.0	100.2	89.2	102.8	110.6	1.96
Single Potash	90.6	98.0	100.6	93.4	109.9	116.9	
Double Potash ..	86.0	98.8	104.2	91.1	107.5	121.1	

Average Yield.	Without Super.	With Super.	Mean.	Standard Error.
Tons per acre ..	5.12	5.62	5.37	0.035
Per cent. ..	95.3	104.7	100.0	0.65

Significant responses to single and double dressings of Sulphate of Ammonia, and to single dressing of Potash. The double dressing of Potash produced no further increase in yield. Significant response to Superphosphate, the benefit being moderate on the plots without Nitrogen and Potash, but large on those plots receiving the highest dressings. No qualitative differences in the kind of Potash supplied.

SUGAR BEET.

MANURING.

Nitrogenous Fertilisers: Sulphate of Ammonia, Nitrate of Soda.
Chloride Dressings: Muriate of Potash, Salt.
Superphosphate.

VARIETAL TEST.

Klein Wanzleben—Kuhn (Johnson's Perfection).

. Long Hoos (Section 5), 1929.

N

	J	K	J	K	K	J	K	J	J	K	J	K	
I.	9	10	11	6	8	3	2	7	5	1	12	4	P
II.	3	5	1	12	11	7	9	6	2	4	8	10	O
III.	1	9	7	2	6	10	4	12	3	8	5	11	O
IV.	8	2	12	3	4	6	10	1	7	5	11	9	P
V.	4	3	10	9	1	5	7	8	12	11	2	6	O
VI.	6	4	3	7	5	9	12	2	11	10	1	8	P
VII.	12	8	5	10	2	11	1	9	4	7	6	3	O
VIII.	2	1	4	8	9	12	11	10	6	3	7	5	P
IX.	10	11	8	1	7	4	6	5	9	2	3	12	P
X.	11	7	6	4	10	2	5	3	8	12	9	1	O
XI.	7	12	9	5	3	1	8	11	10	6	4	2	O
XII.	5	6	2	11	12	8	3	4	1	9	10	7	P

SYSTEM OF REPLICATION: Latin Square.

AREA OF EACH PLOT: 1/90th acre.

TREATMENTS: Sulphate of Ammonia and Nitrate of Soda with seed at the rate of 0.4 cwt. N per acre. Muriate of Potash at the rate of 0.8 cwt. Cl, and Salt in equivalent amount, alone and in combination.

J, K=Pairs of strips one way allotted at random to varieties Kuhn (Johnson's Perfection) and Klein Wanzleben respectively.

O, P=Pairs of strips the other way allotted at random to No Superphosphate and Superphosphate at the rate of 0.6 cwt. P_2O_5 per acre.

The 12 plots of each Nitrogenous and Potassic treatment had 6 allotted to each variety, of which half had no Superphosphate and half had Superphosphate.

All plots had Basal dressing of St. Albans refuse (14 tons per acre) applied March 11-13.

Manures applied: May 2-3.

Seed sown: May 4 (13-16 lb. per acre).

Roots lifted: Oct. 29—Nov. 6.

Previous Crop: Barley.

Key to Treatments.

Manure.	1	2	3	4	5	6	7	8	9	10	11	12
S/Amm.		×			×			×			×	
N/Soda			×			×			×			×
M/Potash ..				×	×	×				×	×	×
Salt							×	×	×	×	×	×

Actual Weights in lb.—Roots.

Row.	1	2	3	4	5	6	7	8	9	10	11	12
I.	174.25	193.25	239.75	116.75	214.75	223.75	203.00	229.00	210.50	190.25	240.25	212.75
II.	187.25	200.00	179.25	153.75	197.50	207.00	183.25	200.75	207.00	117.25	220.50	198.75
III.	160.25	214.75	209.50	169.75	184.75	220.50	196.75	180.75	193.50	165.75	123.00	217.00
IV.	203.00	159.25	216.50	178.25	176.00	199.25	208.00	182.75	123.00	166.50	204.25	222.50
V.	169.25	163.00	161.25	142.75	196.25	114.25	184.25	208.25	207.25	190.75	164.25	211.25
VI.	190.00	229.75	229.50	154.50	195.25	181.25	198.00	130.50	211.50	155.25	242.50	218.00
VII.	169.25	183.25	131.25	179.50	194.50	213.00	164.25	167.00	189.50	194.25	184.25	172.00
VIII.	137.50	170.00	171.75	192.00	150.00	200.50	200.50	205.75	180.50	168.00	192.50	194.00
IX.	172.75	188.00	194.25	170.25	175.50	183.00	179.00	195.00	196.50	160.75	167.00	164.25
X.	135.25	198.75	179.25	197.25	164.50	186.75	137.50	195.00	206.00	187.00	185.25	187.50
XI.	149.75	143.25	172.25	194.00	204.00	197.50	191.00	176.50	196.00	172.00	175.25	177.50
XII.	174.25	200.50	169.50	159.50	243.00	183.50	150.00	194.25	179.75	201.00	210.00	188.00

https://doi.org/10.23637/ERADOC-1-111

Actual Weights in lb.—Tops.

Row.	1	2	3	4	5	6	7	8	9	10	11	12
I.	103.75	128.50	172.50	85.75	151.25	158.25	124.50	183.25	156.75	122.00	185.00	172.25
II.	124.75	132.50	136.75	97.75	136.75	140.75	121.75	159.25	125.75	86.75	173.75	165.00
III.	114.00	146.75	156.50	102.00	149.25	170.50	133.75	127.25	170.50	111.50	107.50	148.75
IV.	111.00	114.75	158.75	113.25	113.25	145.50	132.75	142.75	108.50	97.00	149.25	185.00
V.	104.25	122.50	120.25	95.50	143.00	110.00	101.50	134.75	163.50	132.75	117.00	164.25
VI.	121.25	135.50	176.00	99.75	136.75	137.25	132.25	108.75	162.75	93.75	169.50	139.50
VII.	99.25	126.50	115.50	114.50	146.50	159.00	96.75	140.75	133.75	128.50	141.25	138.25
VIII.	97.75	121.25	116.50	130.50	118.25	142.50	124.50	152.00	146.75	97.25	123.50	154.00
IX.	114.75	125.00	145.75	119.00	108.75	148.00	118.50	138.75	146.25	125.25	118.00	143.25
X.	104.25	140.25	134.75	136.75	139.00	154.00	94.25	143.25	160.25	133.00	162.00	157.00
XI.	114.50	110.25	141.00	131.50	148.25	152.75	157.50	150.25	161.00	111.50	133.00	152.25
XII.	103.75	153.75	150.50	98.75	211.75	147.50	112.00	167.00	144.50	127.25	180.50	167.25

Summary of Results.—(a) **Separate Treatments.**

Klein Wanzleben.—Roots, tons per acre.

		No Nitrogen.		Sulphate of Amm.		Nitrate of Soda.	
		Without Mur. /Pot.	With Mur. /Pot.	Without Mur. /Pot.	With Mur. /Pot.	Without Mur. /Pot.	With Mur. /Pot.
Without Phosphate	Without Salt ..	6.34	6.97	7.25	7.58	6.22	7.13
	With Salt ..	6.51	6.68	7.02	6.80	8.14	7.55
With Phosphate	Without Salt ..	6.49	6.02	7.24	6.98	7.47	7.91
	With Salt ..	7.06	6.86	7.57	7.63	6.47	7.64
		Standard Error=0.271 tons or 3.65 per cent.*					
		Tops, tons per acre.					
Without Phosphate	Without Salt ..	4.12	4.51	5.14	5.68	5.05	5.80
	With Salt ..	3.92	4.66	5.60	5.33	6.16	6.35
With Phosphate	Without Salt ..	4.24	4.00	4.93	4.93	5.70	6.08
	With Salt ..	4.86	4.19	5.95	5.65	5.35	6.03
		Standard Error=0.162 tons or 2.99 per cent.*					

*For comparisons other than Phosphate *versus* No Phosphate.

Kuhn (Johnson's Perfection).—Roots, tons per acre.

		No Nitrogen.		Sulphate of Amm.		Nitrate of Soda.	
		Without Mur. /Pot.	With Mur. /Pot.	Without Mur. /Pot.	With Mur. /Pot.	Without Mur. /Pot.	With Mur. /Pot.
Without Phosphate	Without Salt ..	6.66	6.91	7.52	7.71	7.61	8.13
	With Salt ..	7.65	7.08	8.09	7.30	7.92	8.04
With Phosphate	Without Salt ..	7.60	6.99	8.04	8.48	8.89	7.78
	With Salt ..	8.19	7.09	7.66	9.20	8.28	8.43
		Standard Error=0.271 tons or 3.65 per cent.*					
		Tops, tons per acre.					
Without Phosphate	Without Salt ..	4.73	4.57	5.29	5.88	5.73	6.08
	With Salt ..	5.53	4.76	5.86	5.84	6.09	6.04
With Phosphate	Without Salt ..	4.50	4.66	5.50	6.32	6.62	5.70
	With Salt ..	5.11	4.68	6.00	6.75	6.24	6.85
		Standard Error=0.162 tons or 2.99 per cent.*					

*For comparisons other than Phosphate *versus* No Phosphate.

Sugar Beet : Long Hoos, 1929 (contd.)

Klein Wanzleben.—Sugar Percentage.

		No Nitrogen.		Sulphate of Amm.		Nitrate of Soda.	
		Without Mur./Pot.	With Mur./Pot.	Without Mur./Pot.	With Mur./Pot.	Without Mur./Pot.	With Mur./Pot.
Without Phosphate	Without Salt ..	18.32	18.54	18.20	18.56	18.05	17.81
	With Salt ..	18.82	18.51	18.42	18.09	18.43	18.35
With Phosphate	Without Salt ..	18.64	18.57	18.20	18.04	18.03	18.29
	With Salt ..	18.77	18.95	18.10	18.38	17.91	18.24
		Standard Error=0.103.*					

Kuhn.—Sugar Percentage.

		No Nitrogen.		Sulphate of Amm.		Nitrate of Soda.	
		Without Mur./Pot.	With Mur./Pot.	Without Mur./Pot.	With Mur./Pot.	Without Mur./Pot.	With Mur./Pot.
Without Phosphate	Without Salt ..	18.45	18.55	17.92	18.32	18.35	18.28
	With Salt ..	18.63	18.71	17.97	18.53	18.16	18.51
With Phosphate	Without Salt ..	18.42	18.58	18.62	18.54	18.34	18.33
	With Salt ..	18.52	18.62	18.40	18.17	18.42	18.00
		Standard Error=0.103.*					

*For comparisons other than Phosphate *versus* No Phosphate.

(b) **Effect of Nitrogenous Dressing, averaging for variety, Phosphate and Chloride.**

Average Yield.	No Nitrogen.	Sulphate of Ammonia.	Nitrate of Soda.	Mean.	Standard Error.
Roots, tons per acre ..	6.94	7.63	7.72	7.43	0.068
Roots, per cent. ..	93.4	102.6	103.9	100.0	0.91
Tops, tons per acre ..	4.57	5.67	5.99	5.41	0.040
Tops, per cent. ..	84.4	104.8	110.8	100.0	0.75
Sugar percentage in Roots	18.60	18.28	18.22	18.36	0.026

Significant response to both Nitrogenous dressings in the case of roots and tops. The plots treated with Nitrate of Soda gave a significantly higher yield of tops. The application of a Nitrogenous dressing depressed the sugar percentage in the roots significantly, but this was more than offset by the increased yield. The net increases in sugar per acre were 7.6 per cent. for Sulphate of Ammonia plots and 8.5 per cent. for Nitrate of Soda plots.

(c) **Effect of Chloride and Phosphatic Dressings, averaging for Variety and Nitrogen.**

Average Yield.—Roots, tons per acre.

	Without Phosphate.		With Phosphate.		Standard Error.
	Without Mur./Pot.	With Mur./Pot.	Without Mur./Pot.	With Mur./Pot.	
Without Salt	6.93	7.41	7.62	7.36	0.111
With Salt	7.55	7.24	7.54	7.81	

Average Yield.—Tops, tons per acre.

	Without Phosphate.		With Phosphate.		Standard Error.
	Without Mur./Pot.	With Mur./Pot.	Without Mur./Pot.	With Mur./Pot.	
Without Salt	5.01	5.42	5.25	5.28	0.066
With Salt	5.53	5.50	5.59	5.69	

The increases due to Muriate of Potash and Salt applied separately were 6.4 per cent. and 8.3 per cent. respectively in roots, with a standard error of 2.11; for tops 7.6 per cent. and 9.6 respectively, with a standard error of 1.73. For superphosphate alone the increase was 9.3 per cent. in roots, with a standard error of 3.76, this last being based on only 5 degrees of freedom. This increase should not be regarded as significant. There was no significant response to superphosphate in tops. No further increase was obtained when the Salts were applied in pairs, but the best yield of all resulted from an application of all three together.

(d) Effect of Phosphatic Dressing in Relation to Variety; averaging for Nitrogen and Chloride.

Average Yield.—Roots.

	Tons per acre.		Standard Error.	Per cent.		Standard Error.
	Kuhn.	Klein Wanzleben		Kuhn.	Klein Wanzleben	
Without Phosphate ..	7.55	7.02	0.078	101.6	94.4	1.05
With Phosphate ..	8.05	7.11		108.3	95.7	
Mean	7.80	7.06	0.283	105.0	95.0	3.81

Average Yield.—Tops.

	Tons per acre.		Standard Error.	Per cent.		Standard Error.
	Kuhn.	Klein Wanzleben		Kuhn.	Klein Wanzleben	
Without Phosphate ..	5.53	5.19	0.047	99.8	93.6	0.84
With Phosphate ..	5.74	5.16		103.6	93.0	
Mean	5.64	5.18	0.162	104.3	95.7	2.99

Of the varieties, only the Kuhn responded significantly to the dressing of Superphosphate, Klein Wanzleben showing on the average no significant response.

In addition to the simpler results already described, certain other significant results appeared. A significant depression followed an application of Muriate of Potash in the absence of a nitrogenous dressing, but only on the plots of Kuhn treated with Superphosphate. The crop, however, responded significantly to Muriate of Potash in the presence of the nitrogenous dressings and Superphosphate (*a*) on the plots of Kuhn treated with Sulphate of Ammonia, and (*b*) on the plots of Klein Wanzleben treated with Nitrate of Soda. Again, on the plots without a Nitrogenous dressing the beneficial effect of Salt appeared on Kuhn without Superphosphate, and on Klein Wanzleben with Superphosphate. No response to Salt occurred on the plots receiving Sulphate of Ammonia, but on those receiving Nitrate of Soda the yield of Klein Wanzleben was improved significantly by Salt in the absence of Superphosphate but depressed in presence of Superphosphate.

REPLICATED EXPERIMENTS AT WOBURN:
MALTING BARLEY.

Nitrogenous Fertilisers: Sulphate and Muriate of Ammonia.
Potassic Fertiliser: Sulphate of Potash.
Superphosphate.

Butt Furlong, 1929.

S

B | D

M K	M K P	K	S K P	M K P	K P	K	M K
P	M	S	S K	S K	S	S P	S K P
O	S P	K P	M P	M	O	M P	P
S K P	S	M	M K P	M K P	K P	K	S
S P	K P	K	O	M K	S K	O	M
P	M P	M K	S K	M P	S P	S K P	P

A | C

SYSTEM OF REPLICATION: 4 randomised blocks of 12 plots each.

AREA OF EACH PLOT: 1/60th acre.

O = No Manure.

Sulphate (S) or Muriate (M) of Ammonia at the rate of 0.2 cwt. of Nitrogen per acre; Sulphate of Potash (K) at the rate of 0.6 cwt. K_2O per acre, and Superphosphate (P) at the rate of 0.4 cwt. Phosphoric acid per acre, in all combinations.

Manures applied: March 22.

Barley sown: March 21. Harvested: Aug. 1-3.

VARIETY: Plumage Archer (3 bushels per acre).

Previous Crop: Sugar Beet.

Actual Weights in lb.—Total Grain.

Blocks.	O	P	K	K+P	S	S+P	S+K	S+K +P	M	M+P	M+K	M+K +P
A	47.75	52.75	53.00	55.50	60.50	54.50	56.50	52.00	60.75	64.50	64.75	54.50
B	52.50	51.00	68.00	66.75	63.25	54.25	60.00	60.50	59.50	59.50	63.50	67.25
C	35.75	40.00	43.00	41.75	34.50	43.75	47.25	44.50	37.25	50.00	47.25	51.00
D	52.50	35.75	62.00	62.75	59.50	59.00	62.50	43.00	54.25	53.25	58.75	62.00

Actual Weights in lb.—Total Straw.

Blocks.	O	P	K	K+P	S	S+P	S+K	S+K +P	M	M+P	M+K	M+K +P
A	59.50	67.00	65.75	75.25	81.00	82.00	72.25	81.50	79.75	82.25	85.00	68.25
B	80.00	71.75	89.00	89.75	89.50	91.75	84.25	84.50	86.00	74.25	87.00	86.75
C	51.25	50.25	54.50	53.75	47.25	60.75	67.00	62.75	54.75	70.25	63.75	64.25
D	68.50	45.75	93.50	72.50	78.50	74.25	81.00	56.50	71.25	71.00	76.25	103.25

https://doi.org/10.23637/ERADOC-1-111

(a) **Summary of Results.—Separate Treatments.**

Average Yield per acre.	No P or K	P	K	P+K	Sulph. Amm.	S+P	S+K	S+ P+K	Mur. Amm.	M+P	M+K	M+ P+K
Grain (cwt.) ..	25.2	24.0	30.3	30.4	29.2	28.3	30.3	26.8	28.4	30.4	31.4	31.4
Straw (cwt.) ..	34.7	31.4	40.5	39.0	39.7	41.4	40.8	38.2	39.1	39.9	41.8	43.2

(b) **Summary of Significant Results.—Averaging for Phosphate.**

	Grain—cwt. per acre.			Grain—per cent.		
	No Nitrogen.	S/Amm.	M/Amm.	No Nitrogen.	S/Amm.	M/Amm.
No Potash ..	24.6	28.7	29.4	85.4	99.7	101.9
Sulphate of Potash	30.3	28.5	31.4	105.1	99.0	108.9

Mean—28.8 cwt. Standard Error—0.98 cwt. or 3.39 per cent.

	Straw—cwt. per acre.			Straw—per cent.		
	No Nitrogen.	S/Amm.	M/Amm.	No Nitrogen.	S/Amm.	M/Amm.
No Potash	33.1	40.5	39.5	84.5	103.5	100.9
Sulphate of Potash ..	39.8	39.5	42.5	101.6	100.9	108.6

Mean—39.1 cwt. Standard Error—1.70 cwt. or 4.33 per cent.

Significant responses to Nitrogenous and Potassic fertilisers, but no response to Phosphate. The interaction of Nitrogen and Potash was significant in the case of grain and suggestive with straw—in the absence of one fertiliser the other increased the yield significantly, but in the presence of one, no further effect was produced by adding the other. The grain appears to respond better to Muriate than to Sulphate, but the difference falls short of significance.

POTATOES.

Nitrogenous Fertiliser : Sulphate of Ammonia.
Potassic Fertilisers : Sulphate and Muriate of Potash and Potash Manure Salts (30%.)

Each in single and double dressings.

Superphosphate.

Butt Close, 1929.

N

	G			D			A	
3 / —	— / 9P	— / 4S	7S / —	— / 5S	— / 1	— / 3	— / 1	4M / —
— / 1	— / 2	8S / —	2 / —	3 / —	8P / —	— / 7P	5P / —	— / 2
— / 6P	5M / —	— / 7M	9M / —	— / 6M	4P / —	— / 9S	6S / —	8M / —
4P / —	— / 8P	5S / —	8M / —	— / 3	— / 7P	3 / —	8S / —	— / 4S
6M / —	— / 7S	3 / —	1 / —	5P / —	— / 2	9P / —	— / 5M	2 / —
1 / —	— / 9M	— / 2	— / 9S	— / 6S	4M / —	— / 6P	7M / —	1 / —
8M / —	— / 5P	9S / —	— / 1	9P / —	— / 8S	4P / —	— / 9M	— / 3
4M / —	— / 2	1 / —	— / 4S	— / 7M	— / 2	— / 7S	— / 5S	— / 8P
6S / —	— / 7P	— / 3	5M / —	— / 6P	3 / —	— / 6M	— / 1	— / 2
	I			F			C	

H (left, middle row of blocks) — B (right, middle row of blocks)

SYSTEM OF REPLICATION : 9 randomised blocks of 9 plots each. Each plot divided into 2 sub-plots.

AREA OF EACH SUB-PLOT : 1/80th acre.

TREATMENTS : Sulphate of Ammonia at the rate of 0, 0.3 and .6 cwt. Nitrogen per acre, and Potash at the rate of 0, 0.5 and 1.0 cwt. K_2O per acre, in all combinations as shown in Key to Treatments.

S = Sulphate of Potash.

M = Muriate of Potash.

P = Potash Manure Salts (30%).

Superphosphate at the rate of .4 cwt. P_2O_5 per acre is applied to one out of each pair of sub-plots, indicated by the treatment symbol occurring on that half. All plots received 2 tons Lime per acre, applied in January, and 12 tons Bedford Corporation Manure per acre applied April 20-21. Artificials applied : April 29-30.

Potatoes planted May 1-6. Lifted : September 14-18.

VARIETY : Ally. Blocks C, F, I, once grown.

Previous Crop : Barley.

Key to Treatments.

Treatment No.	1	2	3	4	5	6	7	8	9
S/Ammonia	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	A	B	C	D	E	F	G	H	I
Quantities										
0	0	165.25	120.75	67.00	154.50	132.50	115.50	164.50	156.50	120.50
0	1	176.75	130.50	94.50	148.00	141.00	118.50	211.75	130.50	122.25
0	2	182.00	161.50	85.75	181.75	162.50	99.00	162.75	184.25	111.00
1	0	198.00	146.50	90.50	187.00	130.00	96.75	176.00	152.00	79.00
1	1	223.50	165.00	96.00	182.00	132.00	103.00	164.00	157.50	117.50
1	2	157.50	130.50	89.00	163.75	161.00	89.00	164.25	162.50	97.75
2	0	201.25	133.00	99.50	190.50	134.50	75.50	149.75	159.00	104.75
2	1	183.00	150.00	79.00	147.00	127.50	85.00	166.00	146.00	115.00
2	2	160.50	174.75	120.00	198.00	160.25	93.50	205.00	98.00	141.25

Actual Weights in lb.—Sub-Plots without Phosphate.

S/Amm.	Potash	A	B	C	D	E	F	G	H	I
Quantities										
0	0	160.75	121.00	53.00	148.00	136.50	129.50	141.75	107.00	96.00
0	1	136.00	119.00	98.50	123.00	118.00	123.00	186.25	155.50	118.00
0	2	198.50	154.50	99.00	171.75	114.00	114.25	160.00	154.50	90.00
1	0	162.25	152.00	74.00	191.25	128.50	91.50	185.50	179.25	104.50
1	1	206.75	158.50	114.00	167.50	162.50	97.50	184.00	159.50	114.75
1	2	155.00	148.00	94.00	192.00	145.00	68.00	207.00	169.00	103.00
2	0	163.50	150.50	80.00	200.00	122.50	99.00	131.25	195.25	106.00
2	1	154.00	169.00	88.00	182.00	127.50	91.00	170.25	156.50	118.50
2	2	208.00	174.75	130.00	183.50	206.00	95.00	197.50	172.00	142.00

Summary of Average Yields, Separate Treatments.

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		4.34	5.03	4.95	4.75	4.98	4.95
Single Potash	Sulphate	5.10	5.25	4.76	5.49	5.18	5.07
	Muriate	4.43	5.24	5.08	5.24	5.14	4.43
	Potash Salts	4.49	5.76	5.12	4.44	5.63	4.77
Double Potash	Sulphate	5.06	5.04	6.62	5.38	4.57	5.50
	Muriate	5.10	4.80	5.78	5.04	4.96	4.95
	Potash Salts	4.79	5.42	5.56	5.42	4.94	5.63

Summary of Significant Results.

	Average Yield in tons per acre.						
	Without Superphosphate.			With Superphosphate.			Standard Error.
	No Sulph. Amm.	Single Sulph. Amm.	Double Sulph. Amm.	No Sulph. Amm.	Single Sulph. Amm.	Double Sulph. Amm.	
No Potash	4.34	5.03	4.95	4.75	4.98	4.95	
Single Potash	4.67	5.42	4.99	5.05	5.32	4.76	0.181
Double Potash.. ..	4.99	5.08	5.99	5.28	4.82	5.36	

Potatoes : Butt Close, 1929 (contd.)

	Average Yield per cent.						
	Without Superphosphate.			With Superphosphate.			Standard Error.
	No Sulph. Amm.	Single Sulph. Amm.	Double Sulph. Amm	No Sulph. Amm.	Single Sulph. Amm.	Double Sulph. Amm.	
No Potash	86.1	99.9	98.2	94.2	98.9	98.2	
Single Potash	92.7	107.5	98.9	100.3	105.5	94.3	3.60
Double Potash ..	98.9	100.8	118.8	104.7	95.7	106.4	

General Mean—5.04 tons.

Significant response on the average of all Nitrogenous and Superphosphate comparisons to both dressings of Potash. Evidence of response to Sulphate of Ammonia, which, however, was masked by lower plant numbers. No qualitative differences in the kind of Potash supplied. No response to Superphosphate, an apparent benefit in the case of the plots without Nitrogen being offset by a depression on those plots receiving high dressings of Sulphate of Ammonia and of Potash.

POTATOES :
Effect of Potash.
Butt Close, 1929.

S

K	S	O
O	K	S
S	O	K

System of Replication : Latin Square.
Area of Each Plot : 1/40th acre.
Treatments : Testing Potash Mineral (K) and an equivalent dressing of Sulphate of Potash (S) at the rate of 0.5 cwt. of K_2O per acre. Basal Dressing, 12 tons of Bedford Corporation Manure per acre, applied April 19-21.
Artificials applied : April 29-30.
Variety : Majestic.
Potatoes planted : May 1-5. Lifted : September 14-18.
Previous Crop : Barley.

Actual Yield in lb.

Row.	O	S	K
I.	276.50	239.00	236.00
II.	223.50	235.00	203.75
III.	188.75	174.00	216.25

Summary of Results.

	No Potash.	Sulphate of Potash.	Potash Mineral.	Mean.	Standard Error.
Tons per acre ..	4.10	3.86	3.90	3.95	0.076
Per cent.	103.7	97.6	98.8	100.0	1.93

No response to either dressing of Potash on very low yield.

SUGAR BEET.

Effect of Nitrogenous Fertilisers:

Sulphate of Ammonia, with seed.
Nitrate of Soda (*a*) with seed.
(*b*) as top dressing.

Lansome, 1929.

N.W.

A				B				C			
Ns+NT	S+Ns +NT	O	S+NT	O	S+Ns +NT	Ns+NT	NT	Ns	Ns+NT	S	S+Ns
S	NT	Ns	S+Ns	S+Ns	S+NT	Ns	S	S+NT	O	NT	S+Ns +NT
S+Ns +NT	Ns	S+NT	Ns+NT	NT	S	S+Ns +NT	Ns	S	Ns+NT	O	Ns
NT	S+Ns	S	O	S+NT	Ns+NT	S+Ns	O	S+NT	S+Ns	NT	S+Ns +NT
D				E				F			

System of Replication : 48 plots in 6 randomised blocks.
Area of Each Plot : 1/40th acre.
Treatments :
S=Sulphate of Ammonia with seed
Ns=Nitrate of Soda with seed } in all combinations.
NT=Nitrate of Soda as top dressing
Rate : 0.4 cwt. Nitrogen per acre in all cases.
Basal Manure : Bedford Corporation Manure (10 tons per acre).
Applied : February 3—March 10. Artificials Applied : Basal, May 21-22. Top Dressing : July 10.
Variety : " Klein Wanzleben."
Beet sown : May 23 (16 lb. per acre). Lifted : October. 24-26.
Previous Crop : Clover and Grasses.

Actual Yield in lb.—Roots.

Block.	O	S	Ns	NT	S+Ns	S+NT	Ns+NT	S+Ns +NT
A	359.0	140.0	377.0	251.0	492.5	477.5	176.5	340.0
B	433.0	448.0	461.0	301.5	530.0	469.5	410.5	460.5
C	470.0	456.5	322.5	522.5	343.0	530.0	354.0	448.5
D	560.5	512.0	444.5	364.5	527.5	513.5	516.5	241.0
E	501.0	565.0	562.0	535.5	620.0	554.0	550.5	602.0
F	491.5	468.0	413.5	517.5	570.5	503.5	510.5	478.5

Actual Yield in lb.—Tops.

Block.	O	S	Ns	NT	S+Ns	S+NT	Ns+NT	S+Ns +NT
A	389	220	218	345	530	460	237	502
B	405	463	451	190	562	557	410	502
C	307	416	318	398	231	572	483	406
D	455	504	392	341	480	485	507	255
E	535	504	555	511	513	481	542	548
F	476	419	448	524	465	540	578	526

Sugar Beet : Lansome, 1929 (contd.)

Summary of Results.

ROOTS.	Average Yield—tons per acre.				Average Yield—per cent.			
	Without S/Amm.		With S/Amm.		Without S/Amm.		With S/Amm.	
	Without N/Soda with seed.	With N/Soda with seed.	Without N/Soda with seed.	With N/Soda with seed.	Without N/Soda with seed.	With N/Soda with seed.	Without N/Soda with seed.	With N/Soda with seed.
Without Top Dressing ..	8.38	7.68	7.71	9.18	103.8	95.1	95.5	113.7
With Top Dressing ..	7.42	7.50	9.07	7.65	91.9	92.9	112.4	94.8

Mean—8.07 tons. Standard Error—0.592 tons or 7.34 per cent.

TOPS.	Average Yield —tons per acre.				Average Yield—per cent.			
	Without S/Amm.		With S/Amm.		Without S/Amm.		With S/Amm.	
	Without N/Soda with seed.	With N/Soda with seed.	Without N/Soda with seed.	With N/Soda with seed.	Without N/Soda with seed.	With N/Soda with seed.	Without N/Soda with seed.	With N/Soda with seed.
Without Top Dressing ..	7.64	7.09	7.52	8.28	97.1	90.1	95.5	105.2
With Top Dressing ..	6.87	8.21	9.21	8.15	87.3	104.3	117.0	103.6

Mean=7.87 tons. Standard Error=0.676 tons or 8.58 per cent.

Sugar Percentage.

	Average Sugar Percentage.			
	Without Sulphate of Ammonia.		With Sulphate of Ammonia.	
	Without N/Soda with seed.	With N/Soda with seed.	Without N/Soda with seed.	With N/Soda with seed.
Without Top Dressing	16.91	16.42	16.68	16.63
With Top Dressing ..	15.98	16.30	16.33	16.00

Mean—16.41. Standard Error—0.261 or 1.59 per cent.

There is evidence of a response to Sulphate of Ammonia on those plots which were also treated with Nitrate of Soda, either with the seed or as a top dressing, but on the plots which had all three dressings there was no response. Application of top dressing of Nitrate of Soda has depressed the sugar percentage significantly, while the Nitrogenous dressings applied at time of sowing had no effect.

SUGAR BEET.

Potassic Fertilisers : Muriate of Potash, Potash Manure Salts, Potash Mineral.

Phosphatic Fertilisers : Slag, Superphosphate.

Lansome, 1929.

A				B				C			
Sl K	S M	S O	O O	Sl O	S O	O P	Sl P	S M	O O	O M	S P
Sl P	S P	O M	Sl M	O O	S M	S K	S P	O K	Sl O	Sl P	Sl K
Sl O	O K	S K	O P	Sl M	Sl K	O M	O K	S K	S O	O P	Sl M

Upper letters refer to dressings of Phosphate.
Lower letters refer to dressings of Potash.

SYSTEM OF REPLICATION : 36 plots in 3 randomised blocks.
AREA OF EACH PLOT : 1/40th acre.
TREATMENTS : (*a*) No Potash (O) and Potash in the form of Muriate of Potash (M), Potash Manure Salts (P), and Potash Mineral (K). (Rate 0.8 cwt. K_2O per acre). (*b*) No Phosphate (O), and Phosphate in the form of Slag (Sl), and Superphosphate (S). (Rate 0.6 cwt. P_2O_5 per acre.) (*a*) and (*b*) in all combinations.
Basal Manure : Bedford Corporation Manure, 10 tons per acre, February 3–March 10.
Artificials applied : May 21-22.
Beet sown : May 23 (16 lb. per acre).
Singled : June 20-24.
Lifted : October 23-24.
Previous Crop : Clover and Grasses.

Actual yield in lb.—Roots.

Blocks.	No Potash.			Muriate of Potash.			Potash Manure Salts.			Potash Mineral.		
	No Phosphate.	Slag.	Super.	No Phosphate.	Slag.	Super.	No Phosphate.	Slag.	Super.	No Phosphate.	Slag.	Super.
A	490.5	422.5	490.0	469.5	467.5	455.5	527.0	453.5	506.5	439.0	474.5	497.0
B	432.0	476.5	432.5	482.0	523.0	402.5	480.0	495.0	428.5	506.0	460.0	418.5
C	462.5	438.5	519.0	492.0	473.5	414.5	517.5	409.5	458.5	371.5	343.5	468.5

Actual yield in lb.—Tops.

Blocks.	No Potash.			Muriate of Potash.			Potash Manure Salts.			Potash Mineral.		
	No Phosphate.	Slag.	Super.	No Phosphate.	Slag.	Super.	No Phosphate.	Slag.	Super.	No Phosphate.	Slag.	Super.
A	450	483	409	462	496	452	493	524	500	403	436	495
B	418	356	455	412	441	390	529	441	693	391	342	428
C	458	431	452	420	178	175	378	539	175	376	233	420

Summary of Results.—Roots.

	Average Yield in tons per acre.				Average Yield per cent.			
	No Potash.	Muriate of Potash.	Potash Manure Salts.	Potash Mineral.	No Potash.	Muriate of Potash.	Potash Manure Salts.	Potash Mineral.
No Phosphate ..	8.24	8.59	9.07	7.84	100.1	104.4	110.2	95.2
Slag	7.96	8.71	8.08	7.61	96.7	105.8	98.2	92.4
Superphosphate	8.58	7.57	8.29	8.24	104.2	92.0	100.7	100.1

Mean—8.23 tons. Standard Error—0.422 tons or 5.13 per cent.

https://doi.org/10.23637/ERADOC-1-111

Sugar Beet: Lansome, 1929 (contd.)

Tops.

	Average Yield in tons per acre.				Average Yield per cent.			
	No Potash.	Muriate of Potash.	Potash Manure Salts.	Potash Mineral.	No Potash.	Muriate of Potash.	Potash Manure Salts.	Potash Mineral.
No Phosphate ..	7.89	7.70	8.33	6.96	105.1	102.6	111.0	92.8
Slag	7.56	6.64	8.95	6.02	100.7	88.4	119.3	80.2
Superphosphate	7.83	6.05	8.14	7.99	104.3	80.6	108.5	106.5

Mean—7.51 tons. Standard Error—0.996 tons or 13.27 per cent.

Sugar Percentage.

	No Potash.	Muriate of Potash.	Potash Manure Salts	Potash Mineral.	Mean.
No Phosphate ..	17.88	17.72	17.66	17.74	17.75
Slag	17.50	17.53	17.84	17.42	17.57
Superphosphate ..	17.89	18.28	17.92	17.57	17.91

Mean—17.74 Standard Error—0.251 or 1.41 per cent.

There has been no response whatever to the Phosphatic dressing, while the effect of Potash was insignificant, there being only a slight indication of a depression due to Potash Mineral in the case of roots and tops, and also a depression due to Muriate of Potash with tops only. The plots treated with Superphosphate have given a significantly higher sugar percentage than those treated with Slag. No significant differences in sugar percentage due to the Potassic treatments.

REPLICATED EXPERIMENTS AT OUTSIDE CENTRES.

Grassland. New Hay. Effect of Basic Slag.

(Basic Slag Committee.)

Mr. B. W. H. Pratt, Brooke, Norfolk, 1929.

S

I.	L	H	C	M
II.	H	C	M	L
III.	C	M	L	H
IV.	M	L	H	C

Seed sown : 1925.
SYSTEM OF REPLICATION : Latin Square.
AREA OF EACH PLOT : $\frac{1}{4}$ acre.
Soil : Calcareous boulder clay.
TREATMENTS :
C = Control.
L = Low soluble slag (37.3%).
M = Medium soluble slag (60.9%).
H = High soluble slag (86.8%).
Slags applied at the rate of 100 lb. P_2O_5 per acre in March, 1926.
All plots received 1 cwt. Sulphate of Ammonia and 2 cwt. 20% Potash Manure Salts.

Actual Weights in lb.

Row.	C	L	M	H
I.	273	355	464	386
II.	283	387	348	392
III.	318	344	333	395
IV.	344	330	378	385

Summary of Results.

Average Yield.	Control.	Low Soluble.	Medium Soluble.	High Soluble.	Mean.	Standard Error.
Cwt. per acre.. ..	10.9	12.6	13.6	13.9	12.8	0.45
Per cent.	85.2	99.1	106.6	109.0	100.0	3.52

Significant response to all grades of Slag. The average yield of the plots treated with medium and high soluble Slags is significantly greater than the average of the low soluble plots.

Grassland. Old Hay. Effect of Basic Slag.

(Basic Slag Committee).

Mr. E. Habberfield, Home Farm, Enmore, Somerset, 1929.

I.	L	C	H	M
II.	H	M	L	C
III.	M	H	C	L
IV.	C	L	M	H

System of Replication : Latin Square.
Area of Each Plot : ¼ acre.
Soil : Red clay loam on sandstone.
Treatments :
C=Control.
L=Low soluble slag (37.3%).
M=Medium soluble slag (60.9%).
H=High soluble slag (86.8%).
All plots received 1 cwt. Sulphate of Ammonia and 2 cwt. 20% Potash Manure Salts.
Slags applied at the rate of 100 lb. P_2O_5 per acre in March, 1926.

Actual Weights in lb.

Row.	C	L	M	H
I.	602	537	817	787
II.	618	707	629	395
III.	622	610	520	661
IV.	394	670	662	631

Summary of Results.

Average Yield.	Control.	Low Soluble.	Medium Soluble.	High Soluble.	Mean.	Standard Error.
Cwt. per acre.. ..	20.0	22.5	23.5	22.1	22.0	0.99
Per cent.	90.7	102.4	106.6	100.3	100.0	4.51

The response to the treatment is not significant, but there is evidence that the yield of hay was better on the plots treated with Slag in 1926 than on the plots not so treated. All the Slags seem to give equivalent results.

Potatoes. Effect of Superphosphate

G. Major, Esq., Newton Farm, Lincs., 1929

	A	B	B	A	B	A	A	B
I.	5	5	0	0	2½	2½	10	10
II.	10	10	2½	2½	0	0	5	5
III.	2½	2½	10	10	5	5	0	0
IV.	0	0	5	5	10	10	2½	2½

VARIETIES : British Queen (A) and King Edward (B) in random strips.

SYSTEM OF REPLICATION : Latin Square.

AREA OF EACH SUB-PLOT : 1/50th acre.

TREATMENT : Superphosphate at the rate of 0, 2½, 5 and 10 cwt. per acre. Basal Manuring : 4 cwt. Sulphate of Ammonia and 4 cwt. Sulphate of Potash per acre.

Potatoes set : April 11.

Lifted : October 15-16.

Actual Weights in lb.

Row.	British Queen.				King Edward.			
	0	2½	5	10	0	2½	5	10
I.	509	512	498	563	560	613	614	623
II.	457	524	564	503	582	584	663	640
III.	497	503	538	592	568	569	577	601
IV.	461	553	541	553	548	614	599	624

Summary of Results.

(a) **Separate Varieties.**

Average Yield in tons per acre.	No Superphosphate.	2½ cwt. Superphosphate.	5 cwt. Superphosphate.	10 cwt. Superphosphate.
British Queen ..	10.74	11.67	11.95	12.34
King Edward ..	12.60	13.28	13.69	13.88

(b) **Varietal Difference.**

Average Yield.	British Queen.	King Edward.	Mean.	Standard Error.
Tons per acre ..	11.67	13.36	12.52	0.189
Per cent.	93.3	106.7	100.0	1.51

(c) **Effect of Superphosphate.**

Average Yield.	No Super.	2½ cwt. Super.	5 cwt. Super.	10 cwt. Super.	Mean.	Standard Error.
Tons per acre ..	11.67	12.48	12.82	13.11	12.52	0.147
Per cent.	93.2	99.7	102.4	104.7	100.0	1.17

King Edwards yielded significantly better than British Queen in both yield and size (as observation in field showed). Significant response to Superphosphate with both varieties, but no differential response.

https://doi.org/10.23637/ERADOC-1-111

Sugar Beet: Effect of Nitrogenous Fertilisers.

Col. F. Wilson, Stanway Hall Farm, Colchester, 1929.

I.	A	C	D	B
II.	C	A	B	D
III.	D	B	A	C
IV.	B	D	C	A

Soil : Light sandy loam.
VARIETY : Kuhn P.
SYSTEM OF REPLICATION : Latin Square.
AREA OF EACH PLOT : 1/50th acre.
TREATMENT : 0.4 cwt. of N per acre in the forms Sulphate of Ammonia, Nitrate of Soda with seed and as a top dressing.
Basal Dressing : Dung, Superphosphate at the rate of 0.4 cwt. P_2O_5 per acre and Muriate of Potash at the rate of 0.8 cwt. K_2O per acre.
Artificials applied : Basal, March 10. Top Dressing, June 13.
Beet sown : April 22. Lifted : December 9.

Actual Yields in lb.

Row.	Roots.				Tops.			
	A O	B S/Amm.	C N/Soda (seed).	D N/Soda (T.D.)	A O	B S/Amm.	C N/Soda (seed).	D N/Soda (T.D.)
I.	296.0	312.5	361.0	326.5	229	207	284	313
II.	317.0	369.0	389.0	390.5	229	306	304	313
III.	298.5	370.5	384.5	385.0	242	280	299	333
IV.	346.5	377.0	362.5	382.0	224	277	333	327

Summary of Results.

Average Yield.	No Nitrogen.	Sulphate of Ammonia.	Nitrate of Soda (seed).	Nitrate of Soda (T.D.)	Mean.	Standard Error.
Roots, tons per acre	7.02	7.97	8.35	8.28	7.91	0.213
Roots, per cent.	88.8	100.8	105.6	104.7	100.0	2.69
Roots, sugar percentage ..	18.03	17.86	17.78	17.81	17.87	0.078
Tops, tons per acre	5.16	5.97	6.81	7.18	6.28	0.167
Tops, per cent.	82.1	95.1	108.4	114.3	100.0	2.66

Significant response to all forms of Nitrogenous dressing. Nitrate of Soda significantly better than Sulphate of Ammonia in the case of tops—with roots the difference, while moderately large, is not significant. The difference between the application of Nitrate of Soda with seed, and as a top dressing, is not significant. The Nitrogenous dressings appear to have depressed slightly the percentage of sugar in the roots.

https://doi.org/10.23637/ERADOC-1-111

Sugar Beet: Effect of Chloride Dressings

Col. F. Wilson, Stanway Hall Farm, Colchester, 1929

I.	A	B	C	D
II.	D	C	B	A
III.	C	D	A	B
IV.	B	A	D	C

Soil : Light sandy loam.

VARIETY : Kuhn P.

SYSTEM OF REPLICATION : Latin Square.

AREA OF EACH PLOT : 1/50th acre.

TREATMENTS : Muriate of Potash at the rate of 0.8 cwt. K_2O per acre, Potash Manure Salts (20%) equivalent in Potash to KCl, and Salt equivalent in Chloride to Potash Manure Salts.

Basal Dressing : Superphosphate at the rate of 0.4 cwt. P_2O_5 per acre and Sulphate of Ammonia at the rate of 0.4 cwt. N pe acre.

Artificials applied : March 10.

Beet sown : April 22. Lifted : December 6.

Actual Yields in lb.

Row.	A O	B M/Pot.	C P.M.S.	D Salt.
I.	288.0	285.5	337.0	279.5
II.	233.0	302.0	326.0	311.0
III.	294.0	305.5	364.0	347.5
IV.	246.0	270.5	338.5	293.5

Summary of Results.

Average Yield.	No Potash or Salt	Muriate of Potash.	Potash Manure Salts.	Salt.	Mean.	Standard Error.
Roots, tons per acre..	5.92	6.49	7.62	6.87	6.73	0.256
Roots, per cent.	88.0	96.5	113.3	102.2	100.0	3.80
Roots, sugar percentage	17.64	17.63	18.00	17.84	17.78	0.161
Ratio from 4 plots—100 × roots/tops	83	92	124	87	—	—

Significant response to all manurial treatments. The dressing of Potash Salts gave significantly higher yield than either Muriate or Salt. There was some evidence to show that Potash Salts raised the percentage of sugar in the roots, but the difference was not significant.

Barley: Effect of Sulphate of Ammonia, Sulphate of Potash and Superphosphate.

(Yields determined by sampling method.)

H. G. Nevile, Esq., Wellingore, 1929.

A	NK	NPK	O	NP	N	PK	P	K
B	O	K	NPK	N	NP	P	NK	PK

VARIETY : Plumage Archer.
Soil : Light loam on Lincoln Heath.
SYSTEM OF REPLICATION : 2 randomised blocks of 8 plots each.
AREA OF EACH PLOT : 1/60th acre.
TREATMENTS : Sulphate of Ammonia (N) at the rate of 1 cwt. per acre, Superphosphate (P) at the rate of 3 cwt. per acre, and Sulphate of Potash (K) at the rate of 1½ cwt. per acre, in all combinations.
Manures applied : March 14.
Barley sown : March 12. Harvested : August 22-23.
The plots were harvested by the sampling method, 20 separate metres of drill being selected at random from each plot.

Actual Weights in grams per Sample.

Block.	O	K	N	P	KN	KP	NP	NKP
Grain A ..	729	807	736	749	822	661	859	911
Grain B ..	796	873	848	716	852	723	966	1128
Straw A ..	674	734	674	674	764	580	826	991
Straw B ..	655	740	785	659	841	620	862	972

Summary of Results.

Grain.	Cwt. per acre.				Per cent.			
	Without S/Pot.		With S/Pot.		Without S/Pot.		With S/Pot.	
	Without S/Amm.	With S/Amm.	Without S/Amm.	With S/Amm.	Without S/Amm.	With S/Amm.	Without S/Amm.	With S/Amm.
Without Super.	18.8	19.5	20.7	20.6	92.7	96.2	102.0	101.6
With Super. ..	18.0	22.4	17.0	25.1	88.9	110.8	84.0	123.8

Mean—20.2 cwt. Standard Error—0.89 cwt. or 4.38 per cent.

Significant response to the Nitrogenous dressing, which, however, only shows up on the plots having Superphosphate. Superphosphate depressed the yield on the plots without Nitrogenous fertiliser, but increased the yield significantly on the plots having a Nitrogenous dressing in addition. There was evidence of a small response in the aggregate to Potash, but the difference was not significant.

Straw.	Cwt. per acre.				Per cent.			
	Without S/Pot.		With S/Pot.		Without S/Pot.		With S/Pot.	
	Without S/Amm.	With S/Amm.	Without S/Amm.	With S/Amm.	Without S/Amm.	With S/Amm.	Without S/Amm.	With S/Amm.
Without Super.	16.3	17.9	18.1	19.7	88.2	96.9	97.8	106.5
With Super. ..	16.4	20.7	14.7	24.1	88.5	112.0	79.6	130.3

Mean—18.5 cwt. Standard Error—0.59 cwt. or 3.20 per cent.

Significant responses to the Nitrogenous and Potassic fertilisers, the response to the latter only appearing on the plots dressed with Nitrogen. The interaction between the Nitrogenous and Phosphatic fertilisers was significant, alone and in the presence of Potash: without Potash the response to Phosphate occurred only on the plots treated with a Nitrogenous dressing, those without Nitrogen being unaffected: in the presence of Potash there was a significant depression due to the adding of Superphosphate to plots not treated with Nitrogenous fertiliser, but a significant response to Phosphate on the plots also receiving the Nitrogenous dressing.

Experiments at other centres, carried out by the local workers on the lines of those described on the preceding pages.

Potatoes. Mr. E. J. Roberts, College Farm, Aber, Caernarvonshire, 1929

Latin Square: Plots 1/40th acre. Potatoes set March 27, lifted October 10, 14, 15.
Basal Manuring: 12 tons Farmyard Manure (ploughed in), 2 cwt. Sulphate of Ammonia and 3 cwt. 30% Potash Salt in drills.
Variety: Kerr's Pink. Soil: Light gravelly loam.

Average Yield.	No Superphosphate.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre	14.66	14.25	14.53	14.66	14.52	0.177
Per cent. ..	100.9	98.1	100.1	100.9	100.0	1.22

No response to Superphosphate.

Potatoes. Mr. E. Arden, Owmby Cliff, Lincolnshire, 1929.

Latin Square: Plots 1/80th acre. Soil: Cliff Land (Oölitic Limestone).
Basal Manuring: 4 cwt. Sulphate of Ammonia and 3 cwt. Sulphate of Potash per acre.
Variety: King Edward. Potatoes set March 26, lifted September 18.

Average Yield.	No Superphosphate.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre ..	7.42	7.44	7.34	7.30	7.37	0.153
Per cent. ..	100.6	100.8	99.5	99.0	100.0	2.07

No response to Superphosphate.

https://doi.org/10.23637/ERADOC-1-111

Experiments at other Centres (cont.)

Potatoes. Mr. W. W. Ballardie, Midland Agricultural College, Loughborough, 1929.

Latin Square : Plots 1/48th acre. Soil : Light gravelly nature (Old Valley Gravel).
Basal Manuring : 2 cwt. Sulphate of Ammonia and 2 cwt. Sulphate of Potash per acre.
Variety : King Edward. Potatoes set April 28, lifted September 6-11.

Average Yield.	No Superphosphate.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre	8.00	7.82	7.63	7.97	7.85	0.22
Per cent. ..	101.9	99.6	97.1	101.4	100.0	2.81

No response to Superphosphate on total yield.

Sugar Beet. County School, Welshpool, Montgomeryshire, 1929.

Randomised Blocks : Plots 1/160th acre. Soil : School garden.
Treatment : Nitrogen in the form of Sulphate and Muriate of Ammonia and Cyanamide, at the rate of 0.6 cwt. N per acre.
Basal Manuring : Potash at the rate of 1 cwt. K_2O per acre, and Superphosphate at the rate of 0.8 cwt. P_2O_5 per acre.
Variety : Garton's Warrington. Beet sown May 21, lifted November 5.

Average Yield.	No Nitrogen.	Cyanamide.	Sulphate of Ammonia.	Muriate of Ammonia.	Mean.	Standard Error.
Roots, tons per acre	11.6	13.8	13.5	12.8	12.9	0.26
Roots, per cent. ..	89.7	106.9	104.2	99.1	100.0	1.98
Tops, tons per acre	16.5	19.2	21.1	20.3	19.3	0.93
Tops, per cent. ..	85.6	99.7	109.2	105.4	100.0	4.81
Sugar percentage in Roots	17.90	18.06	17.21	17.66	17.71	0.298

Significant response to all forms of Nitrogenous dressings in both roots and tops. With roots the response to Cyanamide and Sulphate is better than that to Muriate. No significant differences in sugar percentage.

Sugar Beet. South-Eastern Agricultural College, Wye, Kent, 1929.

Latin Square : Plots 1/80th acre. (2 discarded). Soil : Loam on chalk.

Basic Dressing : 4 cwt. Superphosphate, 1 cwt. Steamed Bone Flour and 1 cwt. Muriate of Potash. Nitrogenous Manures—1 cwt. per acre Sulphate of Ammonia, and equivalent dressings of Muriate of Ammonia and Nitrate of Soda.

Variety : Kleinwanzleben E. Beet sown May 3rd, lifted October 16-19.

Average Yield.	No Nitrogen.	Sulphate of Ammonia.	Muriate of Ammonia.	Nitrate of Soda.	Mean.	Standard Error.
Roots, tons per acre (unwashed) ..	9.77	8.73	9.85	9.93	9.57	0.583
Roots, per cent. ..	102.1	91.2	102.9	103.8	100.0	6.09

No response to treatment.

Barley. Mr. J. M. Templeton, Farm Institute, Sparsholt, Winchester, 1929.

Latin Square : Plots 1/20th acre. Soil : Thin flinty loam on chalk.

Treatment : Salt at the rate of 100 lb. and 300 lb. per acre and Muriate of Potash at the rate of 1 cwt. per acre.

Variety : Plumage Archer. Barley sown April 5, harvested August 13.

Average Yield.	No Manure.	Salt 100 lb.	Salt 300 lb.	Muriate of Potash.	Mean.	Standard Error.
Grain, cwt. per acre ..	23.9	24.1	24.4	23.5	24.0	0.74
Grain, per cent. ..	99.7	100.4	101.9	98.0	100.0	3.08

No significant differences due to treatments.

https://doi.org/10.23637/ERADOC-1-111

Errata :—Station Report, 1927-8.

Page 130.—Barley : Hoos Field, 1928.

For plots 7-1, 7-2, 6-1, 6-2 and 1N and 2N (produce per acre) the correct values should be as follows (certain plots having been transposed in error) :

Plot.	Dressed Grain.			Offal Grain per acre.	Straw per acre.	Total Straw per acre.	Proportion of Total Grain to 100 of Total Straw.	76 years' Average.	
	Yield per acre.	Weight per bush.	Yield per acre.					Dressed Grain per acre.	Total Straw per acre.
	bush.	lb.	cwt.	lb.	lb.	cwt.		bush.	cwt.
7-1	9.4	44.3	3.7	18	924	10.6	36.8	22.5‡	13.5‡
7-2	12.7	44.8	5.1	28	2593	29.0	18.4	44.6	28.1
6-1	7.4	43.0	2.8	25	515	6.2	49.3	14.7	8.6
6-2	12.0	44.5	4.8	33	704	8.6	59.0	15.7	9.3
1N	7.6	41.5	2.8	34	913	11.1	27.9	28.7§	17.8§
2N	8.6	42.0	3.2	37	1166	13.2	26.8	31.7§§	20.0§§

Page 123.—Rain and Drainage.

Mean of Evaporation (20 in. gauge).
For 14.557 read 14.537.

Lawes Agricultural Trust

The Incorporated Society for Extending the Rothamsted Experiments

The purpose of this Society is to collect much needed funds for continuing and extending the work of the Rothamsted Station.

Bankers: MESSRS. COUTTS & CO., 15 Lombard Street, E.C. 3.

Auditors: MESSRS. W. B. KEEN & CO., 23 Queen Victoria Street, E.C. 4.

https://doi.org/10.23637/ERADOC-1-111